



**EFFECT OF SOWING DATE AND INTEGRATED WEED
MANAGEMENT IN SOYBEAN (*Glycine max* L.) AND THEIR
RESIDUAL EFFECT ON SUCCEEDING FRENCH BEAN
(*Phaseolus vulgaris*)**

THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF DOCTOR PHILOSOPHY

By

G. Zion

Admn. No. Ph- 299/19 Regn. No. Ph.D./AGR/00332

**Department of Agronomy,
School of Agricultural Sciences,
Nagaland University,
Medziphema Campus – 797106, Nagaland
December, 2025**



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(*Phaseolus vulgaris*)**

BY

Name of candidate- G. Zion

Name of Supervisor- Prof. L.Tongpang Longkumer

Submitted

In partial fulfillment of the requirements for the Degree of Doctor of

Philosophy in

Agronomy of Nagaland University

Dedicated

To

My loving parents and My Siblings

Nagaland University
October, 2024

I, G. Zion, hereby declare that the subject matter of this Thesis is the record of work done by me, that the contents of this Thesis did not form the basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis had not been submitted by me for any research degree in any other university/institute.

This is being submitted to Nagaland University for the degree of Doctor of Philosophy in Agronomy.

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CERTIFICATE – I

This is to certify that the thesis entitled “**Effect of sowing date and integrated weed management in soybean (*Glycine max* L.) and their residual effect on succeeding french bean (*Phaseolus vulgaris*)**” submitted to Nagaland University in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy (Agriculture) in Agronomy is the record of research work carried out by Mr. G. Zion Registration No. Ph.D./AGR/00332 under my personal supervision and guidance.

The result of the investigation reported in the thesis have not been submitted for any other degree or diploma. The assistance of all kinds received by the student has been duly acknowledged.

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CERTIFICATE – II

VIVA VOCE ON THESIS OF DOCTOR OF PHILOSOPHY IN AGRONOMY

This is to certify that the thesis entitled “**Effect of sowing date and integrated weed management in soybean (*Glycine max* L.) and their residual effect on succeeding french bean (*Phaseolus vulgaris*)**” submitted by Mr. G. Zion Admission No. Ph-299/19, Registration No. Ph.D./AGR/00332 to the NAGALAND UNIVERSITY in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy in Agronomy has been examined by the Advisory Board and External examiner on

The performance of the student has been found **Satisfactory/ Unsatisfactory**.

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Date:

Place:

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LIST OF ABBREVIATION

%	Percentage
@	at the rate of
₹	Rupees
⁻¹ or /	Per
ai	active ingredient
BCR	Benefit Cost ratio
CD	Critical Difference
cm	Centimetre
DAA	Days after application
DAS	Days after sowing
df	Degree of freedom
<i>et al.</i>	<i>et allia</i> (and others/co-workers)
<i>fb</i>	Followed by
Fig.	Figure
g	Gram
ha	Hectare
<i>i.e.</i>	Id est (that is)
kg	Kilogram
M	Metre
m ²	Metre square
Max.	Maximum
Min.	Minimum
mm	Millimetre
MOP	Muriate of Potash
msl	Mean sea level
MSS	Mean Sum of Squares
mt	Million tonnes
NPK	Nitrogen Phosphorus Potassium
NS	Not significant
NU	Nagaland University
°C	Degree Celsius
RDF	Recommended Dose of Fertilizers
SAS	School of Agricultural Sciences
SE _m ±	Standard error of mean
Sl. No.	Serial number
SOV	Source of Variation
ss	Sum of square
SSP	Single Superphosphate
t	tonnes
<i>viz.</i>	Videlicet (Namely)

ABSTRACT

A field experiment was conducted to study the “**Effect of sowing date and integrated weed management in soybean (*Glycine max* L.) and their residual effect on succeeding french bean (*Phaseolus vulgaris*)**” at the experimental farm of the School of Agricultural Sciences (SAS), Nagaland University, Medziphema campus during the *kharif* season of 2021 and 2022. The experiment was laid out in split-plot design with three dates of sowing, viz. P₁- 15th June, P₂- 30th June and P₃- 15th July in the main plots, and seven integrated weed managements, viz. W₁- Soil solarisation with black polythene (25 days before sowing) *fb* Hand weeding at 30 DAS, W₂- Mulching with paddy straw 5 t ha⁻¹ *fb* Hand weeding at 30 DAS, W₃- Pendimethalin 30 EC @ 1 kg ha⁻¹ *fb* Imazethapyr 10 SL @100 g ha⁻¹ at 20 DAS, W₄- Pendimethalin 30 EC @ 1 kg ha⁻¹ *fb* Interculture at 30 DAS, W₅- Imazethapyr 10 SL @100 g ha⁻¹ at 20 DAS *fb* Interculture at 30 DAS, W₆- Hand weeding at 20 and 40 DAS and W₇- Weedy check (control) in the sub-plots and were replicated thrice. Results revealed that sowing date 15th June recorded significantly the highest growth and yield attributes and yield of soybean viz. plant height (59.54 cm), number of branches (3.86), leaf area index (2.73), dry matter accumulation (27.22 g plant⁻¹), number of root nodules plant⁻¹ (40.42), dry weight of nodules plant⁻¹ (0.41 g), crop growth rate (13.79 g m⁻² day⁻¹), net assimilation rate (2.32 g m⁻² day⁻¹), number of pods plant⁻¹ (68.20), 100 seed weight (10.63 g), seed yield (2014.54 kg ha⁻¹), stover yield (2441.82 kg ha⁻¹), biological yield (4456.36 kg ha⁻¹) and harvest index (44.89 %). The minimum weed population, weed dry weight, and higher weed control efficiency were also recorded with soybean sown on 15th June. It also recorded significantly lower NPK depletion by weeds and higher NPK uptake by crop. The dominant weed flora observed in the experimental field were *Digiteria sanguinalis*, *Eluesine indica*, *Cynadon dactylon*, *Cyperus iria*, *Cyperus rotundus*, *Ageratum conyzoides*, *Alternanthera sessilis*, *Amaranthus viridis*, *Borreria latifolia*, *Cleome rutidosperma*, *Commelina benghalensis*, *Mimosa pudica*, *Mollugo pentaphylla*, *Scorparia dulcis*. Among the integrated weed management treatments, hand weeding at 20 and 40 DAS recorded higher growth, yield attributes, yield, and protein content of soybean followed by application of pendimethalin 30 EC @ 1 kg ha⁻¹ *fb* imazethapyr 10 SL @100 g ha⁻¹ at 20 DAS. It also recorded the lowest weed

population, weed dry weight, NPK depletion by weed, higher weed control efficiency, NPK content and uptake significantly. The root and shoot length at 30, 60, 90 and 120 DAS of bioassay tested seed viz., maize, cucumber, mustard, and pea was non-significant for any of the applied treatments. The residual effect of sowing dates and weed management on succeeding french beans significantly recorded the highest value for growth and yield attributes at 15th June sowing. Higher cost of cultivation was recorded for all the three sowing dates for the hand weeding treatment at 20 and 40 DAS. Economic analysis revealed that the maximum gross and net returns were obtained from the treatment hand weeding at 20 and 40 DAS. The highest B: C was obtained by a combination of the dates of sowing on 15th June and pendimethalin 30 EC @ 1 kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS. Thus, from the experiment, it can be concluded that the sowing date on 15th June, along with the application of pendimethalin 30 EC @ 1 kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS for weed management, could result in profitable production of soybean.

Keywords: Soybean, French bean, Soil solarisation, Mulching, Pendimethalin, Imazethapyr, yield, economics.

CHAPTER I

INTRODUCTION

INTRODUCTION

Glycine max L., commonly known as soybean, is a leguminous species within the Fabaceae (Leguminosae) family, with its origins tracing back to China more than 3000 years ago. Soybean is a significant source of plant-based protein, rich in valuable amino acids like lysine (5%) and oilseed due to high yield, profitability and crucial role in sustaining soil fertility. So, it is often designated as the “meat of the field,” “meat without bones” or “Wonder Crop” or “Golden bean” or “Miracle bean” of the 21st Century. The crop holds a significant position as the world's most essential seed legume, accounting for 25% of global vegetable oil production and approximately two-thirds of the world's protein concentrate for livestock feeds. It serves as a valuable component in formulated feeds for poultry and fish (Agarwal *et al.*, 2013). Though soybean is categorized as an oilseed crop but is cultivated as pulse crop. Soybean was introduced in India in the 1970s as a supplementary crop grown commercially, revolutionizing the agricultural economy with its immense potential, food quality, feed and numerous industrial production commodities. However, at present, in India out of nine oilseeds grown in India, soybean occupies first place (34%) in oilseed production, followed by groundnut (27%), rapeseed and mustard (27%) and contributes nearly 23% to vegetable oil production (NMOOP- 2018).

The world soybean area, production and productivity estimates for 2019-20 are 122.63 million hectares, 339.00 million metric tons and 2.76 metric tons per hectare, respectively. India's soybean area, production and productivity for 2019-20 are 12.19 million hectares, 9.30 million metric tons, and 0.76 metric tons per hectare, respectively (USDA, April 2021). India also occupies the fourth largest producer of soybean in the world. The major soybean-producing nations are the United States, Brazil, Argentina, China, and India. In India, it is mainly cultivated in Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh, Gujarat, and Chhattisgarh (SOPA, *kharif* 2020). Soybean is also considered an essential crop in the North-Eastern state of India. Meanwhile, in Nagaland, the total estimated area

and production for 2017-18 are 25,040 hectares and 31,520 metric ton (Anonymous, 2020). Soybean is an integral part of the diet in Nagaland. It is widely used as a condiment, 'Akhuni/Axone,' a traditional soybean-based fermented in preparation for various local cuisines in most households.

Soybean is considered a high sustenance crop, plays an essential role in supporting the agricultural economy and enhancing soil health by supplying available nitrogen through its symbiotic association with the nitrogen-fixing bacterium *Bradyrhizobium japonicum*. Its is used for human food, but oil is an essential ingredient. Soybean contains healthy unsaturated Omega fatty acids, a rich source of phytochemicals and folic acid. Soybean oil is utilized in various industrial applications, including biofuel production, lubricants, textiles and cosmetics, etc. It is widely used in various forms, such as soybean sprouts, soy pastes, soymilk, soybean oil and tofu, as primary ingredients in cultural cuisines in many Asian countries.

Soybean is recognized as an economical and superior source of high-quality vegetable protein, comparable to that found in meat, dairy products and eggs. It comprises 40% high-quality protein and 18–20% oil, which is abundant in polyunsaturated fatty acids. Additionally, it is rich in minerals such as calcium, phosphorus, magnesium, iron and potassium, as well as vitamins, particularly B-complex and tocopherols. Soybean is also a significant provider of phytochemicals and quality dietary fiber which help protect the human body against cancer and diabetes (Chouhan, 2007). Furthermore, soybean contains 26% carbohydrates, 4% minerals and 2% phospholipids (Halwankar *et al.*, 1994).

Soybean is a *kharif* season crop; among the various production factors, sowing time is one of the most important factors influencing the growth and yield of soybean. Planting either before or after the ideal sowing date can greatly diminish both the yield and quality of soybean, because photoperiod control the numbers of days to flowering and the period available for vegetative growth and development. Soybeans sown outside the optimal timeframe often suffer yield losses due to poor emergence caused by unsuitable soil temperatures or when planted late, from incomplete development (Bastidas *et al.*, 2008). The optimum sowing time for

soybean is known to vary with agro-climatic conditions. Soybean plants from an early sowing, which matured during hot, dry weather, produce seeds with low germination (Green *et al.*, 1965). They showed that high-quality seeds were made from plants of early maturing cultivars that were sown later and matured after unfavourable weather conditions. During seed development and maturation, the environment can influence soybean seed germination and vigour (TeKrony *et al.*, 1987). Enhancing soybean productivity necessitates a focus on timely planting, access to high-yielding varieties, appropriate fertilizer application, optimal seed rates and targeted plant protection measures.

Weeds is a significant hindrance to the poor performance of soybeans in sustaining crop productivity. During its initial phases, growth is slow and faces intense competition from rapidly proliferating weeds. Weeds have a more comprehensive genetic diversity than agricultural field crops. Weeds represent a significant and manageable threat to crop production, contributing to economic losses through reduced soybean yield and diminished quality due to weed interference. Additionally, the costs associated with weed control exert a substantial economic impact on net returns for producers (Soltani *et al.*, 2017). Furthermore, weeds serve as alternative hosts for insect pests and pathogens (Mishra *et al.*, 2016). Heavy weed infestations in soybeans significantly impede the timeliness and efficiency of harvests and, if not controlled, cause intense losses in crop production. Losses can reach up to 100 percent depending on the soil preparation, status of the crop, weed species present and environmental factors. The first 14-54 days after sowing soybeans should be weed-free (Walling *et al.*, 2012). According to Mishra (2018), the reduction in grain yield attributable to weed infestation in soybeans ranges from 35% to 50% contingent upon the density and intensity of the infestation.

The implementation of enhanced weed management strategies, including mechanical, cultural, biological and chemical (herbicide) methods, can effectively reduce weed populations in soybean fields. Practices that improve the crop's competitive ability against weeds can mitigate the detrimental effects of weeds on crop yield. Attributes such as seedling vigor, rapid early growth and tillering capacity can confer a competitive advantage to the crop (Mujalde *et al.*, 2018). Weeds are

regarded as highly detrimental to agricultural production. In addition to their impact on agro-biodiversity, they indirectly hinder crop production by competing with crops for resources, providing refuge for crop pests, disrupting water management, diminishing yield and quality, and consequently escalating processing costs (Zimdahl, 2013). Among the significant constraints, initial heavy weed infestation is an essential factor hindering its overall growth and productivity. (Mallik and Mallik, 1994). It has been established that weeds directly compete with crop-limited resources, reducing yield and increasing the cost of production. Among the various weed management options, herbicide use is efficient and cost-effective. On the other hand, physical weed control measures, such as mulching, soil solarisation and hand weeding are safe but labour-intensive.

Integrated weed management (IWM) constitutes a science-based decision-making framework that integrates macro and micro-environmental data, alongside weed biology and ecology, with all available technologies. This approach aims to manage weeds through the most cost-effective and ecologically sustainable methods, while minimizing risks to human health and the environment (Sanyal, 2008 & Rao and Nagamani, 2010). Integrated Weed Management (IWM) employs a variety of complementary strategies within a system to control weeds, rather than depending on a singular approach. The primary objective of IWM is to mitigate the selection pressure that leads to the development of resistance against any single weed control method (Chauhan *et al.*, 2017). Relying on a singular method of control is insufficient for achieving long-term weed management, as it frequently leads to the emergence of resistance. Weeds contribute to substantial yield losses, even following the application of specific control strategies. There is an increasing imperative to mitigate these yield losses to sustain the growing human population. Consequently, it is essential to develop effective and sustainable integrated weed management (IWM) programs.

Herbicides are effective in controlling weeds for a limited duration; however, subsequent weed emergence presents additional challenges during the cropping season. Moreover, the high cost of herbicides, their occasional unavailability and the lack of technical expertise complicate weed management,

despite the environmental concerns associated with herbicide use. Therefore, it is imperative to adopt an integrated weed management (IWM) strategy that combines cultural, mechanical and chemical methods (Gharde, 2018).

In the *kharif* season, weed flush co-occurs, restricting workforce availability for weeding crop operations. Untimely and poor weed management affects soybeans' proper growth and yield, so controlling weeds at the appropriate times using a suitable method is necessary for secure, effective weed control to incur high grain yields of soybeans. Due to intermittent rainfall during the rainy season and the unavailability of adequate labour during the peak period of weeding, there is a problem with effective weed management in soybean crops (Nainwal *et al.*, 2010). Therefore, the integrated mechanical, cultural and chemical control approach may be more feasible. Under such conditions, hand hoeing/weeding and weed control through herbicides remain the choice for controlling weeds. Herbicides have become vital in controlling a broad spectrum of weeds in field crops. Proper use of herbicides during critical crop-weed competition periods may control weeds and enhance the productivity of crops. However, concerns about harmful agro-environmental consequences regarding their use led to intense pressure on farmers to reduce the use of herbicides.

Herbicides are anticipated to chemically manage weeds within the application season; however, the persistence of these chemicals in the soil and their residual impact on subsequent crop growth remain unpredictable. Farmers employing crop rotations must ascertain whether the phytotoxic properties of a compound have dissipated before introducing a sensitive crop into previously treated soil. Bioassay serves as a crucial method for the quantitative and qualitative assessment of herbicide residues. In this process, sensitive crop or test crop species are cultivated in the treated soil, which acts as the growth medium, thereby offering valuable insights for each specific context. Residue studies are instrumental in determining the duration of herbicidal efficacy and its impact on subsequent crops. A notable advantage of this methodology is its cost-effectiveness and ease of execution, as it does not necessitate expensive equipment. In this approach, an indicator plant is grown in either a field or pot and subsequently compared with

similar plants grown in untreated soil. Bioassays are employed to investigate the activity, persistence and movement of soil-applied herbicides. Additionally, they examine the influence of various soil properties and environmental conditions on herbicide phytotoxicity, as well as plant absorption, movement and degradation. French bean (*Phaseolus vulgaris*) is a vital *rabi* pulse crop grown and consumed in Nagaland. Its importance and potential to be adopted as an economic crop in soybean-based sequential cropping has been well-marked because it thrives even in marginal and poor exhausted soils.

Therefore, it is necessary to evaluate the performance of soybean crop for different sowing dates and integrated weed management practices under a given set of conditions for their test efficacy. This study aims to evaluate the effectiveness of mulches, solarization and pre- and post-emergence herbicides in controlling weeds in soybean cultivation in comparison to traditional farming practices. Additionally, it seeks to examine the competitive impact of weeds on the growth and yield of soybean, as well as the residual effect on the growth and yield of succeeding French bean crops. The findings will be used to provide recommendations to farmers to mitigate residual phytotoxicity in succeeding crops.

Considering all the critical points mentioned above, the present research work entitled **“Effect of sowing date and integrated weed management in soybean (*Glycine max* L.) and their residual effect on succeeding french bean (*Phaseolus vulgaris*)”** was conducted with the following objectives:

1. To study the effect of sowing dates and integrated weed management on the growth and yield of soybean
2. To find out appropriate integrated weed management practices for soybean
3. To evaluate the effect of integrated weed management on density and dry matter accumulation of associated weed flora in soybean
4. To find out the residual effect of sowing dates and integrated weed management in soybean on the growth and yield of succeeding french bean, and
5. To find out the economics of the treatments under study.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Reviews of literature based on research findings on sowing date, associated weed flora, critical periods of crop-weed competition, losses due to weeds, the effect of hand weeding and inter culture, mulching, solarisation, and herbicides on weed intensity, crop growth, yield attributes, yield and economics of soybean, bioassay studies and on succeeding crop have been cited briefly under proper heading to show the important factors of the study **“Effect of sowing date and integrated weed management in soybean (*Glycine max* L.) and their residual effect on succeeding french bean (*Phaseolus vulgaris*).”**

2.1 Effect of sowing dates on growth, yield attributes, and yield of soybean:

Singh *et al.* (1987) also mention that soybean crops sown on June 15 showed longer vegetative and reproductive phases than late-planted crops (June 30 and July 15), which had a positive impact on leaf area index (LAI).

Paradkar and Deshmukh (2004) reported that the sowing of soybeans on 22nd June gave a significantly higher number of root nodules per plant (46), which was at par with the 29th of June sowing.

Kumar and Badiyala (2005) found that sowing in 1st week of June resulted in significantly higher grain and straw yields. The seed yield recorded in 2001 (1993 kg/ha) and 2002 (2183 kg/ha) was significantly higher when the crop was sown in 1st weeks of June, which was 25.1 and 19.1 percent higher than the crop sown in the 3rd week of June. Delays in sowing resulted in a significant decrease in yield attributes like branches and the number of pods per plant.

Pramila Rani *et al.* (2008) observed that soybean seed yield attributes such as number of pod plants⁻¹ and 100 seed weight were significantly influenced by sowing dates. Soybean sown on the 29th of September was recorded as the highest seed yield, being at par crop planted on the 16th of September, but sowing on later dates showed reduce in yield by 20% (October) and 40% (November) as compare to the highest seed yield.

Ram *et al.* (2010) recorded that soybean sown on June 5th recorded the highest plant height, pods plant⁻¹, 100-grain weight, quality parameters like oil content and protein content, biological yield, and grain yield (2537 kg ha⁻¹), which was statistically at par of soybean sown on June 15th (2386 kg ha⁻¹) but significantly higher than June 25th (2169 kg ha⁻¹) in 2008. While crop sown during 2009, June 15th recorded the highest grain yield (1811 kg ha⁻¹) and was statistically at par with June 5th (1704 kg ha⁻¹) but significantly higher than June 25th sowing (1350 kg ha⁻¹). The thermal heat units' factor was found to be responsive to a reduction of 50% flowering and maturity as the sowing date was delayed.

Yagoub and Hamed (2013) conducted a field experiment on soybeans with different sowing dates: 2nd June, 9th June, 16th June, 23rd June, and 30th June. They observed that soybean sown on 16th June recorded the highest number of pod plants⁻¹ (80.7), weight of pods plant⁻¹ (17.3), number of seeds plant⁻¹ (175.9), shoot dry weight (47.4), 100 seed weight (1.8 g) and yield (788.9 kg ha⁻¹) compared to other sowing date and the lowest values of all the above parameters were recorded on crop sown on late June 30th.

Sadeghi *et al.* (2014) from Iran revealed that the planting of soybean on 10th June had the highest seed yield (3470 kg ha⁻¹), the highest number of pods plant⁻¹ was recorded on 10th May, and 10th June (34.61 and 32.22, respectively) and the highest plant height was recorded on 10th May (110.7 cm).

Taware *et al.* (2015) experimented in order to investigate the effects of planting date on yield and its attributes in soybean. They revealed that 15th June produced significantly higher plant height (65.68 cm), branches per plant (4.23), pod number per plant (73.5), seed index (14.76), straw yield (3863 kg ha⁻¹), and more seed yield (3379 kg ha⁻¹) than later sowing dates (i.e., 30th June, 15th July, and 30th July). The percent reduction in yield over the 15th June sowing date was 9.83, 19.12, and 40.78 percent on the 30th June, 15th July, and 30th July sowing dates, respectively. Significantly, the lowest seed yield (2001 kg ha⁻¹) was obtained on the fourth sowing date (30th July).

Berad *et al.* (2016) researched the effect of sowing dates (21 June, 01 July, and 11 July) on soybean. They revealed that early sowing on 21 June produced the maximum number of pods plant⁻¹, seed pod⁻¹ and seed yield and was statistically at par with 01 July but significantly superior over July 11.

Aastha and Singh (2016) reported that soybean sown during the 1st week of June resulted in significantly higher plant height, number of root nodules, fresh weight of nodules, dry weight of nodules, leaf area index, crop growth rate, relative growth rate and net assimilation rate.

Sulthana *et al.* (2017) noticed that the sowing date significantly affected the seed quality parameters of soybean and reported that the seed sown in the second week of July recorded the highest germination percentage (99%), higher seedling dry weight (89.0 mg) followed by July 1st week sowing and the lowest seed quality was recorded as crop sown on August. These may be due to favorable environmental conditions during the second week of July, i.e., optimum temperature (25°C) during seed filling, seed development, maturity, and harvesting.

Kumagai (2017) reported that early sowing significantly increased pod number, CGR (Crop Growth Rate) and seed yield by increasing cumulative intercepted solar radiation, which enhanced the growth during early reproductive stages.

Mahesh *et al.* (2017) investigated how planting date affects dry matter production and nutrient uptake in soybean. The study found that the 26th June sown crop had considerably higher dry matter production, nitrogen uptake, seed yield and haulm yield than the 6th and 16th July planted crops.

Nath *et al.* (2017) revealed that soybean crops sown up to 27th MW recorded significantly higher plant height, leaf area, leaf area index, dry matter production, pods per plant (26.58), seed weight per plant (4.33 g), 100 seed weight (8.23 g), seed yield (839 kg ha⁻¹), biological yield (2773 kg ha⁻¹) and harvest index (30.26 %). Late sowings, i.e., 30th MW sowing caused a decreased amount of rainfall and increased maximum temperature regime across the total growing period, consequently lowering growth attributes and seed yield (530 kg ha⁻¹).

Sikka *et al.* (2018) conducted field research on the effect of sowing dates on nutrient uptake and productivity of soybean. They found that sowing on 30th June recorded the highest number of pods plant⁻¹ and stover yield. Sowing date significantly affects NPK uptake in soybean. June 30 sowing date resulted in the highest total N uptake, while May 20 sowing date showed the highest total P and K uptake.

Raghuwanshi *et al.* (2018) recorded that soybean sown on 25th June recorded higher values of growth parameters, namely plant height, number of branches, plant dry weight, nodules, and nodules dry weight, CGR, and RGR and yield attributing parameters seeds pod⁻¹, seed yield plant⁻¹, pods plant⁻¹, seed index, grain production efficiency, grain and straw yield were higher as compared to crop sown 15th July sowing.

Nawale *et al.* (2018) reported that sowing soybean in meteorological week 24 (11-17 June) resulted in higher growth and yield attributes viz., number of pods plant⁻¹ (69.17 and 69.49), pod weight plant⁻¹ (26.22 and 27.11 g), number of seeds plant⁻¹ (181.13 and 182.71), seed weight plant⁻¹ (16.19 and 17.22 g), hundred seed weight (13.93 and 14.90 g), seed yield (29.02, 29.80 and 29.41 q ha⁻¹) during both the years and on pooled mean, and it was at par with meteorological week 25

Sumalatha and Uppar (2019) observed that the maximum plant height and number of branches were recorded in the first fortnight of June followed by the second fortnight of June and the lowest was recorded in the first fortnight of July. The first fortnight of June gave significantly the highest seed yield plot⁻¹ (3.25 kg) followed by the second fortnight of June (3.12 kg) and the lowest seed yield was recorded in the first fortnight of July.

Jagtap *et al.* (2019) revealed that the mean leaf area plant⁻¹ and leaf area index were influenced significantly by different dates of sowing at various stages of crop growth. Mean leaf area plant⁻¹ was considerably higher in S₁ (MW 38), and it was significantly superior over S₂ (MW 39) and sowing on S₃ (MW 40) at all days of observation.

Basavaraj *et al.* (2020) reported on soybean that sowing on June II fortnight

(D₁) recorded significant nutrient uptake (NPK) and the highest yield compared to other sowing dates by 7.5, 26.94 and 39.4 % more yield to later sowing dates July I fortnight (D₂), July II fortnight (D₃), and August I fortnight (D₄), respectively.

In soybean, Dandge *et al.* (2020) assessed the performance of varieties under two sowing dates: June 21st (normal sowing) and July 10th (20 days after usual). They found that the yield attributes viz., pods per plant (52.92), seed index, and seed yield kg ha⁻¹ as well as dry matter, CGR, RGR and branches per plant (2.27) were significantly higher during the normal sowing (June) period. Regarding the genotype for late sowing, nearly every genotype showed a seed yield less than half that of a regular sowing date.

Nayak *et al.* (2020) researched soybean with different sowing dates and revealed that a higher seed yield, CGR and dry weight of plant m² was recorded in the August 1st week of sowing (35.6, 87.8 and 161.0 g) than late sowing (23.8, 64.0 and 123.2 g) at 30, 45 and 60 days after sowing (DAS), respectively.

El-Toum *et al.* (2020) reported on soybeans with treatment comprising three planting dates (15th June, 1st July, and 15th July). They observed that the planting date significantly affected soybean growth, grain yield parameters and crude protein. More than 72% of grain yield was produced in crop sown on 1st July than the delayed planting date (15th July). The early planting date (15th June) and mid-planting date (1st July) also significantly increased crude protein by 5% compared to the delayed planting date (15th July).

Kumagai and Takahashi (2020) stated that late sowing led to significant decreases in aboveground biomass (23%), seed yield (29%), harvest index (0.55 to 0.51), decreased the number of pods by 11%, the number of nodes by 15%, and 100-seed weight by 9%, number of seed per pods than in standard sowing plots.

According to El Toum *et al.* (2020), the sowing date had a substantial impact on the weight of 100 seeds, the harvest index, and the seed production of soybean. Additionally, they observed that planting on July 1st increased seed output by 72% compared to planting on July 15th.

Rajasekhar *et al.* (2021) revealed that the sowing date of July 1st fortnight significantly increased the growth attributes of soybeans, viz., plant height (69.88 cm), plant dry weight (23.67 g), LAI and yield attributes, and yield of soybean over July 2nd fortnight and August 1st fortnight.

Saqib *et al.* (2021) conducted field research on the effect of different sowing times, varieties and seed rates on yield attributes and yield of soybean and found that crops sown in the two weeks of June recorded a more significant number of pods per plant grains per pod, 1000-grain weight, grain (1982.61 kg ha⁻¹) and straw yield (3214.78 kg ha⁻¹) than other dates of sowing.

Hamoda *et al.* (2021), in their study on sowing dates and weed control on soybeans indicated that early planting date improved plant height, no. of pods, absolute growth rate (AGR), net assimilation rate (NAR), no. of pods/ plant (55.09), and dry weight of stem (21.67 g), pods (23.55 g) and plant (68.75 g). The interaction between earlier planting date (May 5) and hand hoeing twice recorded the maximum values for the number of pods (67.65 pod/plant), weight of seeds (19.63 g/plant), 100-seed weight (19.12 g) and seed yield (1427.67 kg/fed). Also, results showed that soybean plants sowing on May 5 with hand hoeing twice or using weed herbicides led to increased seed yield/fed and its components under experimental soil conditions.

Patel *et al.* (2022) researched three levels of sowing (T₁: Onset of monsoon, T₂: One week after T₁ and T₃: One week after T₂) and three levels of row spacing. They revealed that sowing soybeans at the onset of monsoon (T₁) obtained higher growth, yield, and quality under rainfed conditions.

Tupe *et al.* (2023) reported that the highest seed yield (22.87 q ha⁻¹), biological yield (59.48 q ha⁻¹) and harvest index (38.44 %) were obtained when the crop was sown on 15th June over 30th June, 13th July and 30th July.

Kaleri *et al.* (2023) researched the effect of various sowing dates on soybean. They mentioned that early sowing exhibited superior growth and yield attributes such as higher plant height, pods per plant, seed per plant, seed weight, seed yield, biological yield, protein content and oil content compared to late sowing.

2.2 Effect of sowing date on weed

Klingaman and Oliver (1994) observed that soybean planting date influence weed interference. Delayed sowing increased weed population, leading to higher yield losses. Optimum planting dates reduced weed interference in soybean cultivation.

Buhler and Gunsolus (1996) reported that soybean planting from mid-May to early June reduced weed densities, enhancing mechanical weed control effectiveness and potentially offsetting yield losses, as indicated in the research on soybean weed management.

Singh and Dhan (1997) concluded that delayed sowing (15 July) reduced weed density and dry matter in soybean. Timely sowing (25 June) was optimal for weed control and enhancing soybean yield.

Pandey *et al.* (2004) studied the effect of sowing date (5 and 20 July), row spacing (30 and 60 cm), and weed control (1.0 kg metribuzin, 2.5 kg alachlor and 1.5 kg pendimethalin/ha) practices on weed growth and productivity of soybean. Weed control efficiency (WCE) was higher in 5 July compared to 20 July sowing.

Coulter and Nafziger (2007) observed that planting date influenced weed management in soybeans. Early planting with timely herbicide applications optimized weed control strategies, impacting weed populations and soybean yield.

Lee *et al.* (2008) reported that early spring sowing of rye, particularly on March 20th resulted in the highest weed suppression (99.3%) in organic soybean fields impacting soybean yield positively .

Silva *et al.* (2009) stated that the sowing date affected the soybean weed population; earlier sowing reduced weed interference. Conventional tillage had higher weed populations than no-tillage, impacting soybean yield components.

Abouziena *et al.* (2013) stated that sowing earlier reduced weed biomass significantly. Late sowing increased weed control efficacy. Early planting enhanced oil yield by 26% compared to delayed planting.

Marangoni *et al.* (2013) investigated the effect of weed interference on soybean cultivars at two sowing times and noted that late sowing increased weed interference, reducing soybean pod production. Early sowing favoured soybean cultivars' competitive ability against weeds, impacting yield.

Akter *et al.* (2016) reported that some weed species were found to dominate the experimental field on different dates. They also found that dry matter in weeds increased with time advancement. Late planting increased the accumulation of dry matter in weeds and early planting decreased the amount of dry matter accumulation.

Samant and Mohanty (2017) concluded from a trial conducted that sowing on June 20 reduced the weed population. Early sowing dates led to higher weed control efficiency, lowering weed density and dry weight, as per the study.

Schievenin *et al.* (2018) stated that the sowing date affected the soybean weed population; delaying sowing combined with weeds, reduced cultivar development due to increased plastochron and fewer nodes per plant.

Sai *et al.* (2019) conducted field research and the study found that the first sowing date (15th July) with two mechanical weeding effectively reduced weed population and dry weight.

Sahu *et al.* (2019) recorded that the sowing date significantly impacted the weed population, nutrient uptake and productivity. Early sowing helped to manage weed competition and enhance crop yield.

Hamoda *et al.* (2021) reported that sowing soybean on May 5 reduced the weed population due to early establishment, enhancing seed yield compared to May 20 and June 3. Early planting dates helped to suppress weed growth in soybean fields.

In a study conducted by Petcu *et al.* (2023) on 14 soybean accessions and two sowing dates, they discovered that the weather conditions of the experimental year had a significant impact on weed infestation. Early sowing of soybean increased weed infestation due to chilling stress, resulting in a negative impact on yield.

2.3 Associate Weed Flora in soybean:

Identifying and understanding the weed community associated with the crops is essential for a successful weed control program. Weed flora differ widely in their diversity depending upon the soil, season, and climatic conditions; therefore, similar work done on soybean and its predominantly associated weed flora observed by many researchers in different parts of the country and other countries is presented below.

The predominant weed flora of the soybean was *Celosia argentic*, *Commelina benghalensis*, *Echinochloa colona*, *Echinochloa crusgalli*, *Cynodon dactylon*, *Digera arvensis* and *Euphorbia hirta*, etc as noticed in Agricultural Research Station, Ummedganj, Kota, Rajasthan by Meena *et al.*, (2009).

Kundu *et al.* (2011) stated that a predominant weed species found in the research field of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal were *Echinochloa colona* and *Echinochloa crusgalli* (grasses), *Cyperus difformis* was the sedge and the broad leaf weeds included *Euphorbia hirta*, *Croton sparsiflorus* and *Digera arvensis*.

Walling *et al.* (2012) reported that the dominant weed species observed in SASRD, Nagaland were *Amaranthus viridis*, *Ageratum conyzoides*, *Cassia tor*, *Chromolaena odorata*, *Mimosa pudica* (among broad-leaved), *Cynodon dactylon*, *Digitaria sanguinalis*, *Elusine indica*, *Imperata cylindrica* (among grasses) and *Cyperus rotundus*, *Cyperus iria*.

Hassan (2013) reported that the significant weed species associated with the soybean crop were *Portulaca oleraceae* L. (Purslane), *Chenopodium murale* L. (Goosefoot), *Amaranthus caudatus* L. (Pigweed) (broad-leaved weeds) and grass weed were *Beta vulgaris* L. (leaf beet), *Chenopodium murale* L. (Goosefoot), *Medicago hispida* L. and *Echinocloa colonum* (Jungle rice) and *Cyperus sp.* L. (nut sedge).

Mishra *et al.* (2013) reported that the significant weeds found in the field of research plots were *Echinochloa colona*, *Eclipta alba*, *Dinebra retroflexa*, *Cyperus iria*, and *Alternanthera Philoxeroides*.

Kale *et al.* (2015) reported that in their experimental field, College of Agriculture, Nagpur, the most common species are *Parthenium hysterophorus*, *Euphorbia hirta*, *Digera arvensis*, *lagasca mollis* among dicot weeds, *Cynodon dactylon*, *Echinochloa crusgalli*, *Ergots major*, *Poa annua*, *Sorghum halepense* among the grasses and *Cyperus rotundus* among sedges.

Thakare *et al.* (2015) reported that the predominant weed species observed in the experimental field were *Xanthium strumarium*, *Parthenium hysterophorus*, *Euphorbia geniculata*, *Lagasca mollis*, *Euphorbia hirta*, *Tridax procumbens*, *Corchorus acutangulus*, *Abelmoschus moschatus*, *Alternanthera sessilis*, *Digera arvensis* and *Celosia argentea* among the dicot weeds and *Cynodon dactylon*, *Cyperus rotundus*, *Commelina benghalensis*, *Dinebra arabica*, *Poa annua*, *Echinochloa crusgalli* and *Eragrostis* among the monocot.

Ariunaa *et al.* (2016) enquired about significant weed species in the soybean experimental plots were Common millet- *Panicum miliaceum* L, couchgrass- (*Agropyron repens* L), Bristle grass- (*Seteria viridis* L) sp (grassy weeds) and broadleaf weeds Redroot Pigweed- (*Amaranthus retroflexus* L), lambsquarters- (*Chenopodium album* L), Aristate goosefoot- (*Chenopodium aristatum* L), black bind weed- (*Polygonum convolvulus* L), Mallow weed- (*Malva mochileviensis* Down), Field bindweed (*Convolvulus arvensis* L), Bristly thistle- (*Cirsium setosum* L), dwarf bifurcate cinquefoil- (*Potentilla bifurca* L), perennial sowthistle- (*Sonchus arvensis* L).

Devi *et al.* (2016) observed at the College of Agriculture, Central Agricultural University, Imphal that the pre-dominant grassy weeds in soybean were *Echinochloa colona*, *Cynodon dactylon*, *Cyperus rotundus*, *Cyperus iria*, and *Fimbristylis miliacea* were the sedges. *Commelina benghalensis*, *Spilanthus paniculata*, *Galinsoga parviflora*, *Chenopodium album*, and *Amaranthus spp.* were the most common among broad-leaved weeds.

At Jabalpur in Madhya Pradesh, monocot weeds like *Echinochloa colona* (29.28%), *Dinebra retroflexa* (35.85%), *Cyperus iria* (1.65%), and dicot weeds like *Euphorbia geniculata* (24.67%), *Phyllanthus niruri* (8.53%) and *Commelina*

benghalensis (2.63%) were found to predominate in the experimental field of soybean (Lal *et al.*, 2017)

Sepata *et al.* (2017) reported from the Indian Agricultural Research Institute, New Delhi among the narrow and broad-leaved categories in soybean *Echinochloa colona* (Link.) and *Digera arvensis* (Forssk) were the prominent weed species. Besides, *Dactyloctenium aegyptium* (L.) Willd, *Leptochloa chinensis* (L.), *Cyperus rotundus* (L.), *Eleusine indica* (L.), *Phyllanthus niruri* (L.), and *Trianthema portulacastrum* (L.) also occurred but relatively at low frequency. As the season progressed, *Commelina benghalensis* (L.), *Chenopodium album* (L.), and *Amaranthus viridis* (L.) were also observed.

Mujalde *et al.* (2018) observed that weed affecting soybeans in Madhya Pradesh was divided into two groups: dicot weeds- *Digera arvensis*, *Corchorus olitorius*, *Euphorbia hirta*, *Amaranthus viridis*, *Phyllanthus niruri*, monocot weeds- *Dinebra arebica*, *Echinochloa colonum*, *Commellina bengalinsis*, *Cynodon dactylon*, *Cyperus rotandus*.

Simaiya *et al.* (2018) stated that *Echinochloa crusgalli*, *Degiteria sanguinalis*, *Dinebra arabica*, *Cyperus rotundus* Linn. and *Commelina benghalensis* were among the monocot weeds. At the same time, *Acalypha indica* Linn, *Eclipta alba*, *Caesulia axillaris* Roxb., *Digera arvensis*, *Corchorous acutangulus*, and *Phyllanthus niruri* were the dicot weeds observed in association with soybean crop.

Parmar *et al.* (2019) indicated that in Sehore, Madhya Pradesh, soybean fields have a presence of dominant grassy weeds, viz. *Echinochloa crusgalli*, *Digitaria adscendens*, *Brachiaria mutica*, *Setaria glauca*, *Cyperus spp*, and broad leaves- *Commelina bengalensis*, *Commelina communis*, *Physalis minima*, *Corchorus spp*. *Digera muricata*, etc.

Kaur *et al.* (2019) from Punjab Agricultural University, Ludhiana, reported the presence of weed flora of soybean viz. *Acrachne racemosa*, *Cyperus rotundus*, *Trianthema portulacastrum*, *Eragrostis spp.*, *Amaranthus viridus*, *Dactyloctenium*

aegyptium, *Digera arvensis*, *Digitaria sanguinalis*, *Commelina benghalensis*, *Echinochloa colona* and *Eleusine indica*.

The combination of dominant weed species found in the experimental field of soybean at Ardabil (Iran) included narrow leaves such as *Sorghum halepense*, *Echinochloa crus-galli*, *Setaria viridis*, *Abutilon theophrasti*, *Hibiscus trionum*, and *Amaranthus retroflexus* L. (Fakhari *et al.*, 2020)

2.4 Critical Period of Crop-Weed Competition of Soybean

Identifying critical periods of crop-weed competition and finding the most effective weed control program when the weeds cause maximum damage to the crop is essential to help the economic crop escape from the real weed competition and realize the maximum benefit from weed control practices and control weeds effectively.

Singh *et al.* (2013) reported a reduction in soybean yield from 35 to 50% depending on the weed flora and density if weeds are not controlled during the critical period of weed-crop competition.

The critical period for weed control (CPWC) is one of the key components of proper integrated weed management. The duration of weed-crop competition affected the development of weed biomass and only weeds emerging after eight weeks of crop had little effect on soybean yield. The critical period for the weed-crop competition was between 2 and 8 weeks after crop emergence. Weed competition for the entire growing season reduced soybean yield by 83%. (Stefanic *et al.*, 2015).

For soybean crops, the most critical period of weed competition ranged between 15 and 45 days after sowing (Dhaker *et al.*, 2015).

Zandona *et al.* (2016) reported that crops may co-exist with weeds for a certain period. However, there are periods where the emergence of weeds modifies the competition with crops that must be avoided and control is essential to maintain high yield levels. The critical period of crop weed interference begins from 14 to 48 days

after emergence (DAE) was reported in soybean crops. Interference of weeds in the crop during the whole cycle reduced soybean yield on an average 73% to 94%.

Suryanto *et al.* (2017) noted that the soybean yield decreased significantly when the weedy period was during 14 days after planting up to 42 days after planting. The critical period for weed control in soybeans for acceptable yield loss of 5, 10, 15, and 20% began 16, 21, 24, and 27 days after emergence and ended at 61, 55, 53 and 49 days after emergence.

Almarie (2017) noted that yield losses of soybean from weed competition were 29.04%. Therefore, weed control of soybean must continue until 35 days after emergence and not delay for this period by using mechanical control methods or herbicides to avoid unacceptable loss of the economic yield and minimize the negative impact of weeds environmentally and economically.

Mishra (2018) studied weed management research of pulses and oilseeds and revealed that the critical period of crop-weed competition of soybean is 20-45 days after sowing and an average yield reduction of 40-60% is recorded due to weeds.

Korav *et al.* (2018) revealed that weeds are not equally damaging throughout the crop period. Weeds exert greater detrimental effects during specific phases of crop development. In the initial stages, crops exhibit slower growth, allowing weeds to more effectively utilize resources and dominate, thereby reducing crop yield. The optimal period for weed control to achieve near-maximum crop yield is referred to as the critical period of crop-weed competition. During this time, maintaining crops free of weeds results in yields comparable to those achieved in the absence of weeds throughout the entire season.

Daramola *et al.* (2019) observed that weed growth until 6 WAS (week after sowing) or longer resulted in a significant yield reduction of soybean.

It is clear from the above review that a critical period of crop weed competition in soybean must be considered to reduce yield losses due to weed infestation.

2.5 Losses Due to Weeds

Kurmawanshi *et al.* (2015) revealed that weed severely infested the soybean field with a large number of weeds and resulted in a reduction of the yield to the extent of 18.83 to 42.37%.

Panda *et al.* (2015) observed that weedy plots recorded maximum (63.1%) yield losses and minimum net monetary returns due to lower seed and haulm yields due to weeds in soybeans.

Mishra *et al.* (2016) reported that one of the major hindrances in sustaining crop productivity is weeds, which compete with crops for nutrients, soil moisture, solar radiation and space and reduce the yield and quality of produce. Besides, they also act as an alternate host for insect pests and disease-causing organisms.

Singh *et al.* (2016) reported that weeds compete, especially during the first 40 days after sowing and cause substantial losses in the yield range of 25 to 70%, depending upon the weed flora and intensity.

Weeds are considered the central problem in all soybean-producing countries and weeds alone cause an average reduction of 37% in soybean yield, while other fungal diseases and agricultural pests account for 22% of losses (Bhimwal *et al.*, 2017)

Soltani *et al.* (2017) reported that soybean weed interference caused a 52.1% yield loss. Monetary losses due to a reduction in soybean yield and decreased quality because of weed interference and the costs of controlling weeds significantly impact net returns to producers.

Gharde *et al.* (2018) conducted On-Farm Research trials on Weed Management in major field crops in different districts of 18 states of India. The study revealed that potential yield losses were high in the case of soybeans (31%) and economic losses of soybeans (USD 1559 million). Three factors viz; location, crop and soil type significantly explained the variability in yield losses due to weeds.

Meena *et al.* (2018) revealed that infestation of grassy weeds (51.6%), broadleaf (34.1%) and sedges (13.2%) throughout the growth period of soybean caused yield reduction up to 69.68% in a field experiment conducted at Kota, Rajasthan.

Based on the above review, it can be concluded that weed causes a more significant reduction in the yield of soybean. Hence, they must be controlled within critical periods of crop weed competition.

2.6 Effect of Integrated Weeds Management on Crop and Weeds:

Estimating crop yield loss due to weed interference and determining economic thresholds (ET) is essential for adopting integrated weed management so that weed densities are below the level of ET. In addition to herbicides, other integrated weed management practices can be used, such as sowing time, crop density, row spacing and fertilization in the growing line. (Gherekhloo *et al.*, 2010, Agostinetto *et al.*, 2017).

Tamang *et al.* (2015) reported that application of Vellore 32 (Pendimethalin 30 EC+ Imazethapyr 2 EC) @1.00 kg a.i. ha⁻¹ was found most effective in reducing the population and dry mass of weeds and producing a maximum yield of soybean and maximum benefit: cost ratio.

Singh *et al.* (2016) reported that the application of pendimethalin (pre) 1000g a.i. ha⁻¹ *fb* one hand weeding minimized total weed density throughout the crop growth period and produced maximum yield.

According to Chauhan *et al.* (2017) IWM is the control of weeds using different, complementary methods within a system rather than relying on a single method. The main aim of IWM is to reduce the selection pressure for the development of resistance to any single method of weed control.

Yadav *et al.* (2017) reported that application of pendimethalin followed by imazethapyr + imazamox/quizalofop-p-ethyl as well as quizalofop-p-ethyl applied alone resulted in complete control of crowfoot grass, large crabgrass, and goosegrass,

but control of broadleaf weeds was variable. It also resulted in soybean branch numbers per plant, number of pods per plant and soybean seed yield comparable to weed-free control and significantly superior to un-weeded plots.

Vijay *et al.* (2018) in an experiment conducted at Jagtial, Telangana, reported that among herbicides application in soybean, the lowest total weed population, lowest weed dry weight, maximum weed control efficiency and higher seed yield were found with the PE application of pendimethalin @ 2.5 L ha⁻¹ followed by imazethapyr @ 75g ha⁻¹ at 20 DAS. A weedy check recorded the highest weed dry matter and the lowest seed yield.

Bharat *et al.* (2019) experimented with integrated weed management on soybeans and confirmed that a maximum dry weight of 4423 kg ha⁻¹ was obtained in 2014 and 4533 kg ha⁻¹ in 2015 due to hand weeding at 25 and 45 days after sowing.

Toppo *et al.* (2019) from Raipur conducted a field experiment on integrated weed management on soybean. They revealed that hand weeding at 20 and 40 DAS proved to attain higher growth, yield and maximum *Rhizobial* population and nodulation during the research period.

Verma and Kushwaha (2019) researched the efficacy of different herbicides against weeds. They recorded that weed density at 30 and 60 DAS was significantly lower with the application of pendimethalin 30 EC + imazethapyr 2 EC 0.75 kg/ha. However, substantially lower weed dry weight and weed control effects were observed in two hands at 20 and 40 DAS and pendimethalin + imazethapyr.

Chauhan (2020) expressed that weeds are a major biotic constraint to production in different cropping systems. A single method of control will not provide adequate long-term weed management, instead often resulting in the development of resistance. Weeds are the cause of significant yield loss, even after the application of a particular control method. There is a growing necessity to reduce this yield loss in order to feed an ever-increasing human population. Therefore, there is a need to develop effective and sustainable IWM programs.

Raj *et al.* (2020) found that manual weeding twice at 25 and 45 DAS was the most effective method for controlling weeds in soybean. Among herbicides, the application of pendimethalin 1.0 kg/ha as PE (Pre-emergence) and imazethapyr 55 g/ha as PoE (Post-emergence) at 25 DAS proved to be more efficient and cost-effective in reducing weed population/m² (53.94 & 67.22), dry weight of weeds/m² (21.16 & 45.86 g) and significantly increasing weed control efficiency (53.86 & 68.83%) in both stages 30 and 60 DAS. They were equally efficient in raising grain yield, straw yield, harvest index, weed index, and gross returns than control, but net returns (39870/ha) and benefit-cost ratio (1.70) were attained only with pendimethalin 1.0 kg/ha and imazethapyr 55 g/ha at 25 DAS.

Khalifa and Fakkar (2020) experimented and found that the application of weed control treatments reduced the dry weight of grassy weeds, broad-leaved, total weeds and highly increased plant height, number of branches/ plants, number, and weight of pod/ plant, seed/pod, seed index, seed yield, oil and protein % of the soybean crop.

Pawar *et al.* (2022) carried out a field experiment on integrated weed management in soybean. They observed that among chemical treatment application of pendimethalin 38.7% CS @ 0.75 kg a.i/ha + imazethapyr 10% SL @ 0.10 kg/ha POE at 20-25 DAS recorded significantly higher growth (Plant height, number of branches plant⁻¹, total dry matter plant⁻¹, effective nodules plant⁻¹), yield (seed yield, test weight), highest weed control efficiency (%) and lowest weed index (%).

Samim *et al.* (2023) conducted a field experiment on weed management on soybean and recorded the maximum growth, yield, and economic efficiency in treatment (Pendimethalin + Imazethapyr), root dry weight (9.42/plant), nodules/plant (25.5), nodes/plant (25.57, 27.68), pods/plant(41.1), seeds/pod (2.5), 1000 seed weight (102.5 g), grain yield (2.20 ton/ha), gross Returns (187.863 AFN/ha), net Returns (134.308 AFN/ha) and benefit: cost ratio (2.504) compared to Un-weeded check and pendimethalin + hand weeding.

Saba *et al.* (2023) conducted a field experiment at Sher-e-Bangla Agricultural University, Dhaka to study the effect of weed management practices on soybean. The treatment pre + post-emergence herbicide + 1 hand weeding (40 DAS) showed the most extended pod length (4.16 cm) and number of seeds pod⁻¹ (3.89). In contrast, the weed-free treatment resulted in the highest 1000-seed weight (111.00 g), seed yield (1.86 t ha⁻¹), stover yield (2.16 t ha⁻¹), biological yield (4.03t ha⁻¹) and harvest index (46.35 %) and at par with treatment pre + post-emergence herbicide + 1 hand weeding (40 DAS). The highest number of pods plant⁻¹ of soybean (28.79) was found in the two-hand weeding (15 and 30 DAS) treatment.

Ahirwar and Ahirwar (2023) researched integrated weed management on yield and economics of soybean. They recorded that the lowest density of weeds, 12/m² was found in weed-free treatment followed by pendimethalin (pre-emergence) + hand weeding (16/m²). Hand weeding at 20 and 40 DAS proved more effective as it reduced the weed population to the tune of 15/m² compared to other treatments. Mean maximum number of pods/plant (69), number of pods/m² (1193), number of seeds/pod (2.65) and test weight (12 g/100 grains), biological yield (7.00 t/ha), harvest index (36%), seed yield (2.58 t/ha) and straw yield (4.46 t/ha) with net profit INR 56425/ha (USD 869.02/ ha) and B: C ratio 2.54 were recorded in weed free. The weedy check (control) plot showed the lowest effect on different parameters such as seed yield, stover yield, and soybean economics.

Roy *et al.* (2023) experimented with research consisting of nine weed management treatments. They observed that weed-free [hand weeding twice 20 and 40 days after sowing (DAS)] followed by pre-emergence application (PE) of pendimethalin 1.0 kg/ha along with post-emergence (PoE) application have significantly reduced total weed density (5.62 m²) and biomass (5.42 g/m²) and attained the highest weed control efficiency (62.57%) and soybean yield. The highest net returns (₹40790/ha) and B: C (2.31) were with pendimethalin 1.0 kg/ha PoE along with PoE at 25 DAS due to the lower cost of herbicide usage compared to hand weeding.

2.7 Effect of hand weeding on crop and weed

Vyas and Kushwah (2008) observed that the minimum weed population at 50 DAS (24 weed/m²) and weed biomass (0.42q ha⁻¹) with the highest weed control efficiency (WCE) of 96.78% and the maximum values of yield attributes viz., branches plant⁻¹, pods plant⁻¹, yield plant⁻¹ and seed index (100 seed weight) was recorded with the hand weeding at 30 and 45 DAS. However, it was at par with in situ mulching of weeds at 30 DAS and with pre-emergence herbicides viz., pendimethalin 1.0 kg ha⁻¹ or clomazone 1.0 kg ha⁻¹ *fb* with one-hand weeding at 30 DAS.

Peer *et al.* (2013) observed that after weed-free treatment, two-hand weeding at 25 and 45 DAS recorded significantly highest number of branches per plant, pod per plant, seed per pod, 100 seed weight, seed yield, straw yield, biological yield, harvest index, crude protein content compared to other treatments.

Jha *et al.* (2014) from Pantnagar reported that weed-free checks were found to be best when the highest nodulation, yield attributes, N uptake, and soil parameters were recorded. It was at par with imazethapyr 10% SL @ 100 g a.i. ha⁻¹, the treatment that showed the highest nodules and plant dry weight, weed control efficiency, grain yield (1975 kg ha⁻¹), straw yield (2445 kg ha⁻¹), N uptake (136.4 kg ha⁻¹ in grain and 40.9 kg ha⁻¹ in straw), soil organic carbon, available N, P, K, microbial counts and dehydrogenase activity among different herbicides treatments

Akter *et al.* (2016) reported that twice hand weeding (20 and 40 DAS) was effective in weed control and recorded the highest number of plants m⁻² (61.33), number of pods plant⁻¹ (32.75), length of pods (31.68 cm), seeds pod⁻¹ (1.91), 1000-seed weight (119.00g), stover yield (2.74t ha⁻¹), biological yield (4.97t ha⁻¹) compared to un-weeded treatment but were statistically similar with chemical treatment Whip Super 9 EC.

Datta *et al.* (2017) reported that total dry matter production was highest under weed-free check at 60 DAS and in soybean harvest (23.14 and 90.82 g/m², respectively).

El-Metwally *et al.* (2017) observed that two-hand-hoeing was more profitable and employed the highest reduction in dry weight of broadleaved grasses and total weeds. Two hand-hoeing recorded the maximum values of plant height, SPAD value, NAR, SLA, LWR, RGR, statistically increased number of pods plant⁻¹, pods dry weight plant⁻¹, seeds weight plant⁻¹, 100- seed weight and seed yield tonne ha⁻¹ as compared to other treatments and the lowest value was recorded in un-weeded plot. The increase in growth and yield attributes may be due to reasonable control of weeds and minimizing weed competition.

Singh *et al.* (2017) from Pant Nagar, Uttarakhand reported that weed-free plots recorded higher grain yield and weed control efficiency (WCE) than sulfentrazone, pendimethalin, and weedy check.

Rajkumari *et al.* (2017) conducted a field experiment on tillage and weed management on soybean. They observed that hand weeding twice at 20 and 40 DAS gave the highest plant height, RGR, CGR, seed yield, stover yield, and highest chlorophyll content significantly compared to other weed control treatments and weedy checks.

Ahirwar *et al.* (2018) recorded the highest values of growth characters and yield attributes such as the number of plants (20.95 per m²), dry matter accumulation of plants at harvest (18.32 g plant⁻¹), number of branches (2.57 plant⁻¹), pods (53.27 plant⁻¹), seed index (9.16 g/100 seeds), straw yield (3235 kg ha⁻¹) with two hand weeding at 20 and 45 DAS which was statistically superior over rest of the herbicides and weedy check except imazethapyr @ 100 g a.i. ha⁻¹.

Patil *et al.* (2018) carried out a field experiment at Junagadh. They observed that weed-free plots obtained the minimum numbers of weeds at 20, 40, and 60 DAS and harvest due to efficient control of weeds at an early stage and later on through weeding and intercultural operation. The highest weed control efficiency of 100%, lower weed density and minimum dry weight of weeds were also registered under weed-free. It was also observed to produce 104% higher grain and 94% stover yields

than un-weeded control. Maximum weed density was recorded throughout the investigation on an unweeded control plot.

Virk *et al.* (2018) reported that two-hand weeding recorded the lowest dry weight of weeds followed by pendimethalin 0.45 kg/ha PE + hand weeding at 70 DAS and harvest. Two-hand weeding at 20 and 40 DAS also recorded the highest number and dry weight of nodules and leghaemoglobin content.

Toppo *et al.* (2019) observed a significant minimum weed density, minimum production of dry matter by all the weed species, highest weed control efficiency based on weed biomass, maximum seed yield and higher harvest index under twice hand weeding at 20 DAS and 40 DAS as compared to others treatments in a field experiment at Raipur.

Jadhav and Kashid (2019) observed that weed-free treatment recorded a significantly lowest weed biomass, higher weed control efficiency and lower weed index and also a significantly higher plant height (75 cm), number of pods plant⁻¹ (29), grain yield (3.73 t ha⁻¹) and straw yield (2.59 t ha⁻¹) of soybean. The highest gross monetary returns (68,269 ha⁻¹) and net returns (45,857 ha⁻¹) were also recorded with Weed free treatment, which was at par with quizalofop-ethyl 0.05 kg ha⁻¹ + chlorimuron-ethyl 0.009 kg ha⁻¹ PoE at 15 DAS + HW at 30 DAS.

Jadon *et al.* (2019) revealed that the highest values of growth characteristics such as plant height, dry matter accumulation (17.94 g plant⁻¹), number of branches plant⁻¹ (2.43), pods plant⁻¹ (47.23), seed index (9.08) and highest soybean seed yield (2204.4 kg ha⁻¹), protein yield (909.6 kg ha⁻¹), and oil yield (424.8 kg ha⁻¹) were recorded in two hand weeding followed by a ready mix of imazamox+ imazethapyr 75 g ha⁻¹ which were significantly superior over treatment and weedy check.

Raj *et al.* (2019) studied the effect of nutrient and weed management practices on the growth and yield of soybean. They reported that hand weeding twice at 25 and 45 DAS recorded significantly higher plant height (55.47), dry weight/plant (18.40 g), no. of leaves/plant (35.10), leaf area index at 60 DAS (5.22), no. of root nodules/plant at 30 DAS (20.14) and 60 DAS (60.30), no. of pods/plant (22.52), no. of grain/pod

(2.42), 100-grain weight (9.50 g), grain yield (16.71 q/ha) and straw yield (28.11 q/ha) over control and was at par with pendimethalin 1.0 kg/ha (Pre-emergence) + imazethapyr 55 g/ha (post-emergence) at 25 DAS.

Samudre *et al.* (2019) recorded the highest plant height, Leaf area plant⁻¹, the maximum number of branches, the highest mean number of nodules plant⁻¹ and the highest mean number of pods plant⁻¹ in the weed-free plot, which was at par with the treatment pendimethalin 30% EC @ 1kg a.i. ha⁻¹ (PE) + imazethapyr 10% SL @ 100g a.i. ha⁻¹ (PoE), but a weedy check recorded the lowest of the parameters mentioned above.

Jaiswal and Lakpale (2022) experimented and revealed that the growth attributes, viz., plant height, number of branches, dry matter accumulation as well as yield attributes viz., number of pods plant⁻¹, number of seed pods⁻¹, seed index (100 seed), seed yields, stover yields, harvest index as well as lowest weed index and highest weed control efficiency were found maximum under weed free check which was at par with two hands weeding 20 and 40 DAS.

Apon and Nongmaithem (2022) studied the weed management on growth, yield, and quality of soybean and reported that hand weeding at 15, 30, and 45 DAS gave the highest seed yield (20.67 q ha⁻¹) and straw yield (26.28 q ha⁻¹).

Meena *et al.* (2022) studied the effect of pre- and post-emergence herbicides on soybean. They recorded that soybean pods/plant, seeds/pods, seed index, stover, seed yield (1800 kg/ha) and higher weed control efficiency (77.79%), lowest biomass grasses, sedges, broad-leaved weeds, and total weeds biomass and net return were recorded with hand weeding twice at 20 and 40 DAS followed by post-emergence application.

Chouhan and Verma (2023) revealed that hand weeding twice at 30 and 45 DAS recorded higher growth and yield attribute followed by the application of imazethapyr 35% + imazemox 35% 70 WG 70 g/ha at 20 DAS (PoE) and pendimethalin 30 EC 1 kg/ha (PE) *fb* imazethapyr 10 SL 100 g/ha (PoE). Application

imazethapyr 35%+imazamox35% 70 WG 70 g/ha (PoE) at 20 DAS recorded the highest net return of ₹73870/ha and cost-benefit ratio 1:3.58.

Saharan *et al.* (2023) from Rajasthan researched the impact of weed control measures on soybeans and revealed that a maximum reduction in yield (36 percent) occurred in weedy check plots. However, in the hand-weeding at 20 and 40 DAS plots, zero % yield reduction was observed compared to other treatments. Pods per plant and number of seeds per pod were significantly superior in hand-weeding at 20 and 40 DAS (154.06 and 2.67, respectively). The minimum seed index (9.02 g) was recorded in the weedy check plot. Hand-weeded plots (20 and 40 DAS) registered the highest seed and stover yield (16.98 q ha⁻¹ and 34.96 q ha⁻¹, respectively).

Kalyan *et al.* (2024) observed that two-hand weeding at 20 and 40 DAS recorded significantly less weed density (66.25 no. m⁻²), weed dry matter accumulation (46.33 g m⁻²) and attained higher weed control efficiency (81.53 %), no. of pods plant⁻¹ (32.27), no. of seeds pod⁻¹ (3.07), grain yield (2094 kg ha⁻¹) and straw yield (2826.90 kg ha⁻¹) and found at par with the post-emergence application of imazethapyr + imazamox @ 70 g a.i. ha⁻¹ fb HW (at 40 DAS) and imazethapyr @ 125 g a.i. ha⁻¹ fb HW (at 40 DAS). The maximum net returns and B-C ratio were recorded higher with imazethapyr + imazamox @ 70 g a.i. ha⁻¹ fb HW (at 40 DAS).

2.8 Effect of mulching on soybean and weed:

Gupta and Saxena (2008) indicated that in-situ mulching recorded maximum weed reduction, weed control efficiency, plant growth, yield attributes, seed yield, gross return and incremental benefit: cost ratio and it was higher than treatments like two-hand weeding (HW) at 30 and 45 DAS and two hoeing at 20 and 40 DAS of soybean.

Singh and Jolly (2008) revealed that soybean covered with 3 tonnes of wheat straw ha⁻¹ (row mulch) or the whole plot with 6 t wheat straw ha⁻¹ (plot mulch) showed a profound effect on improving both the speed of emergence and the final emergence count, possibly by lowering the maximum soil temperature and conserving soil moisture.

Patil *et al.* (2009) from Akola reported that growth characteristics like leaf area plant⁻¹ (dm²), number of branches plant⁻¹ and yield contributing characters, the yield of soybean were found significantly higher with the mulching of wheat straw @ 5 t ha⁻¹ over no mulch.

Singh (2009) observed that mulch treatments had a much faster emergence count than the non-mulch treatments and lower dry weight of weeds was also recorded in row mulch and plot mulch treatments compared to the weedy check. The dry weight of the weed was further reduced when straw mulch was integrated with herbicide pendimethalin 0.45 kg ha⁻¹ and weed control efficiency increased by as much as 58.60 and 72.55%.

Ali *et al.* (2013) stated that mulching with organic materials aims to cover soils and form a physical barrier to limit soil water evaporation, control weeds, maintain a good soil structure and protect crops from contamination.

Xue *et al.* (2013) observed that the highest plant height (35.94 cm), highest number of leaves by 136 % and highest leaf area (20.20 cm²) were noted in treatment where wheat straw mulch was applied when compared with the control. Crop residue mulching suppresses weed emergence and growth through its smothering and allelopathic effects, besides other benefits such as soil moisture retention, organic matter addition, lesser evaporation, higher infiltration and erosion control.

Jamir *et al.* (2016) conducted a field experiment during the *khari*f season in the experimental farm of SASRD, Medziphema. They observed a significantly higher N, P and K content in grain, seed protein content, seed yield (2139.46 kg ha⁻¹), biological yield (4730.53 kg ha⁻¹) and harvest index (45.27%) attributes with mulch application as compared to no mulch (1791.93 kg ha⁻¹, 4227.93 kg ha⁻¹ and 42.38%, respectively). In comparison, there was no significant increase in stover yield (2591.06 kg ha⁻¹), although the mulch treatment recorded a higher value.

Datta *et al.* (2017) observed that weed density and dry weight were significantly lower in the treatments mulching of wheat straw @ 5 t ha⁻¹ after one weeding (5.66 and 3.63 g m², respectively). Weed Control Index (WCI), which is an

index of efficiency of a weed control treatment, was highest under pendimethalin *fb* imazethapyr + mulching at 25 DAS both at 60 DAS and harvest (67.54 and 67.65%, respectively) and thus providing higher crop growth and seed yield of soybean.

Sanbagavalli *et al.* (2017) recorded higher crop growth rate, dry matter production, increased relative water content, rainfall use efficiency, pods plant⁻¹, 100 seed weight (12.79 g) and yield (1219 kg ha⁻¹) with application of straw mulch @ 5 t ha⁻¹ as compared to no mulch (12.18 g and 1006 kg ha⁻¹, respectively). Economic data analysis showed that bajra straw mulch @ 5t ha⁻¹ registered higher net income (38,062 ha⁻¹) with a B: C ratio of 1.45 compared to the control treatment.

Sikka *et al.* (2018) revealed that sowing date on June 30 and mulching recorded the highest number of pods plant⁻¹ and stover yield over no mulch. However, seed yield and total N and K uptake were found to be non-significant.

Fadhli *et al.* (2021) reported that an increased amount of organic mulch inhibited weed germination and emergence, which reduced the competition for nutrients, light, water and space between soybean plants and weeds.

2.9 Effect of soil solarisation on soybean and weeds:

A non-hazardous and non-chemical method of soil heating is called soil solarization. This is a method of solar heating soil by covering it with transparent polyethylene during summer. Direct killing of weed seeds in the soil by lethal soil temperature built under transparent polyethylene mulch is the primary mechanism for reducing weed seed population and emergence. The soil solarization process increases the soil temperature by 18-12°C over the corresponding non-mulched soil (Maheswari & Karthik, 2019).

Singh *et al.* (2004) observed that soil solarisation for five weeks reduced weed population, dry weight of weed, the emergence of jungle rice (*Echinochloa colona*) by 95%, wild jute (*Corchorus sp.*) by 83%, common dayflower (*Commelina communis*) by 80% and gripe weed (*Phyllanthus fraternus*, syn. *P. niruri*) by 58%. Solarisation also resulted in the most remarkable leaf area, crop dry matter per plant, increased

yield attributes and seed yield of soybean and the highest seed yield (1645 kg ha⁻¹) was obtained with solarisation for five weeks, which was higher by 110% than the seed yield of the non-solarized control.

Megueni *et al.* (2006) conducted a field experiment on the performance of two soybean cultivars under solarisation and *Rhizobia* inoculation between 2004 and 2005 in Cameroon. They observed an increase in soybean biomass and seed yield.

Singh (2006) revealed that the emergence of *T. Portulacastrum* was reduced by 91.2% and 87.6% with transparent and black film, respectively, when the plot was mulched for 30 days. Some weed populations, such as *C. rotundus*, was unaffected by solarisation, and the reason might be that the soil temperature did not increase sufficiently at the lower depths to destroy its tubers. A significant increase in growth and yield of soybeans was recorded with solarisation before sowing, especially for 30 days with transparent polyethylene. These might be due to decreased weed competition after solarisation and increased nutrition availability, stimulation of beneficial microflora and reduced incidence of soil-borne diseases through solarisation.

Soil solarisation recorded the lowest total weed population and highest system productivity in the soybean-wheat cropping system, which was closely followed by wheat straw incorporation and repeated tillage with irrigation (Das and Yaduraju, 2008).

Harsimran and Robert (2010) observed that Purple nutsedge was the dominant weed in a field experiment conducted between 2007 and 2008. Although it is known to cause punctures and breaks in plastic films, it was controlled under several solarisation films. Six weeks or longer solarisation times were needed for consistent plastic weed management. Significantly fewer weeds were covered and weed densities were recorded under polyethylene film solarisation than with non-mulched control.

Robert *et al.* (2013) observed that solarisation significantly reduced weed density (% bed coverage) of broad-leaf weeds and grasses at Lamphun and nutsedge at Sankampaeng (Thailand) by about 90%. Soybean plant biomass and pod yield were significantly increased by solarisation. In some cases, the effectiveness of solarisation

was improved by combining it with soil amendments, compared to the non-treated control and standard commercial treatment.

Setyowati *et al.* (2017) conducted a field experiment in Bengkulu, Indonesia. They observed that soil solarisation raised soil temperature to 59⁰ C and inhibited the growth of most weeds, but at the end of the experiment, *C. rotundus* was still able to grow.

Muthumanickam and Anburani (2019) conducted a field experiment on soil solarisation on weed control index and efficiency. They revealed a considerable increase in the weed control index (WCI) with solarisation management treatments. The application of a transparent polyethylene sheet of 0.05 mm thickness significantly recorded the lowest count of weeds (15.85 m², 15.03 m²), highest weed control efficiency (63.29, 63.78), least weed biomass (10.15 g/m², 5.12 g/m²) and the highest weed control index (60.84 %, 67.61 %), respectively in *Amaranthus dubius* and *Amaranthus tristis*. The lowest weed control efficiency, maximum weed biomass and lowest weed control index in both varieties were in control. Compared to the fallow, the weed control index achieved in *Amaranthus dubius* was 60.84% and in *Amaranthus tristis*, it was 67.31% with solarisation with transparent polyethylene film of 0.05 mm thick.

2.10 Effect of pendimethalin on soybean and weeds:

Devi *et al.* (2016) observed that the pre-emergence application of pendimethalin was found effective in controlling both monocot and dicot weeds in soybean and recorded the maximum weed control efficiency (85.60%) over control.

Nagre *et al.* (2017) concluded that a significantly lowest total weed count, weed dry matter and weed index while higher WCE, herbicide efficiency index, crop resistance index, higher growth attributes and higher soybean grain, straw yield, net returns and B: C ratio was recorded with the application of pendimethalin (PE) 0.75 kg ha⁻¹ *fb* one hand weeding and pendimethalin PE 0.75 kg ha⁻¹ *fb* tank mix imazethapyr + propaquizafop (80 + 60 g ha⁻¹).

Application of pendimethalin followed by hoeing and weeding at 30 DAS was significantly superior in reducing weed dry matter of broad-leaved, narrow-leaved and total weeds at harvest and produced substantially higher pooled seed (2168 kg ha⁻¹), straw (3167 kg ha⁻¹) and biological (5335 kg ha⁻¹) yields compared to other treatments (Meena *et al.*, 2017).

Khazi *et al.* (2018) revealed that with the application of PE–pendimethalin 30% EC @ 0.75 kg a.i. ha⁻¹+1 hoeing (30-40 DAS) + 1 hand weeding (40-50 DAS) recorded the minimum weed growth rate, density and dry matter production of weeds and the higher weed control efficiency and highest Soybean equivalent yield.

Kanatas *et al.* (2020) reported that the application of pendimethalin as pre-emergence chemical control resulted in 96% control of annual weeds such as redroot pigweed (*A. retroflexus*) and common purslane (*P. oleracea*) as compared to regular seedbed treatment.

Subbulakshmi (2021) reported that application of pendimethalin @ 0.75 kg/ha PE fb HW on 20 DAS recorded significantly lower weed density and weed biomass, which in turn produced increased growth, yield attributes and yield of the crop.

Hasanuddin *et al.* (2022) studied effect of pendimethalin and sulfentrazone on characteristics of weeds in soybean cultivation and reported that the application of pendimethalin 500 g a.i./ha together with sulfentrazone 500 g a.i./ha increased weed control percentage and decreased weed species, number of weeds and weed dry weight of grasses and broadleaves weed.

2.11 Effect of Imazethapyr on soybean and weeds:

Kundu *et al.* (2011) observed that among the herbicidal treatments, imazethapyr 150 g a.i. ha⁻¹ performed better concerning control of different broad-leaved weeds and recorded the highest herbicide efficiency index but produced a relatively lower yield than imazethapyr 125 g ha⁻¹, whereas the lowest yield of soybean among all the treatments was a weedy check.

Meena *et al.* (2011) reported that application of post-emergence imazethapyr XL 10 % SL at 150 g ha⁻¹ significantly reduced the density and dry weight of all grassy, broad leaf weeds sedges and recorded maximum number of branches plant⁻¹, pods plant⁻¹, seeds pod⁻¹ and seed yield as compared to weedy check and imazethapyr 10 % at 50 g ha⁻¹.

Meena and Dhaka (2013) reported that the use of Imazethapyr, 75 g ha⁻¹ at 15 DAS +1HW at 35 DAS significantly reduced weed density (40.70/m²), weed dry weight (366.30 kg ha⁻¹) at harvest and highest weed control efficiency (56.78%) were obtained over control and other treatment.

In a field experiment at Pantnagar, Singh *et al.* (2014) found that broad leaf weeds were effectively controlled with the application of imazethapyr 100 g ha⁻¹ which remained at par with hand two weedings and showed significant control of *Parthenium hysterophorus*, *Phyllanthus niruri*, and *Cyperus rotundus* than quizalofop-p-ethyl at 30, 45 and 75 DAS.

Chandraker and Paikra (2015) concluded that with the pre-emergence application of imazethapyr 100 g ha⁻¹ *fb* one hoeing at 20 DAS recorded the least weed growth rate, density and dry matter production of weeds, highest weed control efficiency, highest seed yield of soybean and harvest index followed by pendimethalin 1000 g ha⁻¹ *fb* one hand weeding at 20 DAS which was also gave the highest stover yield. The highest weed index was noted under a weedy check.

Sandil *et al.* (2015) conducted a field experiment and observed that the application of imazethapyr at 50, 75, and 100 g/ha controlled broad-leaved and grassy-leaved weeds efficiently compared to herbicide propaquizafop.

Billore (2017) experimented in Madhya Pradesh on soybean and recorded maximum weed control efficiency (83.08%) and highest seed yield (2,030 kg ha⁻¹) with the application of post-emergence imazethapyr @ 100 g a.i. ha⁻¹ being at par with pre-mix formulation of sulfentrazone + clomazone @ 870/725 g a.i. ha⁻¹ was found to be effective against significant soybean weeds.

Chaman *et al.* (2017) revealed that with post-emergence application of ready mix of imazamox+imazethapyr 75 g ha⁻¹ at 15 DAS produced the highest seed (2013.7 kg ha⁻¹), protein (815.7 kg ha⁻¹) and oil yield of soybean (385.7 kg ha⁻¹) which was significantly superior over clodinafop-propargyl, quizalofop-ethyl and weedy check.

Simaiya *et al.* (2018) revealed that with the application of imazethapyr 10 SL 100 g a.i. ha⁻¹ alone or in combination with insecticides indoxacarb 14.5 SC 87 g a.i. ha⁻¹ recorded less weed dry biomass and increased weed control efficiency, controlling dicot and monocot weeds. It also provided significantly higher plant height, branches per plant, plant dry weight, pods per plant, seeds per pod, grain yield per plant and seed index in the combined application or alone application of imazethapyr 10 SL 100 g a.i. ha⁻¹ than control and other treatments.

Emmiganur and Hosmath (2020) revealed that the application of Imazethapyr 10 % SL @ 100 g a.i. ha⁻¹ as early POE recorded higher soybean seed yield (18.08 q ha⁻¹), haulm yield (19.10 q ha⁻¹) and recorded significantly lower weed count (3.59 m²), dry weight (2.28 g m²) and highest weed control efficiency (83.52).

Kutariye *et al.* (2021) studied weed flora associated with soybean crops and found that the infestation by monocot weeds (74.62 and 75.12%) was maximum in comparison to dicot weeds (25.38 and 24.88%). Application of post-emergence (propaquizafop + imazethapyr mixture at 56+78 g/ha) recorded lower dry weight of monocot weed (5.99 and 4.71 g/m²) and dicot weeds (2.77 and 2.35 g/m²) with 95.20 and 95.92% weed control efficiency being statistically at par with hand weeding twice and weed free plots.

Shwetha *et al.* (2024) found that applying post-emergence herbicides imazethapyr + imazamox @ 100 g a.i. and propaquizafop + imazethapyr @ 100 g a.i. effectively suppressed weed density and increased weed control efficiency (88.41% and 84.14%) compared to weed-free control and it also recorded lower monocot and dicot weed dry weight, which was at par with weed-free plots. Yield parameters such as the number of pods per plant, test weight and grain yield were also higher. The BC

ratio was significantly greater in imazethapyr + imazamox @ 100 g a.i. (3.29) and it was comparable to the weed-free check (3.22).

2.12 Nutrient depletion by weeds and uptake by crop

Pandya *et al.* (2005) observed that hand-weeding at 20 and 40 days after sowing resulted in a significant reduction in the uptake of N and P by weeds and an increase in the uptake of these nutrients by soybean compared to all other methods of weed control.

Kumar and Das (2008) reported that two-hand weeding proved to record the lowest density, dry weight and nutrient uptake (2.4 kg N, 0.45 kg P, and 3.1 kg K/ha) by weeds and the highest nutrient uptake (85.5 kg N, 10.5 kg P and 38.2 kg K/ha) by soybean and noted 41.3% more soybean seed yield than the un-weeded control.

Younesabadi *et al.* (2013) recorded that in a year's experiment, the application of pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha was comparable with weed-free check and resulted in higher NPK uptake by soybean and the highest N, P and K uptake by weeds was observed in weedy check.

Kumari and Sagarka (2014) experimented during the *kharif* season. They observed that besides weed-free, significantly higher NPK content, uptake by crop and lower content and uptake by weed were recorded with hand weeding and interculture operations at 20 and 40 DAS, followed by the application of pendimethalin + imazethapyr and improved protein and oil percent.

Sharma *et al.* (2016) stated that the minimum removal of total nitrogen (2.78 kg/ha) and phosphorus (0.40 kg/ha) by weeds and the highest total N and P uptake by the crop (143.8 kg/ha and 15.6 kg/ha, respectively) were observed under weed free treatment which was closely followed by pendimethalin 750 g/ha + hand weeding at 30 DAS and two hand weeding treatment at 15 and 30 DAS, while the maximum total removal of nutrient (33.91 kg/ha N and 4.88 kg/ha P) was recorded under weedy check.

Bali *et al.* (2017) from Chatha-Jammu reported that among weed control treatments, the lowest N, P and K uptake by weeds were recorded in hand-weeding

(15 and 35 DAS), which was statistically at par with imazethapyr @ 75 g ha⁻¹/b hoeing at 35 DAS. The maximum uptake by seed and straw was recorded in the weed-free plot, which was statistically at par with twice hand weeding at 15 and 35 DAS, the highest seed yield, highest weed control efficiency (94.1%), and net return (Rs.24565.17) were observed in imazethapyr @ 75 g a.i ha⁻¹ (PoE) + hoeing at 35 days after sowing in soybean.

Nawale *et al.* (2018) reported that sowing soybean in meteorological week 24 (11-17 June) resulted in the highest NPK uptake (95.81, 96.04, 17.66 kg ha⁻¹) during both the years and on pooled mean and it was at par with that of in meteorological week 25.

Bhimwal *et al.* (2019) experimented and reported that among different weed control treatments, post-emergence and tank mix combination of propaquizafop + imazethapyr (75+75 g ha⁻¹) and imazethapyr + quizalofop-ethyl (75+60 g ha⁻¹) at 21 DAS were most effective in respect of reducing weed density, weed biomass, nutrient removal by weed and promote yield attributes and yield and quality of soybean as compared to rest of weed control treatment. Nutrient loss through uncontrolled weed growth throughout the crop season was recorded as the highest loss of 137.86 kg N ha⁻¹, 21.29 kg P₂O₅ ha⁻¹, 132.99 kg K₂O ha⁻¹, and 8.76 kg S ha⁻¹.

Raj *et al.* (2020) reported that maximum yield (16.71 q/ha) and total uptake of N (136.92 kg/ha), P (9.15 kg/ha), and K (49.84 kg/ha) were noticed with hand weeding twice at 25 and 45 DAS which was significantly superior over control but was at par with pendimethalin 1.0 kg/ha (Pre-emergence) + one hand weeding at 40 DAS and pendimethalin 1.0 kg/ha (Pre-emergence) + imazethapyr 55 g/ha (post-emergence).

Dhakad *et al.* (2022) researched nutrient uptake by weed and soybean crops as influenced by weed management. It was recorded that two-hand weeding at 20 and 40 DAS, sole and ready mixture application of herbicides, proved significantly superior in reducing weed dry matter and nutrient uptake by weeds over un-weeded check, whereas an un-weeded check recorded maximum NPK depletion of 18.4 kg N

ha⁻¹, 8.6 kg P ha⁻¹ and 13.2 kg K ha⁻¹. In the case of NPK uptake by soybean hand weeding at 20 and 40 DAS recorded maximum uptake of N (189.7 kg ha⁻¹), P (17.33 kg ha⁻¹) and K (97.51 kg ha⁻¹). Weedy check resulted in 65.1, 63.9 and 61.2% reduction in N, P and K uptake by crop (Seed +Straw). Two-hand weeding also recorded the highest seed yield (1970 kg ha⁻¹) and straw yield (2636 kg ha⁻¹).

Dhayal *et al.* (2022) studied the bio-efficacy of pre- and post-emergence herbicides on nutrient content and depletion by weeds. They observed that among herbicide management treatments, pendimethalin 30% EC @ 1 kg ha⁻¹ (PE) propaquizafop fb 2.5%w w @ 33.3 g ha⁻¹+ imazethapyr 3.75% w w (pre-mix) ME @ 50 g ha⁻¹ at 20 DAS significantly recorded lowest weed dry matter at harvest and nutrient depletion by weeds, as well as the highest net return and B: C ratio.

Borje *et al.* (2023) studied the effect of different herbicides on weed and crop nutrient uptake in soybean crops (*Glycine max* L.). They reported that the nutrient uptake by soybean was significantly higher in treatment weed-free plots, whereas the weedy check recorded the highest NPK depletion by weeds.

Vishwakarma *et al.* (2023) revealed that among different treatments, the highest total nutrient uptake (235.27 kg ha⁻¹) was recorded under sequential pre-emergence and post-emergence herbicides and followed by hand weeding at 20 and 40 DAS (232.19 kg ha⁻¹) while lowest nutrient (NPK) uptake in soybean was noticed in control plots.

Kaur *et al.* (2024) reported that the sowing date of the 12th of June recorded the highest nitrogen accumulation, phosphorus accumulation and potassium accumulation at harvest and nitrogen content, phosphorus content, and potassium content in seed. While, delayed planting on the 12th of July recorded the lowest NPK accumulation in plant and content in seed.

2.13 Bioassay studies

Silva *et al.* (1999) conducted a bioassay using sorghum as test-plant and result denoted that imazamox had a shorter residual effect in soil having no influence on the

development of the test-plant at 120 DAA even when at double the recommended rate. However, imazethapyr applied at 200 g/ha (double the recommended rate) inhibited the development of sorghum plants.

Babu *et al.* (2015) revealed that the residue of imazethapyr persisted in soil for up to 60 days; there may be a chance for bioaccumulation in the plants through plant uptake. Hence, a pre-harvest interval of 75 days must be allowed after the application of imazethapyr for weed control.

Sangwan *et al.* (2016) explored the efficacy and phytotoxicity of herbicides like pendimethalin and imazethapyr on cluster beans, showing that certain combinations provided good weed control without harming the crop, with no observed carryover effects on succeeding mustard crops.

Chavan *et al.* (2018) conducted a residue test through the field bioassay technique. They observed that pendimethalin, imazethapyr and quizalofop ethylene applied in pigeon pea did not show any phytotoxicity on any of the succeeding green gram. It was also mentioned that pendimethalin applied in pigeonpea was found to persist even after 35 days after its application in pigeonpea.

2.14 Effect of weed management practices on succeeding crop

Sangeetha *et al.* (2012) from Coimbatore, Tamil Nadu conducted a study on the residual effect of different doses of imazethapyr 50, 75, 100, and 200 g ha⁻¹ as early post-emergence and concluded that it did not show any residual effect or influence germination, growth and yield on succeeding crops, sunflower and pearl millet and was statistically at par with checks.

Yadav and Bhullar (2014) conducted a field experiment on the residual effects of pendimethalin, quizalofop, imazethapyr, and imazamox, applied to soybean crops on the succeeding winter season crops, which were determined through field bioassay and observed that the emergence, plant height and dry matter accumulation of all the succeeding crops viz. wheat, barley, spinach, pea, raya, canola and sugar beet

were similar among herbicidal and unsprayed plots indicating that all the herbicides were safe for raising of succeeding winter crops in rotation with soybean.

Deore and Patil (2016) conducted a field experiment on the residual effect of pre (pendimethalin) and post (quizalofop-ethyl, imazethapyr) emergence herbicides of soybean on succeeding crops, i.e., *Rabi* sorghum, bajra, barley, and ragi and observed that germination percentage, plant height, dry matter production were not affected with the application of different herbicide. Thus, the results concluded that these herbicides were safer for growing *rabi* sorghum, bajra, barley and ragi after soybean.

Zahan *et al.* (2016) studied the residual effect of herbicides pendimethalin, pyrazosulfuron-ethyl, butachlor, pretilachlor, orthosulfamuron, acetochlor + bensulfuron methyl, butachlor + propanil and 2,4-D amine) applied in unpuddled transplanted *Aman* rice and concluded that herbicides used in the researched plot had no residual effect on the germination and leaf chlorophyll content, seedling shoot length and dry matter of the succeeding wheat, lentil and sunflower crops.

Zahan *et al.* (2018) investigated the residual effect of eight herbicides (pendimethalin, pretilachlor, triasulfuron, ethoxysulfuron, pyrazosulfuronethyl, carfentrazone-ethyl, 2,4-D amine and carfentrazone-ethyl + isoproturon) on the succeeding crop, i.e., mungbean, jute, and sunflower, through bio-assay techniques. The results revealed that germination and crop growth, leaf chlorophyll and crop dry matters of these succeeding crops were not affected by any of the herbicide residue applied in wheat but were found to be superior over the control plot. Some shoot lengths of mungbean and sunflower were increased in the herbicide-treated plots, but root lengths of some herbicide-treated plots were decreased at a negligible rate compared to the control one. Therefore, the residual effect study claimed that using the tested herbicides in wheat is safe for germinating and growing the succeeding crops.

Sridhara *et al.* (2019) revealed that the application of pre-emergence herbicide effectively reduced weed density and increased weed control efficiency up to 96.76 and 80.20 percent at 30 and 60 DAS. It also obtained maximum grain yield

and no phytotoxicity symptoms were noticed on soybean as well as on succeeding green gram crops, even at higher doses.

Santin *et al.* (2019) researched weed management on soybean with herbicides treatments glyphosate, glyphosate +(diuron+sulfentrazone), glyphosate + diclosulam, glyphosate +(imazethapyr+flumioxazin), glyphosate + flumioxazin, glyphosate + 2,4-D, glyphosate + S-metolachlor, amônio-glufosinate + (diuron + sulfentrazone). They reported that the phytotoxicity caused by the herbicides in the culture is not significant in decreasing the grain yield. Instead, the herbicides present provide low phytotoxicity and high control of the weed plants, and recorded higher productivity compared to the un-weeded control.

Rana *et al.* (2019) researched the effect of imazethapyr and its ready-mix combination with imazamox to control weeds and its impact on succeeding mustard crops. They revealed that there was no residual effect or phytotoxicity on succeeding mustard crops.

2.14 Economic analysis

Idapuganti *et al.* (2005) conducted a field experiment at IARI, New Delhi, and observed that the highest benefit: cost ratio (1.82) was obtained with weed-free up to 60 DAS, which was intimately followed by two HW or two hoeings at 20 and 40 DAS and the lowest benefit: cost ratio was recorded under weedy check comparing to other treatment.

Gayatri Devi *et al.* (2012) recorded that application of imazethapyr 75 g ha⁻¹ at 1 DAS + in situ mulching with weeds after hand weeding 30 DAS gave the highest net returns (21018 ha⁻¹) and benefit: cost (B: C) ratio (1.79).

Hari *et al.* (2013) conducted a field experiment on soybean with different rates and times of application of imazethapyr @ 50, 75, and 100 g ha⁻¹ applied at 15 or 25 DAS, pendimethalin 0.45 kg ha⁻¹ + hand weeding (40 DAS), two hand weedings (20 + 40 DAS), unweeded check. They observed that the highest net returns were recorded in imazethapyr @ 75 g ha⁻¹ applied at 25 DAS, which was significantly higher

than imazethapyr @ 50 g ha⁻¹ applied at 15 or 25 DAS, two hand weeding and unweeded check but statistically at par with other treatments.

Ram *et al.* (2013) reported that applying imazethapyr 10% @ 100 g ha⁻¹ significantly recorded higher gross and net returns with the over-weedy check in soybean.

Tomar *et al.* (2014) conducted field research on soybean with different sowing dates: 28 to 30 June and 12 to 15 July and the results indicated that early sowing of soybeans resulted in higher germination, higher seed yield and B: C ratio compared to late sowing.

Gajbhiye *et al.* (2016) reported that the application of Imazethapyr (Pursuit) 750 ml ha⁻¹ + hw at 45 DAS recorded significantly higher yields and net monetary returns (₹ 38351 ha⁻¹) and B: C ratio (3.82) than other treatment and lowest with weed check.

Sepata *et al.* (2017) reported that the application of pendimethalin at 0.75 kg ha⁻¹, along with one-hand weeding 30 days after sowing, recorded the lowest total weed density and biomass. This treatment also recorded higher grain yield but lower net returns compared to pendimethalin 0.75 kg ha⁻¹ + imazethapyr 0.075 kg ha⁻¹. Overall, the application of pendimethalin as PE and imazethapyr as PoE in ZT proved to be the most effective herbicide strategy for weed management in soybean, leading to higher grain yield and net returns, irrespective of crop establishment practices.

Ahirwar *et al.* (2018) observed that the maximum net returns (₹ 45816 ha⁻¹) and B: C ratio (2.87) were recorded by two hand weeding at 20 and 45 DAS followed by a ready mix of imazamox + imazethapyr @ 75 g a.i. ha⁻¹ at 18 DAS.

Application of imazethapyr gave the highest gross returns (₹ 95,329/- ha⁻¹), net monetary returns (₹ 67,200/- ha⁻¹) and benefit: cost ratio (3.40:1) while minimum gross monetary returns (₹ 81,449/- ha⁻¹), net economic returns (₹ 56,200/- ha⁻¹) were recorded under untreated weedy check. It is more remunerative (1:3.40) than the rest

of the treatments, possibly due to the better weed control efficiency, resulting in higher grain yield and higher returns (Jaybhay *et al.*, 2018).

Rajput and Kasana (2020) reported on soybean that the application of pendimethalin (750 g a.i. ha⁻¹) + one hand weeding at 20 DAS resulted in higher net return (₹ 63500) and B: C (2.58) ratio followed by trifluralin + one hand weeding and hand weeding twice at 20 and 40 DAS.

Rajasekhar *et al.* (2021) concluded that soybean sown in early than the delayed sowing with a spacing of 30 x 10 cm recorded significantly higher seed yield (2.43 t/ha), gross returns (1,03,946 INR/ha), net returns (70,060.8 INR/ha) and benefit-cost ratio (2.07).

Roy *et al.* (2023) experimented with research consisting of nine weed management treatments. They observed that the highest net returns (₹40790/ha) and B: C (2.31) were with pendimethalin 1.0 kg/ha PoE along with PoE at 25 DAS due to the lower cost of herbicide usage compared to hand weeding.

Samim *et al.* (2023) conducted a field experiment on weed management on soybean. They recorded the maximum growth, yield, and economic efficiency in treatment (Pendimethalin + Imazethapyr), gross returns (187.863 AFN/ha), net returns (134.308 AFN/ha), and benefit: cost ratio (2.504) compared to un-weeded check and pendimethalin + hand weeding.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

The details of the experimental materials and the research methodology adopted in relation to the research entitled “**Effect of sowing date and integrated weed management on soybean (*Glycine max* L.) and their residual effect on succeeding french bean (*Phaseolus vulgaris*)**” during the *kharif* season of 2021 and 2022 are presented in this chapter under the appropriate heads.

3.1 General information

3.1.1 Site of the experiment

The experiment was carried out at the experimental research farm of the School of Agricultural Sciences (SAS), Medziphema campus, in the foothill situation of Nagaland. It is located at an altitude of 310 meters above mean sea level (MSL) with the geographical location at 25°45'43" North latitude and 93°53'4" East longitude.

3.1.2 Climatic condition

The experimental farm lies in humid sub-tropical region. The temperature during summer ranges between 21°C - 32°C and winter from 10°C - 15°C with an altitude of 310 meters above the mean sea level. Monsoons start in June and extend up to September, with June and July being the wettest months, with an average annual rainfall varying from 1800 mm to over 2500 mm.

3.1.2.1 Rainfall

The cumulative rainfall recorded during the period of the experiment was 813.5 mm and 1055.4 mm in the years 2021 and 2022, respectively (Table 3.1 a & b). However, the highest rainfall occurred in July (205.90 mm) in 2021 and in August (434.1 mm) in the year of 2022, respectively. Minimum rainfall was received in March (0.9 mm) in 2021-2022 and December (0.2 mm) in 2022-2023.

3.1.2.2 Temperature

During the period of field experiment, the highest maximum monthly average temperature was recorded in the month of August (33.22°C) and the lowest monthly

Table 3.1(a) Weekly meteorological data recorded during the cropping season (2021-22)

Week No.	Temperature		Relative humidity		Rainfall (mm)	Rainy days	Sunshine hours
	Max (°C)	Min (°C)	Max (%)	Min (%)			
22	33.11	22.94	91.29	61.00	17.40	1	4.4
23	33.56	23.63	91.71	63.14	39.1	1	2.8
24	33	24.79	93.29	75.29	19.5	3	3.8
25	33.01	24.51	93.29	67.43	43.4	4	4.3
26	33	25	92.57	69.14	37.6	1	1.9
27	33.17	24.73	88.86	73.43	19.2	2	2.5
28	32.41	24.69	92.71	70.43	105.7	5	3.9
29	33.69	24.66	94.57	69.57	53.3	2	3.9
30	34.49	24.89	89.57	70.43	74.9	2	6.6
31	32.27	25.1	91.57	78.43	34	3	3.9
32	33.2	24.53	92.86	67.86	25.2	3	3.4
33	32.47	24.93	95.57	77	41.8	2	1.6
34	32.37	24.29	91.86	67.71	7	0	3.2
35	32.31	24.29	92.86	72.86	52.9	4	3.0
36	33.19	24.01	94.57	68.43	49.1	3	6.5
37	33.79	23.94	93.57	67.71	42.2	1	5.8
38	32.11	23.31	94	67.71	13.1	2	5.0
39	33.7	23.77	93.14	66	8.1	2	7.1
40	32.29	23.06	94.29	71.14	5	1	5.0
41	33.89	23.57	91.86	62.86	53.8	2	7.8
42	33.3	23.6	95.43	70.14	69.1	3	5.4
43	29.99	18.97	96.86	71.86	2.1	0	7.2
44	30.03	19.07	95.14	57.86	0	0	7.5
45	29.46	15.24	96	49.14	0	0	8.4
46	28.64	16.39	94.86	54.71	0	0	7.5
47	27.76	13.33	96.43	49.29	0	0	8.0
48	26.90	11.40	95.86	45.71	0.00	0	7.9
49	26.43	15.24	95.14	57.71	8.50	1	5.0
50	25.33	11.60	94.86	51.71	0.00	0	6.7
51	24.91	8.93	95.43	46.71	4.70	1	6.7
52	23.35	9.66	96.50	50.00	3.20	1	6.2
1	24.2	8.5	95	47	0.0	0	7.2
2	24.9	10.3	96	54	14.8	1	5.3
3	22.4	10.6	94	55	3.4	1	4.7
4	20.7	11.4	97	67	16.4	3	2.7
5	19.8	9.5	95	58	2.1	0	3.1
6	21.5	9.7	96	51	30.2	2	6.1
7	24.7	7.2	95	39	0.0	0	8.7
8	24.1	10.6	95	47	18.9	2	5.8
9	26.9	12.7	95	44	5.4	1	7.7
10	31.0	12.4	94	37	0.0	0	8.3
11	33.5	15.2	92	37	0.0	0	7.7
12	35.5	17.5	87	32	2.0	0	6.9
13	30.7	19.3	84	57	0.9	0	1.5
14	29.1	19.8	91	69	10.4	2	2.3
15	28.8	19.8	95	78	95.3	3	2.3
16	32.7	19.9	88	62	35.5	3	2.9
17	32.6	20.0	87	61	18.3	1	7.1

Source: ICAR Research Centre for NEH Region, Nagaland Centre, Medziphema

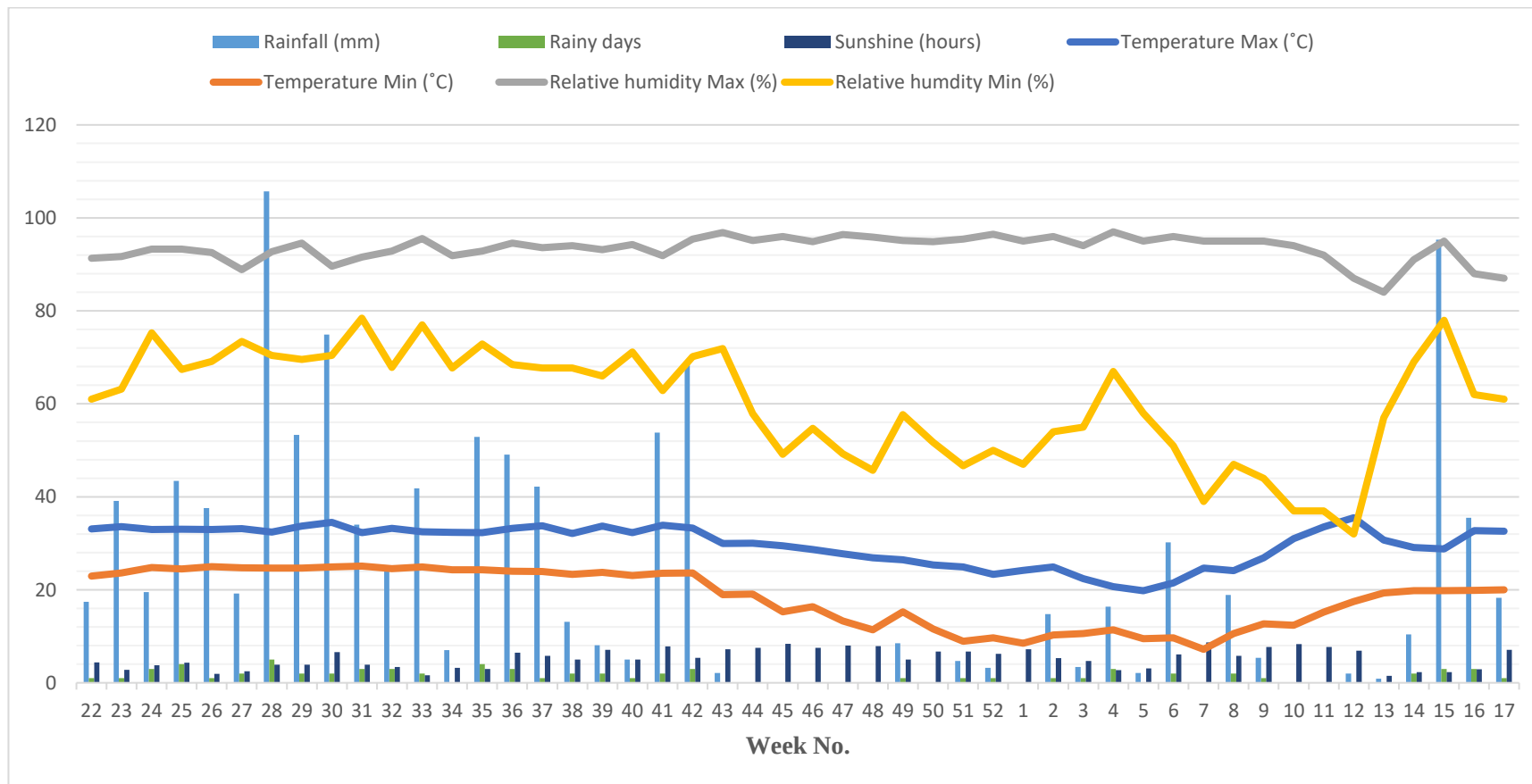


Fig 3.1 (a): Weekly meteorological data during the cropping season (2021-22)

Table 3.1(b) Weekly meteorological data recorded during the cropping season (2022-23)

Week No.	Temperature		Relative humidity		Rainfall (mm)	Rainy days	Sunshine hours
	Max (°C)	Min (°C)	Max (%)	Min (%)			
22	33.3	23.3	93	65	22.5	2	4.8
23	33.0	24.0	94	74	51.1	4	2.9
24	30.3	23.3	95	74	46.7	4	1.3
25	31.2	23.4	95	75	34.8	3	1.8
26	33.3	24.9	93	68	9.9	2	4.5
27	34.2	24.7	91	66	77.1	3	7.2
28	34.1	24.5	90	69	22.9	3	6.9
29	33.9	24.5	92	75	135.3	4	3.4
30	31.8	23.2	96	70	135.3	5	3.6
31	33.6	23.9	93	68	48.8	2	3.1
32	33.3	23.9	96	71	114.7	5	5.1
33	33.6	24.2	91	72	27.5	2	6.1
34	34.1	24.5	94	68	64.2	1	4.1
35	32.7	24.3	93	68	9.0	1	4.6
36	33.4	24.4	89	67	21.7	2	4.9
37	31.9	23.5	91	72	42.8	3	4.1
38	33.5	24.0	91	65	15.3	2	5.6
39	32.8	23.2	91	70	81.2	2	6.3
40	31.9	23.5	95	74	31.0	3	4.4
41	31.8	22.7	91	71	2.9	1	5.0
42	30.9	20.6	94	65	19.7	3	5.9
43	28.1	19.9	95	71	41.0	2	4.7
44	29.8	17.1	96	60	0.0	0	8.0
45	29.3	16.7	96	57	0.0	0	8.2
46	27.9	14.6	98	56	0.0	0	8.2
47	27.7	12.8	96	52	0.0	0	8.0
48	27.8	14.3	96	67	0.0	0	7.4
49	27.6	12.0	95	49	0.0	0	8.0
50	26.4	11.3	96	50	0.0	0	7.0
51	25.7	11.0	96	51	0.2	0	6.4
52	22.7	11.2	97	60	15.2	1	3.9
1	23.2	9.2	97	50	0.0	0	6.9
2	25.4	8.8	96	55	0.0	0	6.9
3	22.8	7.0	94	45	0.0	0	5.7
4	24.9	6.9	93	45	0.0	0	6.0
5	27.0	10.4	93	46	0.0	0	6.2
6	25.6	10.2	94	53	0.0	0	3.7
7	26.9	11.0	91	43	0.0	0	5.3
8	29.0	15.1	93	51	0.0	0	3.4
9	29.1	11.2	89	39	0.0	0	7.0
10	31.4	13.5	91	38	0.0	0	6.1
11	30.0	15.1	92	53	20.8	1	4.7
12	25.5	16.0	96	65	37.0	3	3.4
13	29.7	16.4	90	54	18.2	2	3.8
14	29.1	16.2	91	51	19.3	3	6.8
15	34.7	16.2	82	37	0.0	0	8.0
16	35.1	19.7	89	50	27.7	1	5.5
17	31.7	18.3	86	59	20.2	2	6.1

Source: ICAR Research Centre for NEH Region, Nagaland Centre, Medziphema

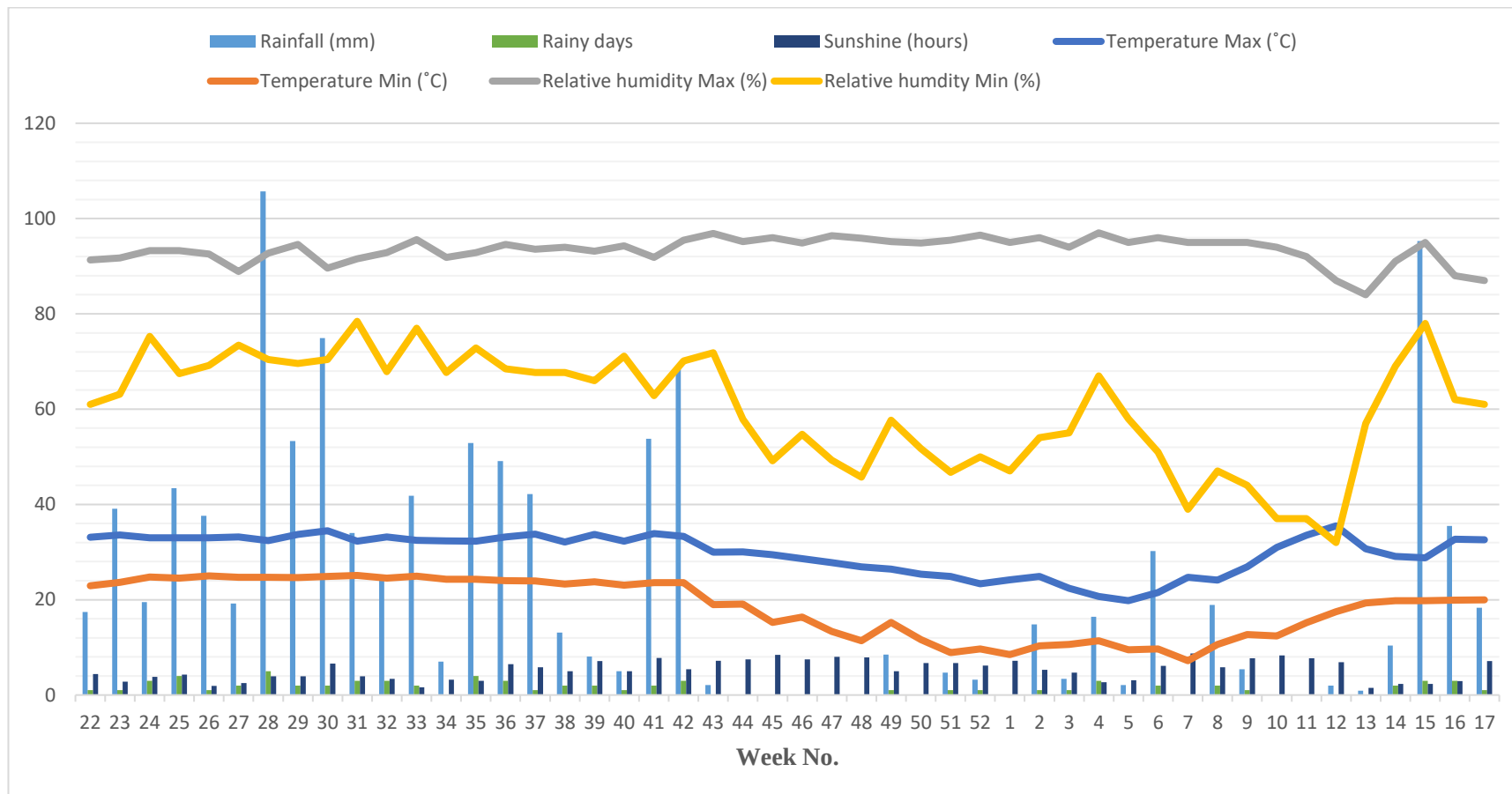


Fig 3.1 (b): Weekly meteorological data during the cropping season (2022-23)

minimum average temperature (14.99°C) was in December during the first experimentation year (2021). In 2022, the highest average maximum temperature was recorded in the month of September (33.47°C), and the lowest monthly mean minimum temperature (14.70°C) was observed in December. The maximum monthly average temperature ranged between 28.30°C - 33.47°C and the minimum monthly average temperature ranged between 14.70°C - 22.05°C during the study period.

3.1.2.3 Relative Humidity

Regarding relative humidity (RH), it was found that during the first year of 2021, the highest monthly relative humidity was recorded in November (96.86%), while the lowest monthly mean minimum relative humidity was in December (45.71%). However, during the second year, the highest monthly mean maximum relative humidity was in December (98%), and the lowest monthly mean minimum relative humidity was in December (52%).

3.1.2.4 Sunshine duration (hrs)

The range of minimum and maximum mean weekly bright sunshine hours ranged from 1.5 to 8.7 hours with an average of 5.19 hours during 2021 and it ranged from 1.3 to 8.2 hours with an average of 5.19 hours during 2022.

3.1.3 Previous cropping history of the experimental field:

The crops grown in the experiment field were as follows:

Table 3.2 Previous cropping history of the experimental field

<i>Year</i>	<i>Crops grown</i>	
	<i>Kharif</i>	<i>Rabi</i>
2017-2018	Fallow	Fallow
2018-2019	Soybean	Fallow
2019-2020	Soybean	Fallow
2020-2021	Fallow	Fallow

3.1.4 Soil condition

The soil of the experimental plot was categorized as sandy loam and well-drained. The fertility status of the soil was ascertained by collecting soil samples randomly from a depth of 0-15 cm by soil auger before and after the harvest of the

crop. The samples were then mixed, air dried, grinded and sieved for analysis following standard procedures as mentioned in Table 3.3.

Table 3.3 Initial soil fertility status of the experimental field

Characteristics	Method followed	2021		2022	
		Content	Inter-ference	Content	Inter-ference
pH	Digital pH meter (Jackson, 1973)	4.74	Strongly acidic	4.80	Strongly acidic
Electrical conductivity (EC)	Solubridge methods (Jackson, 1973)	0.26	Normal	0.28	Normal
Organic carbon (%)	Titrimetric determination (Walkley & Black, 1934)	1.51	High	1.53	High
Available Nitrogen (kg ha ⁻¹)	Alkaline potassium permanganate method (Subbiah and Asija, 1956)	416.24	Medium	410.12	Medium
Available Phosphorus (kg ha ⁻¹)	Bray's No. 1 method (Bray and Kurtz, 1945)	18.60	Medium	20.34	Medium
Available Potassium (kg ha ⁻¹)	Neutral normal ammonium acetate method (Hanway and Heidal, 1952)	218.70	Medium	211.25	Medium

3.2 Experimental Details

3.2.1 Design and Layout

The field experiments were conducted for two consecutive years, during *kharif* 2021 and 2022, at the Agronomy farm of SAS, Nagaland University, Medziphema, Nagaland. The experiment was conducted in a split-plot design with three replications, three main treatments and seven sub-plot treatments. Without disturbing the plot; the same layout was used for raising the subsequent residual crops. Details of the experiment are as follows:

1	Experimental design	Split Plot Design (SPD)
2	Crop	Soybean
3	Variety	JS 97-52
4	Replication	3
5	Treatment	21
6	Total no. of plot	63
7	Plot size	Gross plot: 3m X 4 m = 12 m ² Net plot: 2.6 m X 3.4 m = 8.84 m ²
8	Distances between replication	1 m
9	Distances between plot	0.5 m
10	Total experimental area	992 m ²

11	Spacing	30 cm x 10 cm
12	Recommended seed rate	70 kg ha ⁻¹
13	Sequential crop	French bean (local var.)
14	Recommended doses of fertilizer	20-60-50 kg NPK ha ⁻¹
15	FYM	10 t ha ⁻¹

3.2.2 Treatment details

Three different sowing dates and seven integrated weed management were allocated in the main and sub-plot, respectively. The classified description of the treatments and their corresponding symbols are shown below:

Treatments	Symbol
A. Main plot treatments	
Dates of sowing	
(i) 15 th June	(P ₁)
(ii) 30 th June	(P ₂)
(iii) 15 th July	(P ₃)
B. Sub-plot treatments	
Integrated weed management	
1. Soil Solarization with black polythene (25 days before sowing) <i>fb</i> Hand weeding at 30 DAS.	(W ₁)
2. Mulching with paddy straw 5 t ha ⁻¹ <i>fb</i> Hands weeding at 30 DAS.	(W ₂)
3. Pendimethalin 30 EC @ 1 kg ha ⁻¹ (pre-emergence) <i>fb</i> Imazethapyr 10 SL @ 100 g ha ⁻¹ at 20 DAS (Post emergence)	(W ₃)
4. Pendimethalin 30 EC @ 1 kg ha ⁻¹ <i>fb</i> Intercultural at 30 DAS	(W ₄)
5. Imazethapyr 10 SL@100 g ha ⁻¹ (20DAS) <i>fb</i> Intercultural at 30 DAS	(W ₅)
6. Hand weeding at 20 and 40 DAS	(W ₆)
7. Weedy check (Control)	(W ₇)
<i>fb</i> * - followed by	

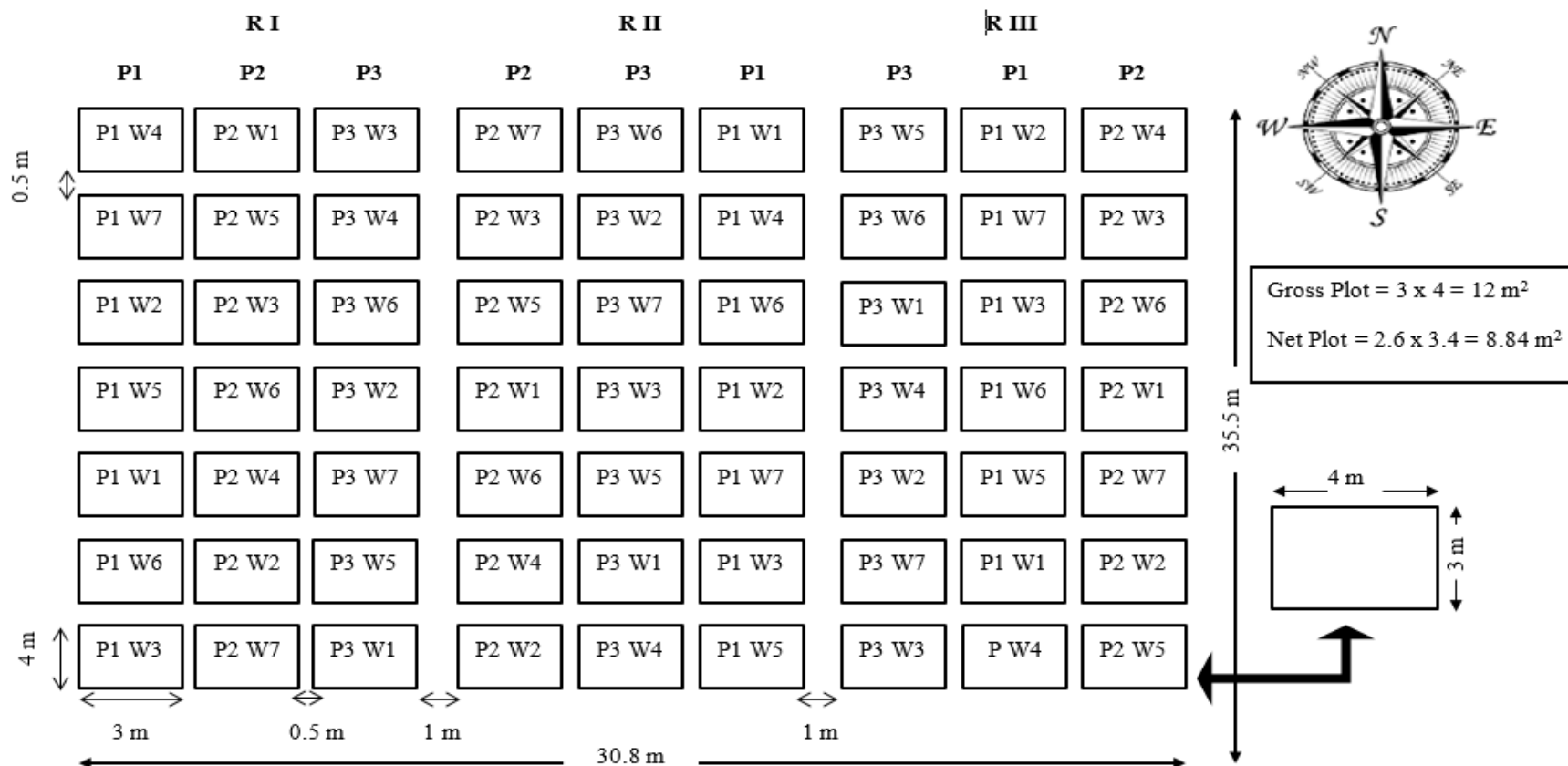


Fig: 3.2: Layout of the experimental field in split plot design

3.2.3 Treatment combination

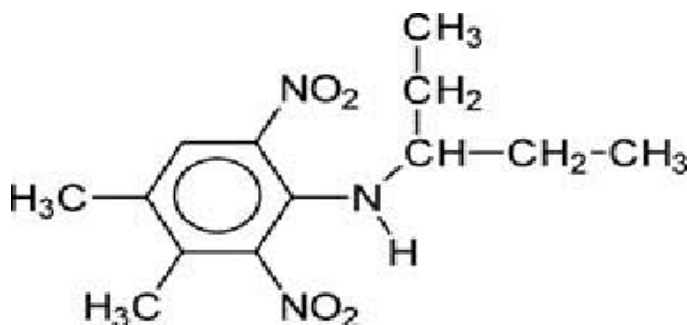
There was a total of 21 treatment combinations as obtained from the multiplication of three main factors and seven sub factors.

P ₁ W ₁	P ₂ W ₁	P ₃ W ₁
P ₁ W ₂	P ₂ W ₂	P ₃ W ₂
P ₁ W ₃	P ₂ W ₃	P ₃ W ₃
P ₁ W ₄	P ₂ W ₄	P ₃ W ₄
P ₁ W ₅	P ₂ W ₅	P ₃ W ₅
P ₁ W ₆	P ₂ W ₆	P ₃ W ₆
P ₁ W ₇	P ₂ W ₇	P ₃ W ₇

3.2.4 Herbicides used

a. Pendimethalin

Common name:	Pendimethalin
Trade name:	Stomp
Chemical formula:	N-(1-ethylpropyl) -3, 4-dimethyl-2, 6-dinitrobenzenamine
Empirical formula:	C ₁₃ H ₁₉ N ₃ O ₄
Formulation:	Emulsifiable concentration (EC)
Chemical group:	Dinitroanilines
Active ingredient:	30 % EC
Molecular weight:	281.31 g mol ⁻¹
Melting point:	47-58°C
Recommended dose:	1 kg a.i. ha ⁻¹
Application time:	Pre or Early post Emergence
Chemical structure:	



Type of weed control: Annual grass and broad-leaf weeds

Selectivity: Selective

Mode of action: Pendimethalin acts as both as pre-emergence and early post emergence. Pendimethalin controls weed by inhibiting microtubule formation in cells. This causes interruption of cell division and elongation in susceptible species of weeds. It controlled a wide range of grasses and small seeded broad leaves weeds from emerging, during the crucial development phase of the crop.

b. Imazethapyr

Common name: Imazethapyr

Trade name: Pursuit

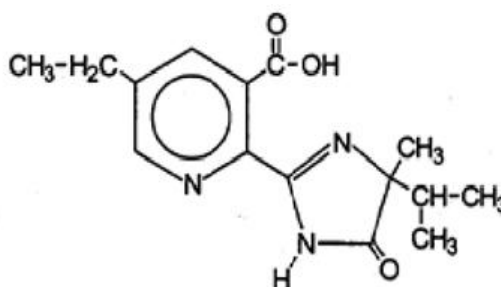
Chemical formula: 5-ethyl-2 [(RS)-4-methyl-5-oxo-2 imidazolin-2-yl] nicotine acid

Empirical formula: $C_{15}H_{19}N_3O_3$

Main boost: Ammonium Sulphate

Chemical group: Imidazolinones

Chemical structure:



Molecular weight: 289.3

Melting point: 169-173⁰C

Active ingredient: 10 % SL

Recommended dose: 100 g a.i. ha⁻¹

Application time: Pre-plant, pre-emergence, post-emergence

Type of weed control: broad leaf weeds, annual grasses

Selectivity: Selective

Mode of action: It is absorbed by foliage and translocated through the xylem and phloem and accumulates in the meristematic regions. So, it controls the entire weed plant, including the root rhizome. It inhibits acetolactate synthase (ALS), also called acetohydroxy acid iso leucine, leucine, and valine. It will not harm the

succeeding crops because it has short soil persistence. It controls both emerged and multiple flushes of shallow germinating weeds.

3.2.5 Selection of Variety

Soybean: The variety JS 97-52 was developed in 2008 at Jawaharlal Nehru Krishi Vishwa Vidyalaya at Jabalpur by the selection of a cross between PK 327 and LI 29. It is a high-yielding cultivar, with 3-4 seeds per pod. The plants grow to 60-80 cm tall and have tawny pubescence on the stems. The variety's growth habits are semi-determinate. Flowers are white, begin 45 days after seeding, and last approximately 75 days. The variety will mature in 98-102 days. The seeds are greenish-golden in colour and glossy with a blackish hilum. The seed size is medium, with 100 seeds weighing roughly 10-12 g. The cultivar is resistant to multiple diseases and pest as well as abiotic stresses. The variety's yield potential ranges between 2.5 and 3.0 q ha⁻¹.

French bean: The local variety was collected from Chumukedima district, Nagaland. It is a long duration landrace which usually take 120-130 Days to mature. It is short and bushy cultivar with white colour flower and seed in brown colour. It is a large seeded variety with approximate yield of 4.7- 5 q ha⁻¹.

3.3 Cultivation Details

The calendar of cultural operations carried out during the course of experimentation is given in Table 3.4

3.3.1 Field preparation

Primary tillage was done with the help of tractor drawn mould board plough during the first week of May. Secondary tillage followed by harrowing was done with the help of a power tiller depending on the sowing dates.

Field preparation was started by the first week of May with the onset of monsoon. All the stubbles were removed and then the field was laid out according to the plan and design of the experimental field. Plots were laid out with beds and channels at the onset of monsoon during *kharif* 2021 and 2022.

3.3.2 Solarization

As per the experimental details, the required plots were solarized with black polythene sheet (0.05 mm) for 25 days before sowing of crop, based on the date of

sowing.

Table 3.4 Details of field operation carried out during the period of experimentation

Sl. No.	Field operations	Date	
		2021	2022
1	Ploughing	10-05-2021	11-05-2022
2	Harrowing and levelling	14-05-2021	15-05-2022
3	Layout of the experiment	17-05-2021	17-05-2022
4	Soil solarization P ₁ P ₂ P ₃	20-05-2021 04-06-2021 19-06-2021	20-05-2022 04-06-2022 19-06-2022
5	Application of fertilizers and seed treatment and sowing P ₁ P ₂ P ₃	15-06-2021 30-06-2021 15-07-2021	15-06-2022 30-06-2022 15-07-2022
6	Mulching and Application of Pendimethalin P ₁ P ₂ P ₃	16-06-2021 01-07-2021 16-07-2021	16-06-2022 01-07-2022 16-07-2022
7	Application of Imazethapyr P ₁ P ₂ P ₃	05-07-2021 21-07-2021 05-08-2021	05-07-2022 21-07-2022 05-08-2022
8	Hand weeding @20DAS P ₁ P ₂ P ₃	05-07-2021 21-07-2021 05-08-2021	05-07-2022 21-07-2022 05-08-2022
9	Hand weeding @40 DAS P ₁ P ₂ P ₃	25-08-2021 10-09-2021 25-09-2021	25-08-2022 10-09-2022 25-09-2022
10	Harvesting P ₁ P ₂ P ₃	11-10-2021 22-10-2021 04-11-2021	11-10-2022 22-10-2022 04-11-2022
11	Threshing and winnowing of soybean	10-11-2021	10-11-2022
12	Sowing of French bean P ₁ P ₂ P ₃	18-10-2021 25-10-2021 08-11-2021	18-10-2022 25-10-2022 08-11-2022
13	Harvesting of French bean P ₁ P ₂	21-01-2022 27-01-2022	21-01-2023 27-01-2023

	P ₃	09-02-2022	9-02-2023
14	Threshing and winnowing of French bean	15-02-2023	17-02-2023

3.3.3 Manures and Fertilizers Application

Well decomposed Farmyard manure @ 10 t ha⁻¹ was broadcasted uniformly over the field and thoroughly incorporated during the final field preparation. The recommended dose of NPK at 20-60-50 kg ha⁻¹ were applied in the form of urea, single super phosphate, and muriate of potash, uniformly to each plot at the time of sowing during both the years. For french beans, the crop was raised exclusively on residual resources of the soybean crop.

3.3.4 Seed rate, treatment and sowing:

The crop was sown manually on an open furrow in lines by dibbling two seeds per hill at a depth of 3-5 cm with a spacing of 30 cm row to row and 10 cm plant to plant spacing with a seed rate of 70 kg ha⁻¹ for all the different sowing dates as per the treatment i.e., 15th June, 30th June and 15th July of 2021 and 2022. The seeds were treated with bavistin @ 2 g kg⁻¹ of seeds followed by inoculation with *Rhizobium japonicum* of soybean @ 5 g kg⁻¹ seeds before sowing to prevent the crop from soil and seed borne diseases. French bean was sown right after the harvesting of soybean

3.3.5 Weeding operations

As per the treatment, pendimethalin (30% EC) @ 1 kg ha⁻¹ at two days after sowing and imazethapyr (10% SL) @ 100 g a.i ha⁻¹ at twenty days after sowing were applied in respective plots with the help of knapsack sprayer fitted with flat fan nozzle. Mulching was done with paddy straw @ 5 t ha⁻¹ in a row at 5 cm thickness one day after sowing. Hand weeding was done manually as per the treatments at 20 and 40 days after sowing. The operations were carried out as per treatment on the required plots on the specified dates and have been depicted in table 3.4.

3.3.6 Gap filling and thinning

Gap filling was done at 7 DAS to maintain the population of the plants. Similarly, thinning was carried out at 15 DAS manually to maintain the optimum population of the plants in all the experimental plots.

3.3.7 Insect pests and disease management

Chlorpyrifos spray was applied on the surface of the plant at 40 and 60 DAS to control the sucking insect pest.

3.3.8 Harvesting and threshing

The soybean crop was harvested manually by sickle when pods were fully matured. The five tagged plants were harvested separately from the net experimental plots to record the post-harvest observations. The harvest materials of each plot were tied in bundles and kept for drying for 2 days and then weighed to record biological yield per plot. Threshing was done by manual labour separately with wooden sticks, followed by winnowing, and yield was recorded for each plot and represented in kg ha⁻¹.

French bean was harvested when most pods had fully matured for different sowing dates. In the same way, the five tagged plants were harvested separately from the net experimental plots to record the post-harvest observations. Thereafter, the harvested plant was allowed to dry for 2-3 days and then threshed to separate the seed from the pods and treatment wise the seed yield was recorded.

3.3.9 HERBICIDE RESIDUE TEST (bioassay test)

Bioassay is a simple, versatile, handy, easy and highly sensitive technique for determining residues of a wide range of toxicants. It is a major tool for quantitative and qualitative determination of herbicide residues. The property of chemical is measured in term of some biological responses through (i) plant part response and (ii) total plant response (Lavy and Santelmann, 1986).

Herbicidal persistence in soils of the experimental plots was monitored at monthly interval during both the growing seasons using method of field bioassay. Composite soil sample from 0-15 cm depth were collected from each of the experimental plots at 30 days interval. A composite sample of 800g were taken in bioassay plates or petri dishes. Two bioassay plates were filled with soil collected from each experimental plot and seeds of available four crops were grown in the petri dishes. Five seeds of each two crops were sown in one bioassay plate, whereas five seeds each of other two crops were sown in second bioassay plate. These plates were placed in laboratory and watered regularly to prevent desiccation. After 8 days, the entire

seedling was uprooted; roots were washed gently to remove soil. Then root and shoot length of these seedlings was measured.

3.4 Observation on crop

3.4.1 Growth attributes

Five plants were selected randomly from each plot and tagged to record the growth attributes at different stages of crop growth (30, 60, 90 DAS, and at harvest). However, for dry matter weight of the plant, five plants were randomly selected from the sampling rows at different growth stages.

3.4.1.1 Plant Population (French bean)

The plant population of crop plants was recorded at 30 DAS and just before harvest, from one-meter row length in 4 rows randomly in each plot and then averaged out. After this, the plant population per square meter was determined for each plot.

3.4.1.2 Plant height (cm)

Plant height from the five tagged plants from the middle rows was recorded at 30, 60 days after sowing (DAS) and at harvest. Plant height was measured by linear scale from the base of the stem to the terminal apex. The mean height from the selected plants was taken as the score for each plot.

For the french bean, the plant height was measured in cm from the ground level to the top of the plant at 30 and 60 DAS; the average plant height was calculated for each of the treatments.

3.4.1.3 Number of branches plant⁻¹

The number of branches per plant of five (5) tagged plants was counted at 30, 60, and 90 days after sowing (DAS) and at harvest. The values were averaged for each plot.

3.4.1.4 Dry matter accumulation plant⁻¹ (g)

The randomly five (5) plants from each plot were carefully uprooted. The uprooted samples were kept separately in paper bags after removing the root portion; the samples were sun-dried and oven-dried at 60⁰ C for 48 hours. After 48 hours, each

sample attains a constant dry weight. Each sample was weighed, and dry matter accumulation was recorded at 30, 60 DAS, and at the harvest stage.

For the french bean, the plant's dry weight was taken at 60 DAS, and then the sample plants were sun-dried and later dried in a hot air oven for about 48 hours at 60⁰ C, each sample was weighed and dry matter accumulation was recorded.

3.4.1.5 Leaf area Index (LAI)

The leaf area of leaves from five selected plants of each plot drawn for biomass observation was used to measure the leaf area with the digital leaf area meter. The LAI was worked out using the formula (Watson, 1947). The LAI of the five (5) tagged plants was taken at 30, 60, and 90 DAS.

$$\text{LAI} = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Unit ground area (cm}^2\text{)}} \times 100$$

3.4.1.6 Crop growth rate (CGR)

Crop growth rate (CGR) is the daily increment of biomass per unit ground area per unit time, which represents the rate of dry matter production, and it was worked out at 30-60 DAS and 60-90 DAS using the dry matter accumulation of plants by adopting the formula given by Watson (1947).

$$\text{CGR} = \frac{W_2 - W_1}{(t_2 - t_1) S} \text{ g m}^2 \text{ day}^{-1}$$

W_1 and W_2 are the dry weight of plants at time t_1 and t_2 , respectively. S is the land area (m^2) over which dry matter was recorded.

3.4.1.7 Relative growth rate ($\text{g g}^{-1} \text{ day}^{-1}$)

The relative growth rate was recorded at 30-60 DAS and 60-90 DAS using the dry matter accumulation of plants and calculated using the formula given by Radford (1967).

$$\text{RGR} = \frac{\ln W_2 - \ln W_1}{(t_2 - t_1)} \text{ g g}^{-1} \text{ day}^{-1}$$

Where, W_1 and W_2 are plant dry weight at time t_1 and t_2 respectively.

3.4.1.8 Net assimilation rate (g m⁻² day⁻¹)

Net assimilation rate indicate the rate of net photosynthesis and it was recorded at 30-60 and 60-90 DAS using the leaf area and dry matter production of plant and calculated by using the formula given by Watson (1947).

$$\text{NAR} = \frac{(W_2 - W_1) \times (\ln L_2 - \ln L_1)}{(t_2 - t_1) \times (L_2 - L_1)}$$

Where, L_1 and W_1 = Leaf area and dry weight of the plant, respectively
at time t_1

L_2 and W_2 = Leaf area and dry weight of the plant, respectively
at time t_2

3.4.1.9 Nodulation studies

Randomly selected five (5) plants were removed along with the soil up to the effective root zone from each plot with the help of a fork and khurpi and then dipped in water for separation of nodules from soil and washed gently with the help of a sieve to avoid washing over of nodules. Number of nodules were recorded at the most active stage at 40 DAS and 60 DAS. The nodules collected were then taken for fresh weight and later shade dry and further dried in an oven at 60°C for 48 hours for nodules dry weight by an electronic digital balance and the average dry weight of nodule plant⁻¹ was worked out and recorded.

3.4.2 Yield attributes

3.4.2.1 Number of pods plant⁻¹

The number of pods per plant was counted from the five tagged plants in each plot and the average was recorded as the numbers of pods plant⁻¹.

3.4.2.2 Pod length (cm)

The five tagged plants after harvest for each plot were measured and the average was recorded as the length of pods.

3.4.2.3 Number of seeds pod⁻¹

The number of seeds per pod was counted from five (5) tagged plants from

each plot and mean was calculated for statistical analysis.

3.4.2.4 Test weight (100 seed wt.)

A hundred seeds randomly taken from the finally cleaned produce of each plot for the recording test weight. Then, the weight of 100 seeds of each plot was recorded separately on an electrical balance.

3.4.3 Yield

3.4.3.1 Seed yield (kg ha⁻¹)

The seed yield per sq. meter area was recorded after winnowing the seed with the help of digital balance. Finally, the seed yield of each plot was converted into seed yield per hectare by multiplying it with the appropriate conversion factor.

3.4.3.2 Stover yield (kg ha⁻¹)

The stover yield per sq. meter area was determined by subtracting the seed yield (Economic yield) of each plot from the biological yield (Bundle weight) of the same plot. This was later converted into stover yield per hectare by multiplying with the same conversion factor used in the case of seed yield per hectare.

3.4.3.3 Biological yield (kg ha⁻¹)

The whole weight after sun drying, bundle of each net plot produce was measured using a digital hanging balance and converted in kg ha⁻¹.

3.4.3.4 Harvest index (%)

It is the ratio of economic yield to the biological yield. It was determined with the help of the following formula and expressed in percentage as follows:

$$\text{Harvest index} = \frac{\text{Economic yield (seed yield)}}{\text{Biological yield (seed and stover yield)}} \times 100$$

3.4.4 Quality parameters

3.4.4.1 Protein content (%)

Protein content in seeds was worked out by using the formula.

$$\text{Protein content (\%)} = \% \text{ N content} \times 6.25$$

3.4.4.2 Protein yield (kg ha⁻¹)

Protein yield of soybean crop were calculated in kg ha⁻¹ in relation to dry matter production ha⁻¹ by using the formula

$$\text{Protein yield} = \frac{\text{Protein content (\%)} \times \text{seed yield}}{100}$$

3.5 Observation of weeds

3.5.1 Weed flora

The weed flora in the experimental field was surveyed periodically and identified to assess the species composition.

3.5.2 Weed population (no.m⁻²)

The weed population were recorded at 20, 40, 60 DAS and at harvest stages of crop from an area of 0.5 m x 0.5 m = 0.25 m² (quadrant size) in net plot of each treatment and converted to per square meter (m²) basis. The present population of grasses, sedges, and broad-leaf weeds were counted category-wise from the same quadrat and subjected to square root transformation. The original values were subjected to square root transformation with the help of the formula $\sqrt{x + 0.5}$, where x is the actual weed count.

3.5.3 Weed dry weight (g m⁻²)

The weed samples present in each quadrat were uprooted and separated as grasses, sedges and broad-leaved weeds at 20, 40, 60 DAS and at harvest stages. The collected weeds were washed, sundried, and oven-dried at 70⁰ C for 48 hrs. The constant weights obtained and the original data were subjected to square root transformation $\sqrt{x + 0.5}$ and analysed statistically.

3.5.4 Weed control efficiency (%)

Weed control efficiency (WCE) was calculated at 20, 40, 60 and at harvest stages by using the formula,

$$\text{WCE (\%)} = \frac{\text{DWC-DWT}}{\text{DWC}} \times 100$$

Where,

DMC = Dry weight of weeds per unit area in control plots

DWT = Dry weight of weeds in treated plots to be compared

3.5.5 Weed index

The weed index is the reduction in yield due to weed infestation and it is calculated using the formula,

$$WI = \frac{\text{Yield of weed free plot} - \text{Yield of treated plot}}{\text{Yield of weed free plot}} \times 100$$

3.6 Chemical analysis of soil samples

3.6.1 Soil analysis

After the harvest of the crop, the soil samples were collected treatment-wise from the experimental field to determine the nutrient status of the soil. The samples were analysed for pH, electrical conductivity, organic carbon, available nitrogen, available phosphorus and available potassium.

3.6.1.1 Soil pH

Soil pH was determined in the soil: water (1:2) ratio by a digital pH meter (Jackson, 1973).

3.6.1.2 Soil Electrical conductivity (EC)

Soil EC was determined by solubridge methods (Jackson, 1973).

3.6.1.3 Organic carbon

Organic carbon was determined by rapid titrimetric determination (Walkley and Black, 1934), and the results were expressed in percentages.

3.6.1.4 Available Nitrogen (kg ha⁻¹)

The soil's available nitrogen was determined by alkaline potassium permanganate (KMnO₄) method proposed by Subbiah and Asija (1956) with the help of 'Kel Plus' nitrogen distillation machine. The data was calculated in terms of kg ha⁻¹.

3.6.1.5 Available Phosphorus (kg ha⁻¹)

The available soil phosphorus was determined by Bray's No. 1 method proposed by Bray and Kurtz (1945) using 0.03 N NH₄F + 0.025 N HCL (pH 3.5) as an extracting solution. In the filtered extract, phosphorus was estimated using spectrophotometers by adding ammonium molybdate and stannous chloride. The intensity (% transmittance) of characteristics of blue colour in the solution gives the measure for the concentration of P in the test solution, which was read in the spectrometer at 660 nm wavelength. After getting the % transmittance of the P in the test solution, the concentration of P was read from the standard curve. The results were expressed in kg ha⁻¹. This method is primarily meant for soils with moderate to strong acids with a pH of around 5.5 or less.

3.6.1.6 Available Potassium (kg ha⁻¹)

Available Potassium was extracted from 5 g of soil by shaking with 25 ml of neutral ammonium acetate (pH 7.0) solution for 5 minutes. The extract was filtered immediately through a dry filter paper (Whatman No.1) and then potassium concentration in the extract was determined using neutral normal ammonium acetate methods (Hanway and Heidal, 1952). It was expressed in terms of kg ha⁻¹.

3.6.2 Plant analysis

3.6.2.1 N, P, and K depletion by Weeds

Weed samples were drawn from each plot at 60 DAS of the crop for determination of N, P, and K content in weed plants. Collected samples were dried and grinded thoroughly and analyzed as per standard procedure of modified Kjeldahl method for N (Jackson, 1973), Vanado-molybdo-phosphoric yellow colour method (Jackson, 1973) for P and flame photometric method for K as suggested by Jackson, (1973).

$$\text{Nutrient depletion (kg ha}^{-1}\text{)} = \frac{\text{Nutrient (\%)} \text{ in weeds} \times \text{weed dry matter of weed (kg ha}^{-1}\text{)}}{100}$$

3.6.2.2 N, P and K content and uptake in seed and straw

Randomly selected plant samples were collected treatment wise for chemical estimation. Straw and seed were separated, air-dried and finally oven dried at a

temperature of 65 to 70°C and grinded. Seed and straw samples were analyzed for nitrogen by modified Kjeldahl's method (Jackson, 1973), phosphorus by di-acid digestion and yellow colour development method (Jackson, 1973) and potassium by flame photometric method (Jackson, 1973).

The uptake was further calculated by using the formula

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\% in seed or straw x seed or straw yield (kg ha}^{-1}\text{))}}{100}$$

3.7 Economic analysis

The economic analysis of the treatments is very important to assess the practical utility of treatments for farmers' point of view. Therefore, economics of different treatments were worked out in terms of cost of cultivation, gross monetary returns (GMR), net monetary returns (NMR) and benefit-cost ratio (B:C) on per hectare area basis to ascertain the economic viability of the treatments. The details for determination of economics are given in Appendix for reference.

3.7.1 Cost of cultivation (₹ ha⁻¹)

The common cost of cultivation and variable cost for each treatment was worked out on the basis of different inputs used for raising the crop under different treatments on one hectare area basis in order to get total cost of cultivation.

3.7.2 Gross monetary return (₹ ha⁻¹)

The values realized from the produce obtained under each treatment was computed on the basis of existing market price of the produce (both seed and stover) as the gross monetary returns (GMR) per hectare under different treatments.

Gross monetary returns = Value of seed + Value of stover

3.7.3 Net monetary returns (₹ ha⁻¹)

The net monetary returns (NMR) per hectare under each treatment were determined by subtracting the cost of cultivation of a particular treatment from the gross monetary return of the same treatment.

Net monetary returns = Gross monetary returns - Total cost of cultivation

3.7.4 Benefit-cost ratio (B: C)

To estimate the benefits obtained under different treatments for each rupee of expenditure incurred, B: C ratio of each treatment was calculated as below: -

$$\text{B: C ratio} = \frac{\text{Net returns}}{\text{Cost of cultivation}} \times 100$$

3.8 Statistical analysis

Data obtained from various studies was processed, classified, tabulated systematically and statistically analyzed in split plot design using the technique of Analysis of variance as described by Gomez and Gomez (1984). The significance differences were tested by 'F' test. Critical difference of different groups of treatments and their interactions at 5% probability level were calculated whenever 'F' test was significance.

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

This chapter outlines the findings of the field experiment titled “Effect of sowing date and integrated weed management in soybean (*Glycine max* L.) and their residual effect on succeeding french bean (*Phaseolus vulgaris*),” conducted over two consecutive years (*kharif*, of 2021 and 2022). The research data were subjected to statistical analysis, and following the evaluation of significance tests, the results are presented through appropriate tables, graphs, figures and photographs.

4.1 Soybean

4.1.1 Growth attributes

4.1.1.1 Plant height (cm)

The data on plant height of soybean recorded at 30, 60 DAS, and at harvest during the *kharif* season of 2021 and 2022 are presented in Table 4.1 (a) and Table 4.1 (b). It was noticed that plant height increased rapidly up to 60 DAS and further slowed down at a later stage owing to the attainment of the reproductive stage. This may result from the translocation of photosynthates towards the development of flower, pods and seeds.

4.1.1.1.1 Effect of sowing dates on plant height of soybean

The sowing dates significantly influenced the plant height of soybean at all the different growth stages [Table 4.1 (a)]. Being photosensitive, early sowing on 15th June recorded the highest pooled value of plant height significantly at 30 DAS (31.75 cm), 60 DAS (61.35 cm) and harvest (59.54 cm). This was followed by sowing on 30th June. Conversely, the shortest plant height was recorded on 15th July at 30 DAS (23.62 cm), 60 DAS (50.90 cm) and harvest (48.92 cm) in both years.

This might be because early sowing allows soybean plants to have favourable climatic conditions and temperature and comparatively enjoy more extended growth periods, which enables the plant to improve its growth and development to its full potential. The results conform with those of Ram *et al.* (2010), Yagoub and Hamed (2013), Sumalatha and Uppar (2019), Dandge *et al.* (2020). In addition, the reduction

in plant height with delay in planting might be due to quick changes in photoperiod, which accelerated development towards reproductive stages. Hence, less time was available for vegetative growth. Similar observation were reported by Kumagai and Takahashi (2020).

4.1.1.1.2 Effect of integrated weed management on plant height of soybean

It was also found that integrated weed management treatments significantly influenced the plant height at different stages of soybean in the years of investigation and their pooled value [Table 4.1 (a)], in comparison to the weedy check (W₇).

At 30 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) led to a significantly higher plant height (31.69, 33.34 cm) in both years. This treatment was statistically at par with treatment W₄ (Pendimethalin 30 EC @ 1 kg a.i. ha⁻¹ fb interculture at 30 DAS) and was significantly higher than the other treatments. Similar results were also obtained by Samudre *et al.* (2019) and Pawar *et al.* (2022).

At 60 DAS (61.60, 63.54 cm) and harvest (59.76, 62.66 cm), treatment W₆ (hand weeding at 20 and 40 DAS) recorded significantly higher plant height. This treatment was statistically at par with treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both years. At the same time, the least plant height was observed in weedy check (W₇) in both years. It conforms to the findings of Jadon *et al.* (2019) and Chouhan and Verma (2023).

The significant increase in plant height in W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) and W₆ (hand weeding at 20 and 40 DAS) may be attributed to the effective control of weeds at critical stages of crop weed management, which resulted in increased availability of growth-promoting conditions, viz. sufficient space, light, moisture, nutrients, and accumulation of photosynthates owing to higher plant height and plant spread of soybean crop. Nagre *et al.* (2017) also reported similar findings. The decrease in crop plant height in weedy check might be due to crop weed competition as the weeds were not controlled which leads to cell division or enlargement inhibition (Akter *et al.* 2016).

Table 4.1(a) Effect of sowing dates and integrated weed management treatments on plant height (cm) of soybean

Treatments	Plant height (cm)								
	30 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)									
P₁ 15th June	30.50	33.00	31.75	59.94	62.77	61.35	58.04	61.05	59.54
P₂ 30th June	27.66	29.61	28.63	55.29	57.47	56.38	53.69	55.97	54.83
P₃ 15th July	22.46	24.79	23.62	49.91	51.88	50.90	47.43	50.41	48.92
SEm±	0.68	0.63	0.46	0.86	0.81	0.59	0.83	0.85	0.59
CD at 5%	2.66	2.49	1.51	3.37	3.17	1.92	3.27	3.32	1.94
Integrated weed Management (W)									
W₁	25.47	28.38	26.93	55.62	58.20	56.91	52.49	55.83	54.16
W₂	25.10	27.47	26.28	53.59	56.57	55.08	51.70	54.21	52.96
W₃	31.69	33.34	32.51	59.42	61.68	60.55	57.91	61.05	59.48
W₄	30.66	32.91	31.78	57.33	58.94	58.13	55.20	57.33	56.27
W₅	27.42	29.57	28.50	57.71	59.91	58.81	55.43	58.56	56.99
W₆	29.75	31.75	30.75	61.60	63.54	62.57	59.76	62.66	61.21
W₇	18.00	20.51	19.26	40.06	42.80	41.43	38.87	41.02	39.95
SEm±	0.91	1.11	0.72	1.35	1.43	0.98	1.29	1.53	1.00
CD at 5%	2.61	3.18	2.02	3.88	4.09	2.77	3.71	4.38	2.82

Table 4.1(b) Interaction effect of sowing dates and integrated weed management treatments on plant height (cm) of soybean

Treatments	Plant height (cm)								
	30 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	28.61	32.68	30.65	59.84	64.52	62.18	57.02	61.51	59.26
P₁W₂	28.40	32.22	30.31	57.65	62.31	59.98	56.91	60.29	58.60
P₁W₃	35.16	36.62	35.89	65.17	66.34	65.75	62.98	65.45	64.21
P₁W₄	34.18	36.48	35.33	62.70	64.61	63.65	61.11	63.42	62.26
P₁W₅	31.21	32.70	31.96	63.22	65.84	64.53	61.51	64.14	62.82
P₁W₆	33.56	34.62	34.09	66.52	68.19	67.35	64.52	67.22	65.87
P₁W₇	22.41	25.64	24.03	44.45	47.60	46.02	42.22	45.32	43.77
P₂W₁	26.17	28.83	27.50	55.92	58.49	57.20	53.95	55.58	54.77
P₂W₂	26.14	27.94	27.04	53.89	55.44	54.67	51.74	53.51	52.62
P₂W₃	31.91	33.55	32.73	60.35	62.40	61.37	58.77	61.93	60.35
P₂W₄	30.56	32.49	31.53	57.24	59.12	58.18	55.91	57.91	56.91
P₂W₅	28.57	29.88	29.22	57.70	60.74	59.22	56.12	59.58	57.85
P₂W₆	30.48	32.32	31.40	62.44	63.60	63.02	60.72	62.81	61.77
P₂W₇	19.77	22.25	21.01	39.50	42.53	41.02	38.64	40.50	39.57
P₃W₁	21.64	23.63	22.64	51.11	51.58	51.35	46.49	50.42	48.45
P₃W₂	20.77	22.24	21.50	49.24	51.95	50.60	46.45	48.84	47.65
P₃W₃	28.00	29.85	28.93	52.73	56.29	54.51	51.99	55.78	53.89
P₃W₄	27.25	29.75	28.50	52.04	53.08	52.56	48.59	50.67	49.63
P₃W₅	22.49	26.13	24.31	52.19	53.14	52.67	48.66	51.94	50.30
P₃W₆	25.22	28.30	26.76	55.84	58.82	57.33	54.04	57.95	55.99
P₃W₇	11.83	13.63	12.73	36.23	38.27	37.25	35.76	37.25	36.50
SEm± (PxW)	1.58	1.92	1.24	2.34	2.47	1.70	2.24	2.64	1.73
SEm± (WxP)	1.33	1.37	0.95	1.78	1.74	1.24	1.72	1.84	1.26
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

4.1.1.1.3 Interaction effect of sowing dates and integrated weed management on plant height

The findings detailed in Table 4.1(b) indicate that the interaction effect of sowing dates and integrated weed management on plant height did not significantly affect plant height at all growth stages in both years.

4.1.1.2 Number of primary branches plant⁻¹

The branch's production of soybean continued up to physiological maturity. Data on a number of primary branches plant⁻¹ recorded at 30, 60, and 90 DAS and harvest are presented in Table 4.2 (a) and Table 4.2 (b).

4.1.1.2.1 Effect of sowing dates on number of primary branches plant⁻¹ of soybean

The data on a number of primary branches plant⁻¹ showed a significant effect due to the different sowing dates at successive stages, i.e., 30, 60, 90 DAS and at harvest. At 30 DAS, the highest number of primary branches plant⁻¹ was recorded with early sowing on 15th June (2.10, 2.26), which was statistically at par with the sowing date of 30th June during the first year. Conversely, the lowest value was recorded on 15th July (1.73, 1.82) in both years.

At 60 DAS, the maximum number of primary branches plant⁻¹ was recorded on 15th June (4.00, 4.12) across both years and pooled value, which was statistically at par with the sowing date of 30th June during both years. The lowest value was recorded on 15th July (3.02, 3.21) in both years.

The pooled values at 90 DAS (3.95) and harvest (3.86), the highest number of primary branches plant⁻¹ was recorded on 15th June, followed by sowing on 30th June, while significantly lowest values were observed under late sowing on 15th July.

This significant variation in the number of primary branches plant⁻¹ among sowing dates can probably be due to timely sowing and a fairly longer growth period, which influences adequate nutrient uptake during early growth stages and supports vigorous vegetative growth linearly and lateral stretch, flowering and pod formation, ultimately contributing to higher yields. While in late sowing, the exposure to the same growth ambiance for a longer period was subdued, resulting in lower branches. These finding align with the findings of Raghuwanshi *et al.* (2018) and El-Toum *et al.* (2020).

4.1.1.2.2 Effect of integrated weed management on the number of primary branches plant⁻¹ of soybean

The impact of various weed management strategies on the number of primary branches of plant⁻¹ is evident at all the stages of observation. At 30 DAS, treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) recorded significantly highest number of primary branches plant⁻¹ (2.39, 2.66), which was statistically at par with W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS) during the first year. A similar result in a higher number of primary branches plant⁻¹ with the application of pendimethalin and imazethapyr was reported by Samudre *et al.* (2019) and Pawar *et al.* (2022).

However, at 60, 90 DAS, and at harvest, treatment W₆ (hand weeding at 20 and 40 DAS) exhibited the highest number of primary branches plant⁻¹. This result was statistically at par with W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). In contrast, the lowest values were found in W₇ (weedy check).

Effective weed management strategies may have led to a reduction in dry matter production by weeds and minimized crop-weed competition for essential growth resources like light, space, nutrients, and moisture. This, in turn, facilitated improved growth and development of the crop, resulting in luxuriant growth and an increased number of branches plant⁻¹. Jaiswal and Lakpale (2022) reported similar observation. Conversely, the presence of weedy checks (W₇) due to greater weed competition resulted in a reduced number of branches plant⁻¹, as also noted by Jadon *et al.* (2019).

4.1.1.2.3 Interaction effect of sowing dates and integrated weed management on the number of primary branches plant⁻¹

The interaction result of sowing dates and integrated weed management did not have a significant effect on the number of primary branches plant⁻¹ at all the stages of observation in both years, as given in Table 4.2 (b).

4.1.1.3 Leaf area index

Table 4.3 (a) and Table 4.3 (b) displays the data related to the LAI recorded at 30 and 60 DAS. The higher the LAI, the higher the PAR interception, which is the source of energy for photosynthesis, accumulating more photosynthates for

Table 4.2(a) Effect of sowing dates and integrated weed management treatments on the number of primary branches plant⁻¹ of soybean

Treatments	Number of primary branches plant ⁻¹											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	2.10	2.26	2.18	4.00	4.12	4.06	3.87	4.04	3.95	3.80	3.91	3.86
P₂ 30th June	2.03	2.06	2.05	3.70	3.89	3.79	3.38	3.65	3.52	3.28	3.48	3.38
P₃ 15th July	1.73	1.82	1.77	3.02	3.21	3.12	2.89	3.02	2.95	2.78	2.96	2.87
SEm±	0.05	0.05	0.03	0.08	0.08	0.05	0.07	0.08	0.05	0.06	0.07	0.05
CD at 5%	0.18	0.19	0.11	0.30	0.31	0.18	0.27	0.30	0.17	0.25	0.26	0.15
Integrated weed Management (W)												
W₁	1.82	1.88	1.85	3.42	3.60	3.51	3.19	3.33	3.26	3.23	3.37	3.30
W₂	1.77	1.73	1.75	3.22	3.38	3.30	3.04	3.18	3.11	3.15	3.28	3.22
W₃	2.39	2.66	2.53	3.98	4.15	4.06	3.71	3.98	3.84	3.68	3.85	3.77
W₄	2.27	2.34	2.31	3.54	3.69	3.61	3.35	3.49	3.42	3.39	3.57	3.48
W₅	1.95	1.92	1.94	3.63	3.90	3.77	3.56	3.76	3.66	3.47	3.69	3.58
W₆	1.97	2.08	2.03	4.23	4.36	4.29	3.97	4.14	4.06	3.87	4.04	3.95
W₇	1.48	1.72	1.60	3.01	3.10	3.05	2.83	3.11	2.97	2.21	2.35	2.28
SEm±	0.08	0.08	0.06	0.13	0.13	0.09	0.12	0.12	0.08	0.11	0.11	0.08
CD at 5%	0.22	0.24	0.16	0.37	0.37	0.26	0.35	0.34	0.24	0.33	0.31	0.22

Table 4.2(b) Interaction effect of sowing dates and integrated weed management treatments on number of primary branches plant⁻¹ of soybean.

Treatments	Number of primary branches plant ⁻¹											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.87	2.05	1.96	3.93	4.13	4.03	3.69	3.80	3.74	3.85	3.91	3.88
P₁W₂	1.85	1.84	1.84	3.66	3.73	3.69	3.53	3.67	3.60	3.69	3.75	3.72
P₁W₃	2.61	3.09	2.85	4.26	4.42	4.34	4.33	4.40	4.36	4.26	4.33	4.30
P₁W₄	2.51	2.68	2.60	4.00	4.20	4.10	3.93	3.93	3.93	3.90	4.05	3.98
P₁W₅	2.01	2.05	2.03	4.16	4.33	4.24	4.27	4.33	4.30	4.06	4.25	4.15
P₁W₆	2.10	2.26	2.18	4.55	4.59	4.57	4.46	4.54	4.50	4.41	4.48	4.44
P₁W₇	1.73	1.88	1.80	3.42	3.47	3.44	2.88	3.60	3.24	2.42	2.61	2.51
P₂W₁	1.92	1.89	1.91	3.46	3.61	3.53	3.21	3.33	3.27	3.16	3.33	3.25
P₂W₂	1.85	1.73	1.79	3.33	3.55	3.44	3.07	3.27	3.17	3.15	3.31	3.23
P₂W₃	2.49	2.61	2.55	4.40	4.46	4.43	3.53	4.20	3.87	3.62	3.85	3.73
P₂W₄	2.42	2.38	2.40	3.54	3.73	3.64	3.27	3.47	3.37	3.39	3.60	3.50
P₂W₅	2.08	1.94	2.01	3.60	4.06	3.83	3.33	3.74	3.53	3.46	3.75	3.60
P₂W₆	2.00	2.18	2.09	4.46	4.53	4.50	4.06	4.36	4.21	3.82	4.10	3.96
P₂W₇	1.47	1.68	1.58	3.14	3.27	3.21	3.19	3.20	3.20	2.34	2.42	2.38
P₃W₁	1.65	1.72	1.68	2.87	3.06	2.97	2.67	2.87	2.77	2.69	2.88	2.78
P₃W₂	1.63	1.63	1.63	2.68	2.86	2.77	2.53	2.60	2.57	2.61	2.80	2.70
P₃W₃	2.08	2.27	2.18	3.27	3.59	3.43	3.27	3.33	3.30	3.17	3.36	3.27
P₃W₄	1.90	1.96	1.93	3.07	3.13	3.10	2.87	3.07	2.97	2.88	3.05	2.96
P₃W₅	1.77	1.78	1.78	3.13	3.33	3.23	3.07	3.20	3.13	2.90	3.09	3.00
P₃W₆	1.81	1.81	1.81	3.66	3.96	3.81	3.39	3.53	3.46	3.37	3.55	3.46
P₃W₇	1.24	1.59	1.42	2.47	2.57	2.52	2.41	2.54	2.47	1.87	2.03	1.95
SEm± (PxW)	0.13	0.14	0.10	0.22	0.23	0.16	0.21	0.20	0.15	0.20	0.19	0.14
SEm± (WxP)	0.10	0.10	0.07	0.16	0.17	0.12	0.15	0.16	0.11	0.14	0.14	0.10
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

translocation to seed, resulting in higher yield.

4.1.1.3.1 Effect of sowing dates on leaf area index of soybean

The data presented in Table 4.3 (a) revealed a significant effect of different sowing dates on the leaf area index. At 30 DAS, soybean sown on 15th June recorded significantly the highest leaf area index (0.62, 0.69) followed by 30th June. The lowest figures was recorded on 15th July (0.45, 0.48) during both years.

At 60 DAS, sowing on 30th June resulted in significantly larger leaf area (2.69, 2.77) in both years. However, during the second year, 30th June was found to be at par with 15th June. The lowest leaf area index (1.91, 1.99) was observed in the delayed sowing on 15th July during both years.

The observed variation in LAI might also be due to differences in average temperatures, or heat units, associated with varying sowing dates. The increase in the LAI for earlier sowing dates is consistent with the findings of Singh *et al.* (1987), Nath *et al.* (2017), Jagtap *et al.* (2019), and Rajasekhar *et al.* (2021).

4.1.1.3.2 Effect of integrated weed management on leaf area index

The LAI demonstrated an inverse relationship with the weed population. An upsurge in LAI result from enhanced utilization of solar energy and depends upon the no. of leaves plant⁻¹ and the rate of leaf expansion. The variation in LAI at 30 and 60 DAS was significant due to the integrated weed management. The highest leaf area index (0.64, 0.73) at 30 DAS was observed with pendimethalin @ 1.0 kg a.i ha⁻¹ *fb* imazethapyr @ 100g a.i. ha⁻¹ at 20 DAS (W₃) and par with W₄ (Pendimethalin 1.0 kg a.i ha⁻¹ *fb* hand weeding at 30 DAS) in both the years. Conversely, the lowest LAI was registered in the control treatment (W₇).

However, at 60 DAS, hand weeding at 20 and 40 DAS (W₆) recorded significantly higher values (2.72, 2.79). It was at par with the application of pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ *fb* imazethapyr 10SL @ 100g a.i ha⁻¹ at 20 DAS (W₃) both year and pooled value and W₄ (imazethapyr 10SL@ 100g a.i ha⁻¹ (20DAS) *fb* interculture at 30DAS) in both years but not in pooled value.

The effective herbicidal management of weed densities created an environment conducive to enhanced nutrient uptake, evidenced by an increased leaf area index. This

Table 4.3(a) Effect of sowing dates and integrated weed management treatments on Leaf Area Index (LAI) of soybean

Treatments	Leaf Area Index (LAI)					
	30 DAS			60 DAS		
	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)						
P₁ 15th June	0.62	0.69	0.65	2.69	2.77	2.73
P₂ 30th June	0.54	0.60	0.57	2.42	2.55	2.48
P₃ 15th July	0.45	0.48	0.46	1.91	1.99	1.95
SEm±	0.01	0.02	0.01	0.06	0.06	0.04
CD at 5%	0.06	0.06	0.03	0.22	0.23	0.13
Integrated weed Management (W)						
W₁	0.51	0.55	0.53	2.28	2.35	2.31
W₂	0.48	0.52	0.50	2.09	2.24	2.16
W₃	0.64	0.73	0.68	2.64	2.66	2.65
W₄	0.61	0.67	0.64	2.34	2.51	2.42
W₅	0.53	0.59	0.56	2.47	2.57	2.52
W₆	0.58	0.63	0.60	2.72	2.79	2.75
W₇	0.41	0.43	0.42	1.84	1.95	1.90
SEm±	0.02	0.02	0.02	0.09	0.10	0.07
CD at 5%	0.06	0.07	0.04	0.27	0.27	0.19

Table 4.3(b) Interaction effect of sowing dates and integrated weed management treatments on Leaf Area Index (LAI) of soybean

Treatment	Leaf Area Index (LAI)					
	30 DAS			60 DAS		
	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	0.59	0.65	0.62	2.65	2.70	2.67
P₁W₂	0.53	0.60	0.57	2.28	2.51	2.39
P₁W₃	0.74	0.84	0.79	3.10	3.03	3.07
P₁W₄	0.70	0.78	0.74	2.71	2.83	2.77
P₁W₅	0.62	0.70	0.66	2.88	2.99	2.93
P₁W₆	0.67	0.74	0.71	3.13	3.19	3.16
P₁W₇	0.48	0.50	0.49	2.09	2.16	2.12
P₂W₁	0.52	0.56	0.54	2.34	2.40	2.37
P₂W₂	0.50	0.53	0.52	2.18	2.29	2.23
P₂W₃	0.63	0.74	0.68	2.78	2.85	2.81
P₂W₄	0.58	0.66	0.62	2.38	2.70	2.54
P₂W₅	0.53	0.58	0.55	2.55	2.68	2.61
P₂W₆	0.57	0.63	0.60	2.82	2.94	2.88
P₂W₇	0.44	0.47	0.46	1.89	1.97	1.93
P₃W₁	0.42	0.44	0.43	1.85	1.95	1.90
P₃W₂	0.39	0.42	0.40	1.81	1.92	1.86
P₃W₃	0.56	0.61	0.58	2.04	2.10	2.07
P₃W₄	0.53	0.56	0.54	1.91	1.99	1.95
P₃W₅	0.45	0.48	0.46	1.97	2.05	2.01
P₃W₆	0.49	0.51	0.50	2.20	2.23	2.22
P₃W₇	0.31	0.32	0.31	1.55	1.72	1.64
SEm± (PxW)	0.04	0.04	0.03	0.16	0.17	0.12
SEm± (WxP)	0.03	0.03	0.02	0.12	0.12	0.08
CD at 5%	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS

finding was in accordance with Raj *et al.* (2019) and Samudre *et al.* (2019).

Weedy check (W₇) recorded the lowest number of leaf area index significantly in both years at all the stages of observations, a result likely attributable to the increased physical suppression and competition within crops and weed offered by uncontrolled weeds.

4.1.1.3.3 Interaction effect of sowing dates and Integrated Weed management on leaf area index

Throughout both years, the interaction between the sowing dates and integrated weed management did not significantly affect the LAI at any stage of observation, as shown in Table 4.3 (b).

4.1.1.4 Dry weight of plant (g plant⁻¹)

Dry matter accumulation refers to the ratio of the economic yield to the dry-matter accumulation at harvest, which indicates the ability to convert the photosynthetic products into economic products and total nutrient uptake by the plant to stimulate the growth. Table 4.4 (a) presented the data on dry mass of plant (g plant⁻¹) recorded at 30, 60 DAS as well as at harvest.

4.1.1.4.1 Effect of sowing dates on dry weight of plant (g plant⁻¹)

Data on the dry weight of the plant presented in Table 4.4 (a) revealed a gradual increase in the dry matter production plant⁻¹ with an advancement in the age of the crop till harvest in all the treatments during both years. Significantly, the highest dry weight of the plant at 30 DAS (1.65 g, 1.68 g plant⁻¹), 60 DAS (10.95 g, 12.11 g plant⁻¹), and harvest (26.18 g, 28.26 g plant⁻¹) was recorded on 15th June compared to the subsequent delayed sowing dates at all the stages of growth.

Early sowing might have ensured more significant opportunity for vegetative growth, photosynthesizing for a more extended period, and utilizing the soil and climate resources, which might have ultimately culminated in a higher plant height, more branches, number of leaves, and larger leaf area, higher accumulation of carbohydrates, thereby increasing dry matter production. The results lend support to that of Dandge *et al.* (2020), Rajasekhar *et al.* (2021), and Hamoda *et al.* (2021).

The lowest dry weight plant⁻¹ at 30 DAS (1.36 g, 1.40 g plant⁻¹), 60 DAS (6.51

g, 7.21 g plant⁻¹) and at harvest (18.68 g, 20.27 g plant⁻¹) was recorded on late sowing July 15th.

4.1.1.4.2 Effect of integrated weed management on the dry weight of soybean

The dry matter of soybean crops increased as the crops advanced through their growth. Additionally, the data that integrated weed management also significantly affected the dry weight plant⁻¹ at all observed stages.

At 30 DAS, the highest dry weight (1.70, 1.74 g plant⁻¹) was observed with the application of pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ fb imazethapyr 10SL @ 100g a.i ha⁻¹ at 20 DAS (W₃), which was at par with pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ fb interculture at 30 DAS (W₄). The lowest value (1.18, 1.20 g plant⁻¹) was recorded in the weedy check (W₇).

However, at 60 DAS and harvest, W₆ (Hand weeding at 20 and 40 DAS) was recorded as significantly the highest dry weight (12.08, 13.29 g plant⁻¹), (27.63, 29.65 g plant⁻¹) which is closely followed by W₃ (Pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ fb imazethapyr 10SL @ 100g a.i ha⁻¹ at 20 DAS). The minimum values were recorded under W₇ (weedy check) across all the stages during the two years of experimentations attributed to intense competition with weed flora.

The increase in plant dry matter accumulation in weed management plots, as compared to control plots can be linked to efficacious control of the weeds and less in competition at crucial stages of growth, which indirectly provided favourable conditions for proper growth and development, consequently increasing production and accumulation of photosynthates in vegetative parts of the plant, such as higher plant height, more branches, higher leaf area and number of pods per plant to its full yield potential. These results align with the research conducted by Jadon *et al.* (2019), Bharat *et al.* (2019) and Pawar *et al.* (2022). The lower dry weight in the control plot might be attributed to intense weed competition and its shading effect leading to lower photosynthates production and restriction of crop development and growth.

4.1.1.4.3 Interaction effect of sowing dates and integrated weed management on dry weight plant⁻¹ of soybean

The interaction effect of sowing dates and integrated weed management on the dry weight of plants was not significant at any of the observation times in both years

Table 4.4(a) Effect of sowing dates and integrated weed management treatments on dry weight of plant (g plant⁻¹) of soybean

Treatments	Dry weight of plant (g plant ⁻¹)								
	30 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)									
P₁ 15th June	1.65	1.68	1.67	10.95	12.11	11.53	26.18	28.26	27.22
P₂ 30th June	1.45	1.48	1.47	8.97	9.31	9.14	24.11	25.19	24.65
P₃ 15th July	1.36	1.40	1.38	6.51	7.21	6.86	18.68	20.27	19.48
SEm±	0.02	0.03	0.02	0.21	0.26	0.17	0.33	0.57	0.33
CD at 5%	0.09	0.13	0.07	0.83	1.03	0.55	1.31	2.25	1.08
Integrated weed Management (W)									
W₁	1.43	1.46	1.44	7.79	8.70	8.25	21.89	23.35	22.62
W₂	1.37	1.40	1.38	6.88	8.38	7.63	21.47	22.17	21.82
W₃	1.70	1.74	1.72	10.67	11.17	10.92	24.69	26.77	25.73
W₄	1.66	1.69	1.67	9.05	9.13	9.09	22.49	24.26	23.38
W₅	1.49	1.54	1.52	9.61	10.43	10.02	23.20	25.07	24.14
W₆	1.59	1.63	1.61	12.08	13.29	12.69	27.63	29.65	28.64
W₇	1.18	1.20	1.19	5.58	5.71	5.65	19.56	20.75	20.16
SEm±	0.03	0.04	0.02	0.30	0.40	0.25	0.43	0.53	0.34
CD at 5%	0.08	0.10	0.06	0.87	1.14	0.70	1.24	1.52	0.96

Table 4.4(b) Interaction effect of sowing dates and integrated weed management treatments on dry weight of plant (g plant⁻¹) of soybean

Treatment	Dry weight of plant (g plant ⁻¹)								
	30 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.61	1.64	1.63	9.88	11.57	10.72	25.11	26.97	26.04
P₁W₂	1.55	1.58	1.56	9.29	11.27	10.28	24.44	25.81	25.12
P₁W₃	1.85	1.88	1.86	12.73	13.55	13.14	28.19	30.48	29.34
P₁W₄	1.83	1.84	1.84	11.95	12.08	12.01	25.98	28.34	27.16
P₁W₅	1.67	1.75	1.71	12.06	12.72	12.39	26.55	29.19	27.87
P₁W₆	1.76	1.79	1.78	13.28	15.80	14.54	30.81	33.33	32.07
P₁W₇	1.30	1.32	1.31	7.45	7.79	7.62	22.17	23.72	22.95
P₂W₁	1.38	1.42	1.40	7.72	8.06	7.89	22.87	23.86	23.36
P₂W₂	1.29	1.32	1.31	6.62	7.92	7.27	22.43	22.83	22.63
P₂W₃	1.67	1.72	1.69	11.28	11.20	11.24	26.07	27.52	26.80
P₂W₄	1.63	1.65	1.64	8.88	8.79	8.84	23.53	24.65	24.09
P₂W₅	1.44	1.48	1.46	9.89	11.07	10.48	24.78	25.41	25.10
P₂W₆	1.58	1.59	1.58	13.02	12.85	12.93	28.55	30.41	29.48
P₂W₇	1.17	1.19	1.18	5.36	5.31	5.34	20.53	21.64	21.09
P₃W₁	1.28	1.32	1.30	5.77	6.49	6.13	17.69	19.23	18.46
P₃W₂	1.27	1.29	1.28	4.72	5.95	5.33	17.53	17.88	17.71
P₃W₃	1.59	1.62	1.61	8.00	8.74	8.37	19.82	22.29	21.06
P₃W₄	1.52	1.57	1.54	6.32	6.53	6.43	17.96	19.79	18.88
P₃W₅	1.37	1.38	1.37	6.88	7.51	7.20	18.27	20.62	19.45
P₃W₆	1.44	1.50	1.47	9.94	11.24	10.59	23.54	25.20	24.37
P₃W₇	1.08	1.09	1.09	3.93	4.03	3.98	15.97	16.90	16.44
SEm± (P×W)	0.05	0.06	0.04	0.52	0.69	0.43	0.75	0.92	0.59
SEm± (W×P)	0.05	0.06	0.04	0.42	0.54	0.34	0.65	1.04	0.61
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

(Table 4.4b).

4.1.1.5 Number of root nodules plant⁻¹

Table 4.5 (a) and Table 4.5 (b) displays the data concerning the effect of sowing dates and integrated weed management on the no. of root nodules plant⁻¹ as observed at 40 DAS and 60 DAS.

4.1.1.5.1 Effect of sowing dates on the number of root nodules plant⁻¹ on soybean

Throughout all observation stages, the number of root nodules plant⁻¹ showed significant variation based on the sowing date. At 40 DAS, sowing on 15th June resulted in the highest count of root nodules plant⁻¹ (17.62, 20.79) in both years, followed by 30th June. The lowest number of root nodules plant⁻¹ was found on 15th July (11.51, 14.93) in 2021 and 2022.

At 60 DAS, a similar trend in variation on the number of root nodules was recorded, where sowing on 15th June recorded significantly the highest number of root nodules plant⁻¹ (39.57, 41.28) in both years, followed by 30th June. The lowest number of root nodules in plant⁻¹ was found on 15th July (28.04, 30.87) in both years.

The early sowing resulted in the higher number of root nodules plant⁻¹, likely due to the optimal temperature and soil moisture levels that promoted *rhizobium* infection and increased nodule formation. These results align with the findings of Paradkar and Deshmukh (2004), Aastha and Singh (2016) and Raghuwanshi *et al.* (2018).

4.1.1.5.2 Effect of integrated weed management on the number of roots nodules plant⁻¹ on soybean

Analysis of data from both years and pooled data indicated that integrated weed management had a notable influenced on the number of root nodules plant⁻¹ at both observation stages. Application of pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ fb imazethapyr 10SL @ 100g a.i ha⁻¹ at 20 DAS (W₃) was recorded a significantly higher number of root nodules plant⁻¹ (17.93, 21.33) in both years. In contrast, the lowest number of root nodule plant⁻¹ was obtained in W₇ (weedy check) at 40 DAS in both years of study, attributing to intense competitive stress. This significantly higher nodulation can be due to the effect of early weed control measures adopted that

suppress the growth of competitive weeds. Samim *et al.* (2023) reported similar observations.

However, at 60 DAS, data from both years and their pooled value revealed that hand weeding at 20 and 40 DAS (W₆) recorded a significantly higher value (46.18, 49.95) followed by W₃ (Pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ fb imazethapyr 10SL @ 100g a.i ha⁻¹ at 20 DAS). The physical alteration of soil involved in hand weeding and better control of weeds by chemical herbicide application might have created a favorable microclimate, microbial activity and increased aeration in the rhizosphere for the growth of *rhizobia*, which led to more roots and effective nodulation for better nitrogen fixation. These results are consistent with those reported by Topo *et al.* (2019).

The lowest values of 21.83 and 23.22 were observed in W₇ (weedy check), which can be likely due to higher crop weed competition that adversely affected the nodule formation and decline nitrogenase activity. A similar result was reported by Raj *et al.* (2019) and Samim *et al.* (2023).

4.1.1.5.3 Interaction effect of sowing dates and integrated weed management on the number of root nodules on soybean

As indicated in Table 4.5 (b), the sowing dates and integrated weed management did not have a interaction effect on the number of root nodules plant⁻¹ at any of the stages observed over the two years.

4.1.1.6 Dry weight of root nodules plant⁻¹

The data concerning the dry mass of root nodules plant⁻¹ recorded at 40 and 60 DAS are depicted in Table 4.6 (a) and Table 4.6 (b).

4.1.1.6.1 Effect of sowing dates on the dry weight of root nodules plant⁻¹ on Soybean

The data for both years and pooled value on the dry weight of root nodules revealed a significant variation among the sowing dates at all the stages of observation. At 40 DAS, sowing on 15th June recorded significantly the highest dry weight of root nodules plant⁻¹ (0.20 g, 0.24 g), which was at par with 30th June. Conversely, the lowest values (0.15 g, 0.19 g) were observed with the July 15th sowing in both the years.

Table 4.5(a) Effect of sowing dates and integrated weed management treatments on number of root nodules plant⁻¹ of soybean

Treatments	Number of root nodules plant ⁻¹					
	40 DAS			60 DAS		
	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)						
P₁ 15th June	17.62	20.79	19.21	39.57	41.28	40.42
P₂ 30th June	15.45	17.70	16.57	34.26	36.80	35.53
P₃ 15th July	11.51	14.93	13.22	28.04	30.87	29.45
SEm±	0.25	0.34	0.21	0.59	0.70	0.46
CD at 5%	0.99	1.34	0.69	2.33	2.74	1.49
Integrated weed Management (W)						
W₁	13.70	16.96	15.33	31.06	32.30	31.68
W₂	12.74	16.01	14.38	26.73	29.58	28.16
W₃	17.93	21.33	19.63	40.11	44.31	42.21
W₄	16.60	19.73	18.16	34.60	36.05	35.32
W₅	16.16	18.16	17.16	37.16	38.81	37.99
W₆	16.36	19.33	17.84	46.18	49.95	48.07
W₇	10.53	13.12	11.82	21.83	23.22	22.52
SEm±	0.35	0.37	0.25	1.10	0.85	0.69
CD at 5%	0.99	1.07	0.72	3.14	2.43	1.95

Table 4.5(b) Interaction effect of sowing dates and integrated weed management treatments on root nodules plant⁻¹ of soybean

Treatment	Number of root nodules plant ⁻¹					
	40 DAS			60 DAS		
	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	16.76	20.55	18.65	35.08	36.18	35.63
P₁W₂	14.67	18.69	16.68	31.26	34.03	32.64
P₁W₃	21.15	24.07	22.61	46.96	50.52	48.74
P₁W₄	19.69	22.83	21.26	40.39	40.17	40.28
P₁W₅	19.33	21.12	20.22	43.08	44.32	43.70
P₁W₆	19.41	22.33	20.87	53.26	55.78	54.52
P₁W₇	12.33	15.95	14.14	26.95	27.97	27.46
P₂W₁	14.57	16.95	15.76	31.90	32.58	32.24
P₂W₂	14.29	16.23	15.26	27.24	27.80	27.52
P₂W₃	18.44	21.32	19.88	39.94	46.81	43.38
P₂W₄	16.76	19.52	18.14	34.77	37.87	36.32
P₂W₅	16.14	17.36	16.75	37.10	40.76	38.93
P₂W₆	16.57	19.48	18.03	47.65	49.66	48.65
P₂W₇	11.39	13.02	12.21	21.19	22.10	21.65
P₃W₁	9.77	13.39	11.58	26.21	28.13	27.17
P₃W₂	9.26	13.11	11.18	21.70	26.92	24.31
P₃W₃	14.21	18.61	16.41	33.43	35.58	34.51
P₃W₄	13.34	16.85	15.09	28.62	30.12	29.37
P₃W₅	13.02	16.00	14.51	31.31	31.35	31.33
P₃W₆	13.09	16.18	14.63	37.63	44.43	41.03
P₃W₇	7.85	10.39	9.12	17.34	19.58	18.46
SEm± (PxW)	0.60	0.64	0.44	1.90	1.47	1.20
SEm± (WxP)	0.50	0.64	0.41	1.31	1.34	0.93
CD at 5%	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS

Analysis of data collected over the two-years period at 60 DAS, indicates that sowing on 15th June recorded the highest dry weight of root nodules plant⁻¹ (0.39 g, 0.42 g), which was significantly higher than the other treatments and the lowest dry weight of root nodules plant⁻¹ was recorded with the late sowing on July 15 across both years. The increased dry weight of root nodules in earlier sown soybean might be due to an amiable environment for shoot and root growth, resulting in a higher number of healthy root nodules and consequently leading to a higher dry weight of root nodules. A similar finding was also reported by Aastha and Singh (2016).

4.1.1.6.2 Effect of integrated weed management on the dry weight of root nodules on soybean

The study demonstrated a significant impact on the dry weight of root nodules plant⁻¹ at both stages of observation. Application of pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ fb imazethapyr 10SL @ 100g a.i ha⁻¹ at 20 DAS (W₃) was recorded significantly higher dry weight of root nodules plant⁻¹ (0.21 g, 0.25 g). It was at par with W₄ (Pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ fb hand weeding at 30 DAS), while the lowest values (0.14 g, 0.17 g) have been obtained in weedy check (W₇) at 40 DAS during both the years of experimentations. However, at 60 DAS, hand weeding at 20 and 40 DAS (W₆) recorded a significantly higher value (0.43 g, 0.47 g) than the other treatments. In contrast, significantly lower values were observed in W₇ (weedy check) in both years and pooled values. Pawar *et al.* (2022) and Samim *et al.* (2023) also observed higher nodule dry weight due to effective control of weeds under weed control treatments.

4.1.1.6.3 Interaction effect of dates of sowing and integrated weed management on the dry weight of root nodules on soybean

The interaction effect of both treatments on the dry weight of root nodules plant⁻¹ does not show any significant effect in either year, nor in the pooled value (Table 4.6 b).

4.1.1.7 Crop growth rate (g m⁻² day⁻¹)

The term Crop growth rate (CGR) denotes the photosynthetic efficiency of a plant, depends upon the leaf area index of the crop. Data collected on crop growth rate

Table 4.6(a) Effect of sowing dates and integrated weed management treatments on nodules dry weight plant⁻¹ (g) of soybean

Treatments	Nodules dry weight plant ⁻¹ (g)					
	40 DAS			60 DAS		
	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)						
P₁ 15th June	0.20	0.24	0.22	0.39	0.42	0.41
P₂ 30th June	0.18	0.21	0.20	0.34	0.36	0.35
P₃ 15th July	0.15	0.19	0.17	0.29	0.32	0.31
SEm±	0.005	0.005	0.004	0.006	0.007	0.005
CD at 5%	0.020	0.022	0.012	0.023	0.028	0.015
Integrated weed Management (W)						
W₁	0.18	0.21	0.19	0.32	0.34	0.33
W₂	0.16	0.20	0.18	0.29	0.31	0.30
W₃	0.21	0.25	0.23	0.40	0.43	0.42
W₄	0.18	0.22	0.20	0.34	0.37	0.35
W₅	0.18	0.22	0.20	0.36	0.40	0.38
W₆	0.19	0.23	0.21	0.43	0.47	0.45
W₇	0.14	0.17	0.15	0.24	0.28	0.26
SEm±	0.007	0.009	0.006	0.01	0.01	0.01
CD at 5%	0.021	0.027	0.017	0.02	0.02	0.02

Table 4.6(b) Interaction effect of sowing dates and integrated weed management treatments on nodules dry weight plant⁻¹ (g) of soybean

Treatment	Nodules dry weight plant ⁻¹ (g)					
	40 DAS			60 DAS		
	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	0.20	0.23	0.22	0.37	0.39	0.38
P₁W₂	0.18	0.22	0.20	0.36	0.37	0.36
P₁W₃	0.23	0.27	0.25	0.44	0.48	0.46
P₁W₄	0.21	0.25	0.23	0.38	0.42	0.40
P₁W₅	0.22	0.26	0.24	0.41	0.46	0.43
P₁W₆	0.22	0.26	0.24	0.47	0.51	0.49
P₁W₇	0.14	0.20	0.17	0.29	0.33	0.31
P₂W₁	0.18	0.21	0.20	0.32	0.33	0.33
P₂W₂	0.16	0.21	0.19	0.27	0.29	0.28
P₂W₃	0.20	0.25	0.22	0.40	0.44	0.42
P₂W₄	0.17	0.21	0.19	0.34	0.36	0.35
P₂W₅	0.18	0.22	0.20	0.37	0.41	0.39
P₂W₆	0.20	0.23	0.21	0.43	0.47	0.45
P₂W₇	0.15	0.16	0.16	0.23	0.26	0.25
P₃W₁	0.15	0.18	0.17	0.27	0.30	0.29
P₃W₂	0.13	0.18	0.15	0.24	0.27	0.26
P₃W₃	0.18	0.23	0.20	0.35	0.38	0.37
P₃W₄	0.15	0.19	0.17	0.30	0.31	0.31
P₃W₅	0.15	0.19	0.17	0.31	0.34	0.32
P₃W₆	0.16	0.20	0.18	0.40	0.43	0.42
P₃W₇	0.12	0.14	0.13	0.19	0.24	0.21
SEm± (PxW)	0.01	0.02	0.01	0.01	0.01	0.01
SEm± (WxP)	0.01	0.01	0.01	0.01	0.01	0.01
CD at 5%	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS

(CGR) ($\text{g m}^{-2} \text{ day}^{-1}$) at 30-60 DAS and 60-90 DAS as influenced by sowing dates and integrated weed management are presented in Table 4.7 (a) and Table 4.7 (b).

4.1.1.7.1 Effect of sowing dates on the crop growth rate of soybean

The data revealed that variations in Crop Growth Rate (CGR) owing to different sowing dates were significant at all the stages of observation. Sowing on 15th June recorded significantly highest CGR at 40 DAS (10.33, 11.58 $\text{g m}^{-2} \text{ day}^{-1}$) and 60 DAS (12.69, 14.88 $\text{g m}^{-2} \text{ day}^{-1}$) followed by 30th June and the lowest values were found under 15th July at 30 and 60 DAS in both the years. This could be because there was enough time for both vegetative and reproductive growth, leading to a higher crop growth rate. Similar, higher CGR in earlier sowing than the late sowing of soybean was also reported by Kumagai (2017), Raghuwanshi *et al.* (2018), and Nayak *et al.* (2020).

4.1.1.7.2 Effect of integrated weed management on crop growth rate of soybean

The influence of integrated weed management on crop growth rate was markedly significant during both observation phases. Application of pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ fb imazethapyr 10SL @ 100g a.i ha⁻¹ at 20 DAS (W₃) was recorded significantly highest CGR (11.53, 12.84 $\text{g m}^{-2} \text{ day}^{-1}$) at 30-60 DAS in both years. The lowest values (4.89, 5.01 $\text{g m}^{-2} \text{ day}^{-1}$) were recorded in the weedy check (W₇).

At 60-90 DAS, hand weeding at 20 and 40 DAS (W₆) recorded significant maximum CRG (15.22, 18.26 $\text{g m}^{-2} \text{ day}^{-1}$) in both years of observation, while the significantly lowest values (5.64, 6.36 $\text{g m}^{-2} \text{ day}^{-1}$) were recorded in weedy check (W₇). The inhibition of weeds at a critical growth stage of the crop through hand weeding and herbicide application might have enhanced vegetative growth, resulting in more nutrients to be utilized by crops, which helped in the instilling of more plant biomass and, consequently, a higher CGR. These findings are consistent with those reported by Rajkumari *et al.* (2017).

4.1.1.7.3 Interaction effect of dates of sowing and integrated weed management on crop growth rate of soybean

The interaction effect of dates of sowing and integrated weed management on

Table 4.7(a) Effect of sowing dates and integrated weed management treatments on crop growth rate (CGR) ($\text{g m}^{-2}\text{day}^{-1}$) of soybean

Treatments	Crop Growth Rate ($\text{g m}^{-2}\text{day}^{-1}$)					
	30-60 DAS			60-90 DAS		
	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)						
P₁ 15th June	10.33	11.58	10.96	12.69	14.88	13.79
P₂ 30th June	8.35	8.70	8.53	10.32	11.17	10.74
P₃ 15th July	5.72	6.46	6.09	7.26	8.55	7.91
SEm$\pm$	0.22	0.29	0.18	0.28	0.37	0.23
CD at 5%	0.88	1.13	0.59	1.10	1.45	0.76
Integrated weed Management (W)						
W₁	7.07	8.05	7.56	8.49	9.95	9.22
W₂	6.12	7.76	6.94	7.43	9.48	8.45
W₃	11.53	12.84	12.18	12.74	13.56	13.15
W₄	8.21	8.27	8.24	10.06	10.64	10.35
W₅	9.02	9.89	9.45	11.07	12.47	11.77
W₆	10.09	10.60	10.34	15.22	18.26	16.74
W₇	4.89	5.01	4.95	5.64	6.36	6.00
SEm$\pm$	0.34	0.44	0.28	0.71	0.65	0.48
CD at 5%	0.96	1.27	0.78	2.04	1.87	1.36

Table 4.7(b) Interaction effect of sowing dates and integrated weed management treatments on crop growth rate (CGR) (g m⁻²day⁻¹) of soybean

Treatment	Crop Growth Rate (g m ⁻² day ⁻¹)					
	30-60 DAS			60-90 DAS		
	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	9.19	11.03	10.11	11.03	13.43	12.23
P₁W₂	8.60	10.77	9.69	10.29	12.96	11.63
P₁W₃	12.71	15.47	14.09	15.33	17.09	16.21
P₁W₄	11.24	11.37	11.30	13.37	14.33	13.85
P₁W₅	11.55	12.19	11.87	14.10	15.50	14.80
P₁W₆	12.19	13.07	12.63	17.10	22.01	19.55
P₁W₇	6.84	7.19	7.02	7.65	8.83	8.24
P₂W₁	7.05	7.37	7.21	8.46	9.34	8.90
P₂W₂	5.92	7.33	6.62	7.12	8.83	7.98
P₂W₃	12.61	12.37	12.49	13.48	13.48	13.48
P₂W₄	8.06	7.94	8.00	10.02	10.05	10.04
P₂W₅	9.38	10.65	10.02	11.40	13.16	12.28
P₂W₆	10.78	10.68	10.73	16.41	17.61	17.01
P₂W₇	4.65	4.58	4.61	5.38	5.67	5.53
P₃W₁	4.98	5.74	5.36	5.98	7.09	6.53
P₃W₂	3.84	5.17	4.50	4.87	6.64	5.75
P₃W₃	9.28	10.69	9.98	9.42	10.11	9.77
P₃W₄	5.34	5.51	5.43	6.80	7.54	7.17
P₃W₅	6.12	6.82	6.47	7.70	8.76	8.23
P₃W₆	7.29	8.04	7.66	12.17	15.14	13.66
P₃W₇	3.17	3.26	3.22	3.89	4.58	4.24
SEm± (PxW)	0.58	0.77	0.48	1.23	1.13	0.84
SEm± (WxP)	0.46	0.59	0.37	0.72	0.80	0.54
CD at 5%	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS

crop growth rate given in Table 4.7 (b) implied non-significant at all the stages of observation in both years.

4.1.1.8 Relative growth rate ($\text{g g}^{-1} \text{ day}^{-1}$)

Data on relative growth rate (RGR) ($\text{g g}^{-1} \text{ day}^{-1}$) recorded at 30-60 DAS and 60-90 DAS are presented in Table 4.8 (a) and Table 4.8 (b).

4.1.1.8.1 Effect of dates of sowing on the relative growth rate of soybean

A perusal of the data presented in Table 4.8 (a) showed variation in the RGR at (30-60 DAS). The maximum RGR ($0.063, 0.065 \text{ g g}^{-1} \text{ day}^{-1}$) was found in early sowing on 15th June, which was found to be significantly higher over the 30th June and 15th July sowing dates. Nonetheless, no significant differences were noted in the RGR at 60-90 DAS in both years and the pooled value.

Similar, higher RGR in earlier sowing than the late sowing of soybean was also reported by Aastha and Singh (2016) and Raghuwanshi *et al.* (2018). In addition, Dandge *et al.* (2020) also recorded the highest value of relative growth rate (RGR) at 45-60 DAS observed at normal sowing in June and declined later on.

4.1.1.8.2 Effect of integrated weed management on the relative growth rate of soybean

The findings presented in Table 4.8 (a) pertaining to RGR are significant due to the implementation of integrated weed management at 30-60 DAS. Application of pendimethalin 30EC @ $1.0 \text{ kg a.i ha}^{-1}$ fb imazethapyr 10SL @ $100 \text{ g a.i ha}^{-1}$ at 20 DAS (W_3) achieved the highest RGR ($0.065, 0.067 \text{ g g}^{-1} \text{ day}^{-1}$). This was statistically at par with W_6 (hand weeding at 20 and 40 DAS), whereas the weedy check (W_7) recorded significantly lower values in both years and pooled values. Relative growth rate at 60-90DAS was found to be non-significant in both years.

The results designated that weed influx has a significant impact on soybean growth in the weedy check. Whereas better RGR were recorded in W_3 (Pendimethalin 30EC @ $1.0 \text{ kg a.i ha}^{-1}$ fb imazethapyr 10SL @ $100 \text{ g a.i ha}^{-1}$ at 20 DAS), followed by W_6 (hand weeding at 20 and 40 DAS). This might be because of successful weed control and low weed biomass, which allowed plants receiving treatments to have a higher photosynthetic rate during the early stage of crop growth at 30-60 DAS

Table 4.8(a) Effect of sowing dates and integrated weed management treatments on relative growth rate (RGR) ($\text{g g}^{-1}\text{day}^{-1}$) of soybean

Treatments	Relative growth rate ($\text{g g}^{-1}\text{day}^{-1}$)					
	30-60 DAS			60-90 DAS		
	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)						
P₁ 15th June	0.063	0.065	0.064	0.024	0.025	0.024
P₂ 30th June	0.060	0.060	0.060	0.023	0.024	0.024
P₃ 15th July	0.051	0.053	0.052	0.023	0.024	0.024
SEm$\pm$	0.001	0.001	0.001	0.001	0.001	0.001
CD at 5%	0.003	0.004	0.002	NS	NS	NS
Integrated weed Management (W)						
W₁	0.056	0.058	0.057	0.023	0.024	0.023
W₂	0.053	0.059	0.056	0.023	0.023	0.023
W₃	0.065	0.067	0.066	0.024	0.025	0.025
W₄	0.055	0.055	0.055	0.023	0.024	0.023
W₅	0.061	0.063	0.062	0.024	0.025	0.024
W₆	0.063	0.064	0.063	0.025	0.027	0.026
W₇	0.051	0.051	0.051	0.021	0.023	0.022
SEm$\pm$	0.001	0.002	0.001	0.002	0.002	0.001
CD at 5%	0.004	0.005	0.003	NS	NS	NS

Table 4.8(b) Interaction effect of sowing dates and integrated weed management treatments on relative growth rate (RGR) ($\text{g g}^{-1}\text{day}^{-1}$) of soybean

Treatment	Relative growth rate ($\text{g g}^{-1}\text{day}^{-1}$)					
	30-60 DAS			60-90 DAS		
	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	0.060	0.065	0.063	0.023	0.024	0.024
P₁W₂	0.060	0.065	0.063	0.023	0.024	0.023
P₁W₃	0.066	0.071	0.068	0.024	0.025	0.025
P₁W₄	0.062	0.063	0.062	0.023	0.024	0.024
P₁W₅	0.066	0.066	0.066	0.024	0.025	0.024
P₁W₆	0.066	0.067	0.067	0.025	0.027	0.026
P₁W₇	0.058	0.059	0.059	0.022	0.024	0.023
P₂W₁	0.057	0.058	0.058	0.023	0.024	0.023
P₂W₂	0.054	0.059	0.057	0.023	0.023	0.023
P₂W₃	0.068	0.067	0.068	0.024	0.025	0.025
P₂W₄	0.056	0.056	0.056	0.023	0.024	0.023
P₂W₅	0.064	0.067	0.065	0.024	0.024	0.024
P₂W₆	0.066	0.065	0.065	0.025	0.027	0.026
P₂W₇	0.050	0.049	0.050	0.021	0.023	0.022
P₃W₁	0.050	0.052	0.051	0.022	0.023	0.023
P₃W₂	0.044	0.051	0.047	0.022	0.023	0.023
P₃W₃	0.061	0.064	0.063	0.024	0.024	0.024
P₃W₄	0.047	0.048	0.047	0.023	0.023	0.023
P₃W₅	0.054	0.056	0.055	0.023	0.024	0.024
P₃W₆	0.057	0.058	0.058	0.025	0.027	0.026
P₃W₇	0.043	0.043	0.043	0.021	0.023	0.022
SEm$\pm$ (PxW)	0.002	0.003	0.002	0.003	0.003	0.002
SEm$\pm$ (WxP)	0.002	0.002	0.001	0.002	0.002	0.002
CD at 5%	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS

(Rajkumari *et al.*, 2017).

4.1.1.8.3 Interaction effect of dates of sowing and integrated weed management on relative growth rate of soybean

Upon reviewing the data in Table 4.8 (b) reveals that the interaction of sowing dates and integrated weed management did not exert a significant effect on the relative growth rate in both years.

4.1.1.9 Net assimilation rate (g m^{-2} of leaf area day^{-1})

Data collected on net assimilation rate (g m^{-2} of leaf area day^{-1}) at 30-60 DAS and 60-90 DAS are presented in Table 4.9 (a).

4.1.1.9.1 Effect of sowing dates on Net assimilation rate (NAR) ($\text{g m}^{-2} \text{day}^{-1}$) of soybean

Significant variations in Net Assimilation Rate (NAR) were observed across different sowing dates at all stages of observation. Sowing on 15th June yielded highest NAR ($3.18, 3.78 \text{ gm}^{-2} \text{ day}^{-1}$) and was comparable to June 30th during the first year only. The lowest values were found on July 15th at 30-60 DAS. Observation from both years at 60-90 DAS revealed that early sowing on June 15th resulted in the highest NAR value of 2.19 and $2.45 \text{ gm}^{-2} \text{ day}^{-1}$ followed by 30th June and the lowest NAR value of $1.68, 1.89 \text{ gm}^{-2} \text{ day}^{-1}$ was recorded on 15th July. This may be due to the higher availability of solar energy (radiation) in the early sowing of crops. Aastha and Singh (2016) and Hamoda *et al.* (2021) also advocated that earlier sowing of soybeans resulted in higher NAR.

4.1.1.9.2 Effect of integrated weed management on Net assimilation rate ($\text{g m}^{-2} \text{day}^{-1}$) of soybean

Table 4.9 (a) presents the significant findings related to NAR, influenced by IWM across various stages. It was achieved that at 30-60 DAS, application of pendimethalin 30EC @ $1.0 \text{ kg a.i ha}^{-1}$ *fb* imazethapyr 10 SL @ $100 \text{ g a.i ha}^{-1}$ at 20 DAS (W_3) yielded better results, comparable to hand weeding twice (W_6) in both years and pooled value followed by imazethapyr 10SL @ $100 \text{ g a.i ha}^{-1}$ at 20 DAS *fb* interculture at 30 DAS (W_5) in both years. The weedy check showed significantly lower values

Table 4.9(a) Effect of sowing dates and integrated weed management treatments on net assimilation rate (NAR) (g m⁻² day⁻¹) of soybean

Treatments	Net assimilation rate (g m ⁻² day ⁻¹)					
	30-60 DAS			60-90 DAS		
	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)						
P₁ 15th June	3.18	3.78	3.48	2.19	2.45	2.32
P₂ 30th June	2.86	3.21	3.04	1.98	2.05	2.01
P₃ 15th July	2.42	3.15	2.79	1.68	1.89	1.79
SEm±	0.09	0.09	0.06	0.05	0.10	0.05
CD at 5%	0.35	0.34	0.20	0.19	0.37	0.17
Integrated weed Management (W)						
W₁	2.58	3.27	2.92	1.71	1.92	1.82
W₂	2.41	3.35	2.88	1.60	1.92	1.76
W₃	3.51	4.05	3.78	2.29	2.36	2.32
W₄	2.75	2.98	2.86	1.96	1.96	1.96
W₅	3.07	3.63	3.35	2.07	2.23	2.15
W₆	3.21	3.66	3.44	2.62	3.02	2.82
W₇	2.22	2.72	2.47	1.39	1.50	1.44
SEm±	0.16	0.20	0.13	0.14	0.14	0.10
CD at 5%	0.45	0.56	0.35	0.40	0.40	0.28

Table 4.9(b) Interaction effect of sowing dates and integrated weed management treatments on net assimilation rate (NAR) ($\text{g m}^{-2} \text{ day}^{-1}$) of soybean

Treatment	Net assimilation rate ($\text{g m}^{-2} \text{ day}^{-1}$)					
	30-60 DAS			60-90 DAS		
	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	2.94	3.81	3.38	1.97	2.30	2.14
P₁W₂	3.14	4.00	3.57	2.00	2.31	2.16
P₁W₃	3.34	4.18	3.76	2.40	2.64	2.52
P₁W₄	3.34	3.50	3.42	2.28	2.37	2.33
P₁W₅	3.42	3.81	3.61	2.36	2.44	2.40
P₁W₆	3.38	3.85	3.61	2.61	3.26	2.93
P₁W₇	2.73	3.29	3.01	1.69	1.84	1.77
P₂W₁	2.55	2.97	2.76	1.72	1.84	1.78
P₂W₂	2.25	3.18	2.72	1.60	1.84	1.72
P₂W₃	3.78	3.75	3.76	2.36	2.28	2.32
P₂W₄	2.75	2.81	2.78	2.00	1.82	1.91
P₂W₅	3.19	3.79	3.49	2.10	2.33	2.21
P₂W₆	3.35	3.54	3.44	2.73	2.77	2.75
P₂W₇	2.14	2.45	2.30	1.35	1.47	1.41
P₃W₁	2.24	3.03	2.63	1.45	1.63	1.54
P₃W₂	1.82	2.87	2.35	1.21	1.62	1.41
P₃W₃	3.40	4.22	3.81	2.10	2.16	2.13
P₃W₄	2.15	2.64	2.40	1.59	1.70	1.64
P₃W₅	2.60	3.29	2.95	1.76	1.93	1.85
P₃W₆	2.91	3.59	3.25	2.51	3.04	2.77
P₃W₇	1.80	2.42	2.11	1.12	1.19	1.16
SEm$\pm$ (PxW)	0.27	0.34	0.22	0.24	0.24	0.17
SEm$\pm$ (WxP)	0.19	0.21	0.14	0.13	0.19	0.12
CD at 5%	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS

(2.22, 2.72 gm⁻²day⁻¹) throughout both years and pooled value.

At 60-90 DAS, the data revealed that W₆ (Hand weeding at 20 and 40 DAS) recorded the highest NAR and was at par with W₃ (Pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ fb imazethapyr 10SL @ 100g a.i ha⁻¹ at 20 DAS) during 2021 only. The lowest value was obtained in weedy check (W₇) 1.39, 1.50 gm⁻²day⁻¹.

4.1.1.9.3 Interaction effect of sowing of dates and integrated weed management on Net assimilation rate (g m⁻² day⁻¹) of soybean

Table 4.9 (b) revealed that the interaction of the sowing dates and integrated weed management did not have notable effect on the net assimilation rate in either years.

4.1.2 Yield attributes

4.1.2.1 Number of pods plant⁻¹

This factor plays a crucial role in determining the yield potential of a crop. Table 4.10 (a) provides data on the no. of pods plant⁻¹, influenced by sowing dates and IWM.

4.1.2.1.1 Effect of sowing dates on the number of pods plant⁻¹ of soybean.

Data on the number of pods showed that different sowing dates had a significant effect in both years. Early sowing on 15th June significantly increased the number of pods (66.62, 69.78) in both years and pooled value, which was at par with 30th June. The lowest values (35.53, 37.11) were observed with the late sowing date of 15th July.

Early sowing of soybean crops might have received more favourable conditions (i.e., rainfall, temperature, humidity and longer sunshine duration), especially at the vegetative and reproductive stages, which favour better rooting density and uptake of NPK as compared to late sowing and helps in the initiation of more branches, flowering nodes, buds and better seed filling with the maintenance of better source-sink relationship ultimately leading to the development of a higher number of pods plant⁻¹. The results are in accordance with the findings reported by Taware *et al.* (2015) and Saqib *et al.* (2021).

4.1.2.1.2 Effect of integrated weed management on the number of pods plant⁻¹ of soybean

A significant difference was observed in a number of pods due to integrated weed management. Significantly, the lowest values (36.16, 38.17) were recorded in W₇ (weedy check). It might be due to the competition of soybean with weeds for their growth and development factors like nutrients, moisture and sunlight. While hand weeding at 20 and 40, DAS (W₆) recorded significantly highest number of pods (72.10, 73.10), followed by W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both the years.

The increase in the number of pods plant⁻¹ under weed management treatments might be due to better control of weeds and availability of resources during the crop growth period, leading to reduced competition between crops and weeds for limited resources. According to Raj *et al.* (2019), Saba *et al.* (2023), Samim *et al.* 2023 and Kalyan *et al.* (2024), performing two-hand weeding at 20 and 40 DAS resulted in significantly higher number of pods plant⁻¹, number of seeds per pod, and bold seeds and seed yield hectare⁻¹.

4.1.2.1.3 Interaction effect of sowing dates and integrated weed management on the number of pods plant⁻¹ of soybean

Results presented in Table 4.10 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect on the number of pods plant⁻¹ in either years.

4.1.2.2 Pod length (cm)

The data on pod length as influenced by sowing dates and integrated weed management are presented in Table 4.10 (a) and Table 4.10 (b).

4.1.2.2.1 Effect of sowing dates on pod length of soybean

The difference in the pod's length due to different sowing dates did not have a significant effect over the two-years of the experiment. However, soybean sown on 15th June exhibited a slightly greater higher length compared to those sown on other dates.

4.1.2.2.2 Effect of integrated weed management on pod length of soybean.

In both years, integrated weed management did not show any significant effect on pods length in both years. Nonetheless, the pod length in W₇ (weedy check) was numerically shorter.

4.1.2.2.3 Interaction effect of sowing dates and integrated weed management length of pod of soybean.

As indicated in Table 4.10 (b), revealed that interaction of sowing dates and integrated weed management did not significantly effect on pod length.

4.1.2.3 Number of seeds pod⁻¹

The data on number of seeds pod⁻¹ as influenced by sowing dates and integrated weed management are presented in Table 4.10 (a) and Table 4.10 (b).

4.1.2.3.1 Effect of sowing dates on number of seed pod⁻¹ of soybean

The variation in the number of seeds pod⁻¹ resulting from different sowing dates did not have a significant effect in either years.

4.1.2.3.2 Effect of integrated weed management on number of seed pod⁻¹ of soybean.

The no. of seeds pod⁻¹, influenced by integrated weed management did not lead to a notable difference in either year.

4.1.2.3.3 Interaction effect of sowing dates and integrated weed management number of seed pod⁻¹ of soybean.

Table 4.10 (b) revealed that interaction of sowing dates and integrated weed management does not significantly effect on number of seeds pod⁻¹.

4.1.2.4 Test weight (100 seed wt.) (g)

It is an important yield determination factor of a crop and it expresses the magnitude of seed development for obtaining better seed quality and yield potential per hectare. The Table 4.10 (a) and Table 4.10 (b) presents data on the impact of sowing dates and integrated weed management on the seed index.

4.1.2.4.1 Effect of sowing dates on test weight of soybean

The sowing dates showed a significant effect on the test weight of soybean seed in both years. Higher test weight was associated with soybean sown on 15th June compared to the subsequent delayed sowing on 30th June and 15th July during both years of experimentation. This result could be attributed to the short vegetative growth period and the long reproductive and seed-filling time, which increased 100-seed weight. Furthermore, this increase in the 100-seed weight is most likely associated with soybean plants' ability to boost photosynthesis, resulting in an increase in the accumulation of nutrients in soybean seeds. The outcome of this experiment is in accordance with Kumagai and Takahashi (2020).

4.1.2.4.2 Effect of integrated weed management on test weight of soybean

In both years, integrated weed management showed a significant effect on the test weight of soybean seed. Weed management with hand weeding at 20 and 40 DAS (W_6) recorded a significantly higher pooled value of test weight (11.43 g). It was at par with W_3 (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). The increase in the seed test wt. can be attributed to greater availability of photosynthates and improved partitioning of dry-weight production. Weedy check (W_7) recorded a significantly lower hundred-grain weight (8.83 g). The results conform with that of Samim et al. (2023).

4.1.2.4.3 Interaction effect of sowing dates and integrated weed management on test weight of soybean.

As indicated in Table 4.10 (b), the timing of sowing combined with integrated weed management did not significantly affect test weight.

4.1.2.5 Seed yield (kg ha⁻¹)

The seed yield of a crop is the net result of interaction among various yield attributes that are influenced and affected by various environment and crop management practices and is a valid criterion for comparing the effectiveness of various treatments. The data on the seed yield of soybean during both the years of experimentation as influenced by sowing and integrated weed management are presented in Table 4.11(a), Table 4.11(b), Fig 4.1 and Fig 4.2.

Table 4.10(a) Effect of sowing dates and integrated weed management treatments on yield attributes of soybean

Treatments	Number of pods plant ⁻¹			Pod length (cm)			Number of seeds pod ⁻¹			100- seed weight (g)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	66.62	69.78	68.20	3.54	3.66	3.60	2.63	2.66	2.64	10.53	10.72	10.63
P₂ 30th June	63.35	65.02	64.18	3.50	3.52	3.51	2.54	2.62	2.58	10.00	10.25	10.13
P₃ 15th July	35.53	37.11	36.32	3.47	3.48	3.47	2.49	2.52	2.51	9.57	9.87	9.72
SEm±	1.29	1.32	0.92	0.04	0.04	0.03	0.03	0.04	0.03	0.16	0.12	0.10
CD at 5%	5.06	5.18	3.01	NS	NS	NS	NS	NS	NS	0.61	0.48	0.32
Integrated weed Management (W)												
W₁	50.64	52.51	51.57	3.50	3.54	3.52	2.53	2.56	2.55	9.60	10.21	9.90
W₂	49.17	50.08	49.62	3.48	3.53	3.50	2.50	2.52	2.51	9.03	9.92	9.47
W₃	65.79	67.05	66.42	3.54	3.56	3.55	2.62	2.68	2.65	11.15	10.70	10.92
W₄	53.13	58.96	56.05	3.50	3.54	3.52	2.53	2.59	2.56	9.94	10.30	10.12
W₅	59.18	61.26	60.22	3.52	3.55	3.53	2.59	2.63	2.61	10.41	10.45	10.43
W₆	72.10	73.10	72.60	3.56	3.63	3.59	2.68	2.74	2.71	11.90	10.96	11.43
W₇	36.16	38.17	37.16	3.44	3.50	3.47	2.44	2.48	2.46	8.22	9.43	8.83
SEm±	2.20	2.29	1.59	0.05	0.06	0.04	0.07	0.06	0.05	0.29	0.21	0.18
CD at 5%	6.31	6.57	4.47	NS	NS	NS	NS	NS	NS	0.84	0.62	0.51

Table 4.10(b) Interaction effect of sowing dates and integrated weed management treatments on yield attributes of soybean

Treatments	Number of pods plant ⁻¹			Pod length (cm)			Number of seeds pod ⁻¹			100- seed weight (g)		
	2021	2022	Pooled	2021	2021	2022	Pooled	2021	2021	2022	Pooled	2021
P₁W₁	61.79	64.28	63.03	3.53	3.62	3.58	2.60	2.60	2.60	10.26	10.50	10.38
P₁W₂	61.51	61.29	61.40	3.51	3.61	3.56	2.60	2.60	2.60	9.40	10.36	9.88
P₁W₃	77.67	81.94	79.81	3.57	3.67	3.62	2.67	2.73	2.70	11.70	11.14	11.42
P₁W₄	63.78	72.70	68.24	3.55	3.62	3.59	2.60	2.67	2.63	10.60	10.61	10.60
P₁W₅	71.77	74.98	73.38	3.57	3.63	3.60	2.67	2.67	2.67	11.07	10.71	10.89
P₁W₆	84.68	85.53	85.11	3.59	3.85	3.72	2.73	2.80	2.77	12.41	11.52	11.97
P₁W₇	45.14	47.73	46.44	3.47	3.59	3.53	2.53	2.53	2.53	8.30	10.24	9.27
P₂W₁	59.09	58.79	58.94	3.50	3.52	3.51	2.53	2.60	2.57	9.49	10.28	9.88
P₂W₂	55.76	57.05	56.40	3.47	3.51	3.49	2.47	2.53	2.50	9.04	9.88	9.46
P₂W₃	74.99	75.59	75.29	3.55	3.53	3.54	2.60	2.67	2.63	11.07	10.67	10.87
P₂W₄	62.22	66.69	64.46	3.51	3.52	3.51	2.53	2.60	2.57	9.88	10.34	10.11
P₂W₅	67.94	69.15	68.55	3.52	3.53	3.52	2.60	2.67	2.63	10.38	10.47	10.43
P₂W₆	82.04	83.40	82.72	3.56	3.54	3.55	2.67	2.73	2.70	11.80	10.93	11.37
P₂W₇	41.38	44.48	42.93	3.43	3.48	3.46	2.40	2.53	2.47	8.36	9.18	8.77
P₃W₁	31.03	34.46	32.75	3.46	3.48	3.47	2.45	2.49	2.47	9.05	9.85	9.45
P₃W₂	30.24	31.90	31.07	3.44	3.47	3.46	2.45	2.43	2.44	8.64	9.52	9.08
P₃W₃	44.71	43.62	44.17	3.52	3.49	3.50	2.58	2.63	2.60	10.67	10.29	10.48
P₃W₄	33.38	37.50	35.44	3.46	3.48	3.47	2.45	2.49	2.47	9.35	9.93	9.64
P₃W₅	37.83	39.64	38.74	3.47	3.49	3.48	2.51	2.56	2.54	9.77	10.16	9.97
P₃W₆	49.57	50.37	49.97	3.54	3.49	3.52	2.65	2.69	2.67	11.49	10.43	10.96
P₃W₇	21.94	22.31	22.13	3.41	3.44	3.42	2.38	2.36	2.37	7.99	8.87	8.43
SEm± (PxW)	3.81	3.97	2.75	0.08	0.10	0.07	0.12	0.11	0.08	0.51	0.37	0.32
SEm± (WxP)	2.75	2.83	1.97	0.07	0.08	0.05	0.07	0.08	0.05	0.35	0.26	0.22
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

4.1.2.5.1 Effect of sowing dates on seed yield of soybean.

The optimization of planting dates is an imperative and least expensive agricultural strategy that influences soybean yield (Robinson *et al.*, 2009). Significant differences in seed yield were observed among the various sowing dates, yield of soybean progressively decreased with delayed sowing from June 15th to 15th July. The highest seed yield (1944.11, 2084.96 kg ha⁻¹) was noted for the 15th June sowing date, followed by June 30th. Early sowing of soybean was more beneficial for plants owing to the increased cumulative solar radiation (Kumagai 2017) and the optimum period available throughout the vegetative growth and reproductive phase might have enhanced better growth and yield attributes, which led to the accumulation of large quantities of photosynthates in seed (sink) and better yield-related traits and prolonged pod-filling period after flowering under earlier planted crops compared to those planted later. The increase in yield due to early sowing on 15th June was 15.93 %, 13.22 %, and 41.10 %, 34.75 % higher over June 30th and July 15th, respectively, over both years of experimentation. The lowest seed yield (1145.17, 1360.35 kg ha⁻¹) was obtained on the late sown soybean crop on 15th July. Bateman *et al.* (2020) also noted that delayed sowing reduced the time required for plant growth and development from 122 to 83 days. The results conform with those of Taware *et al.* (2015) and Tupe *et al.* (2023).

4.1.2.5.2 Effect of integrated weed management on seed yield of soybean

Weed can cause computational stress on soybean growth and reduction of the yield by 58 – 85 %, depending on the intensity of infestation (Meena *et al.*, 2020). The significance of integrated weed management on soybean was evident in both years of the experiment as well as in the pooled value from two years.

Significant maximum seed yield (2145.69, 2285.12 kg ha⁻¹) was recorded from W₆ (hand weeding at 20 and 40 DAS) followed by W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) during both years and pooled value. The minimum seed yield of 738.94 and 890.88 kg ha⁻¹ was obtained in the weedy check (W₇) during the first and second years, which was 65.56 and 61.01 % lower than the W₆ (Hand weeding at 20 and 40 DAS). Meena *et al.* (2018) also found similar results on significantly lower yield on weedy check compared to all the

treatments. Also, they reported a minimum seed yield in the weedy check with a yield reduction of up to 69.68 %.

Higher seed yield in treatments W₆ (Two hand weeding) and W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) can be attributed to the prevention of weed competition, non-phytotoxicity and providing a weed-free environment at critical period resulting in better nutrients, light, moisture availability and uptake which helped in the attainment of optimum crop growth and enhanced yield attributes resulting in higher yield. These results were in line with earlier findings of Vijay *et al.* (2018), Pawar *et al.* (2022) and Roy *et al.* (2023).

4.1.2.5.3 Interaction effect of sowing dates and integrated weed management on seed yield of soybean

The interaction effect of sowing dates and integrated weed management on seed yield was found to be significant. Data presented in Table 4.11 (b) revealed that the sowing of soybean on 15th June, along with hand weeding at 20 and 40 DAS (W₆), recorded significantly highest seed yield in both years, followed by W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). These were significantly superior to other treatment combinations in both years of study. While sowing on 15th July, in combination with a weedy check (W₇), gave the lowest yield.

Favourable climatic conditions and photoperiod at the time of flowering and pod-filling stages, along with effective weed management, might have helped the plant to utilize the resources efficiently, resulting in higher growth and yield attributes and ultimately higher yield. Hamoda *et al.* (2021) also revealed that the interaction between earlier planting date and hand hoeing twice recorded the maximum values of the number of pods, weight of seeds, 100 seed weight, and seed yield (1427.67 kg ha⁻¹).

4.1.2.6 Stover yield (kg ha⁻¹)

Data of stover yield recorded for both the years of experiments for different sowing dates and integrated weed management treatments are mentioned in Table 4.11 (a) and Table 4.11 (b).

4.1.2.6.1 Effect of sowing dates on stover yield of soybean

Significant differences in stover yield were recorded due to the sowing dates

and it is evident from the data that stover yield progressively decreased with delay in sowing. Soybean sown on 15th June recorded significantly highest stover yield (2401.63, 2482.01 kg ha⁻¹) followed by 30th June. The lowest stover yield was witnessed under the late sowing of soybean on 15th July (2122.94, 2145.11 kg ha⁻¹), which is 11.60, 13.57 % lower than the 15th June sowing date.

Higher stover yield in earlier sowing of soybean crops be likely because of efficient utilization of resources and an extended vegetative growth phase resulting in higher plant height, a more significant number of branches plant⁻¹, higher dry matter accumulation and ultimately, stover yield. The results conform with those of Sikka *et al.* (2018) and Tupe *et al.* (2023).

4.1.2.6.2 Effect of integrated weed management on stover yield of soybean

Different integrated weed management significantly influences the stover yield. Significantly maximum values (2787.64, 2768.31 kg ha⁻¹) were recorded from W₆ (Hand weeding at 20 and 40 DAS) and at par with application pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) during both years and pooled value. The minimum stover yield of 1478.02, 1497.75 kg ha⁻¹ was obtained in weedy check (W₇) because of poor assimilation of photosynthate in the source. Ahirwar and Ahirwar (2023) also reported a minimum stover yield in the weedy check with a yield loss of 29.37 %.

Higher stover yield in W₆ (Hand weeding at 20 and 40 DAS) and W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) can be attributed to enhanced photosynthate production in source, improved partitioning in different plant parts and prevention of weed competition. This weed-free environment during critical period facilitates enhanced crop growth, increased branching and greater dry matter production, thereby ensuring maximum vegetative growth and yields components of soybean plant. Consistent with seed yield, the increase in stover yield may be ascribed to the beneficial effect of a weed-free environment (Raj *et al.*, 2019). Jaiswal and Lakpale (2022) have reported comparable findings.

4.1.2.6.3 Interaction effect of sowing dates and integrated weed management on the stover yield of soybean

As demonstrated by the finding in Table 4.11 (b), the interaction between sowing dates and integrated weed management did not exert a significant influence on stover yield in either year.

4.1.2.7 Biological yield (kg ha⁻¹)

The data pertaining to biological yield, as recorded during 2021 and 2022 for various treatments are presented in Table 4.11 (a) and Table 4.11 (b).

4.1.2.7.1 Effect of sowing dates on biological yield of soybean

Significant differences in biological yield were recorded due to the sowing dates. Early sowing of soybean on 15th June recorded significantly the highest biological yield (4345.74, 4566.97 kg ha⁻¹) followed by 30th June. The lowest biological yield (3268.11, 3505.46 kg ha⁻¹) was observed under the late sowing date of 15th July. The higher biological yield in early sowing of soybean crops compared to late sowing is confirmed by the findings of Nath *et al.* (2017) and Tupe *et al.* (2023).

4.1.2.7.2 Effect of integrated weed management on biological yield of soybean

The implementation of different integrated weed management significantly influenced the biological yield in both years. Weed management with hand weeding at 20 and 40 DAS (W₆) recorded significant maximum biological yield in first year (4933.34 kg ha⁻¹) but was found at par with W₃ (Pendimethalin 30 EC @1kg ha⁻¹ *fb* imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in the second year; the lowest biological yield of 2216.96 kg ha⁻¹ and 2388.63 kg ha⁻¹ was obtained from weedy check (W₇) during both years.

The increased biological yield observed in associated with hand weeding and herbicide application can be attributed to the elimination of weed competition, thereby maintaining a weed-free environment during critical growth stages. This condition facilitates the enhanced development of plant traits, crop growth and additional branching. These findings align with those reported by Akter *et al.* (2016).

4.1.2.7.3 Interaction effect of sowing dates and integrated weed management on the biological yield of soybean

The findings presented in Table 4.11 (b) indicate that the interaction between sowing dates and IWM did not exert a statistically significant effect on the biological yield in either year.

4.1.2.8 Harvest Index (%)

The harvest index is a measure of the physiological productivity of the crop and the ability of a plant to convert the dry matter into economic yield. Data on harvest index recorded during 2021 and 2022 for different treatments are presented in Table 4.11 (a) and Table 4.11 (b).

4.1.2.8.1 Effect of sowing dates on harvest index of soybean.

Soybean sown on the 15th of June recorded a significantly higher harvest index (45.40 %) in second year but data pertaining to the first year of the 30th of June was found to be at par with the sowing date of the 15th of June. The lowest harvest index (34.42, 38.24 %) was found on the late sowing date of 15th July; this can be due to poor development of pods and seeds due to lower temperature.

This could be a result of early sowing's cumulative impact on all growth factors, including plant height, number of branches and dry weight of plant, as described earlier. These findings are consistent with those reported by Tupe *et al.* (2023).

4.1.2.8.2 Effect of integrated weed management on harvest index of soybean.

The Harvest index of soybeans was influenced significantly by different integrated weed management. Hand weeding at 20 and 40 DAS (W₆) recorded significantly higher values (43.17, 45.13 %) than other weed management treatments except values were observed to be at par with W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) and W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS) during both years. The lowest harvest index (33.05, 37.14%) was recorded in W₇ (Weedy check) as compared to the rest of the treatments in both years, and this can be due to poor partitioning of photosynthates towards the sink.

Table 4.11(a) Effect of sowing dates and integrated weed management treatments on yield of soybean

Treatments	Grain yield (kg ha ⁻¹)			Stover yield (kg ha ⁻¹)			Biological yield (kg ha ⁻¹)			Harvest index (%)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1944.11	2084.96	2014.54	2401.63	2482.01	2441.82	4345.74	4566.97	4456.36	44.39	45.40	44.89
P₂ 30th June	1634.39	1809.32	1721.86	2271.17	2387.92	2329.54	3905.56	4197.24	4051.40	40.80	42.64	41.72
P₃ 15th July	1145.17	1360.35	1252.76	2122.94	2145.11	2134.02	3268.11	3505.46	3386.79	34.42	38.24	36.33
SEm±	49.28	23.90	27.39	50.06	51.12	35.78	46.46	72.86	43.21	1.12	0.38	0.59
CD at 5%	193.51	93.84	89.31	196.58	200.74	116.68	182.42	286.10	140.91	4.41	1.51	1.94
Integrated weed Management (W)												
W₁	1432.03	1623.47	1527.75	2124.16	2242.63	2183.39	3556.19	3866.10	3711.14	39.48	41.39	40.44
W₂	1261.81	1491.63	1376.72	1917.53	2122.29	2019.91	3179.34	3613.92	3396.63	39.00	40.90	39.95
W₃	1976.04	2130.54	2053.29	2632.99	2685.46	2659.22	4609.02	4816.00	4712.51	42.57	44.13	43.35
W₄	1646.48	1845.29	1745.89	2357.23	2437.69	2397.46	4003.71	4282.98	4143.35	40.61	42.81	41.71
W₅	1820.93	1993.88	1907.41	2559.15	2614.29	2586.72	4380.08	4608.17	4494.13	41.19	43.12	42.16
W₆	2145.69	2285.12	2215.41	2787.64	2768.31	2777.298	4933.34	5053.44	4993.39	43.17	45.13	44.15
W₇	738.94	890.88	814.91	1478.02	1497.75	1487.89	2216.96	2388.63	2302.80	33.05	37.14	35.09
SEm±	39.65	34.35	26.23	73.28	87.90	57.22	84.93	98.80	65.14	0.98	1.06	0.72
CD at 5%	113.72	98.52	73.95	210.19	252.11	161.32	243.58	283.38	183.65	2.80	3.05	2.04

Table 4.11(b) Interaction effect of sowing dates and integrated weed management treatments on yield of soybean

Treatments	Grain yield (kg ha ⁻¹)			Stover yield (kg ha ⁻¹)			Biological yield (kg ha ⁻¹)			Harvest index (%)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1930.06	2074.95	2002.51	2433.46	2518.28	2475.87	4363.53	4593.23	4478.38	44.25	45.17	44.71
P₁W₂	1630.42	1798.19	1714.30	2116.85	2214.48	2165.67	3747.27	4012.67	3879.97	43.56	44.85	44.21
P₁W₃	2323.00	2456.67	2389.83	2653.39	2805.17	2729.28	4976.38	5261.84	5119.11	46.70	46.97	46.84
P₁W₄	2051.17	2206.70	2128.93	2542.90	2584.64	2563.77	4594.07	4791.34	4692.71	44.72	46.14	45.43
P₁W₅	2152.32	2360.58	2256.45	2562.72	2710.23	2636.47	4715.04	5070.81	4892.92	45.66	46.64	46.15
P₁W₆	2495.45	2583.16	2539.30	2845.43	2914.65	2880.04	5340.87	5497.80	5419.34	46.73	46.99	46.86
P₁W₇	1026.36	1114.47	1070.42	1656.67	1626.64	1641.65	2683.02	2741.12	2712.07	39.11	41.01	40.06
P₂W₁	1460.61	1675.78	1568.20	2120.51	2222.97	2171.74	3581.12	3898.76	3739.94	40.84	42.97	41.91
P₂W₂	1319.66	1589.58	1454.62	1958.73	2182.27	2070.50	3278.39	3771.85	3525.12	40.21	42.45	41.33
P₂W₃	2102.82	2190.90	2146.86	2669.48	2762.27	2715.88	4772.31	4953.18	4862.74	44.14	44.24	44.19
P₂W₄	1747.51	1930.85	1839.18	2367.83	2518.16	2442.99	4115.34	4449.01	4282.17	42.66	43.36	43.01
P₂W₅	1940.77	2065.24	2003.00	2599.74	2683.35	2641.54	4540.51	4748.58	4644.55	42.70	43.47	43.08
P₂W₆	2268.55	2334.92	2301.74	2787.83	2814.75	2801.29	5056.39	5149.67	5103.03	44.89	45.42	45.16
P₂W₇	600.81	877.97	739.39	1394.06	1531.67	1462.86	1994.87	2409.63	2202.25	30.15	36.54	33.34
P₃W₁	905.41	1119.67	1012.54	1818.49	1986.64	1902.57	2723.91	3106.32	2915.11	33.35	36.04	34.69
P₃W₂	835.34	1087.11	961.23	1677.01	1970.13	1823.57	2512.35	3057.24	2784.80	33.24	35.40	34.32
P₃W₃	1502.29	1744.04	1623.17	2576.09	2488.94	2532.52	4078.38	4232.98	4155.68	36.87	41.20	39.03
P₃W₄	1140.76	1398.32	1269.54	2160.97	2210.28	2185.62	3301.73	3608.60	3455.17	34.46	38.93	36.70
P₃W₅	1369.69	1555.83	1462.76	2515.00	2449.29	2482.14	3884.69	4005.12	3944.90	35.22	39.26	37.24
P₃W₆	1673.08	1937.30	1805.19	2729.67	2575.54	2652.61	4402.75	4512.84	4457.79	37.89	42.96	40.42
P₃W₇	589.65	680.19	634.92	1383.33	1334.95	1359.14	1972.98	2015.14	1994.06	29.89	33.86	31.88
SEm± (PxW)	68.68	59.50	45.43	126.93	152.25	99.11	147.10	171.13	112.83	1.69	1.84	1.25
SEm± (WxP)	88.00	48.04	50.13	101.19	109.33	74.49	101.84	143.95	88.17	2.03	1.05	1.14
CD at 5%	196.98	170.65	128.08	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	312.30	156.12	153.73	NS	NS	NS	NS	NS	NS	NS	NS	NS

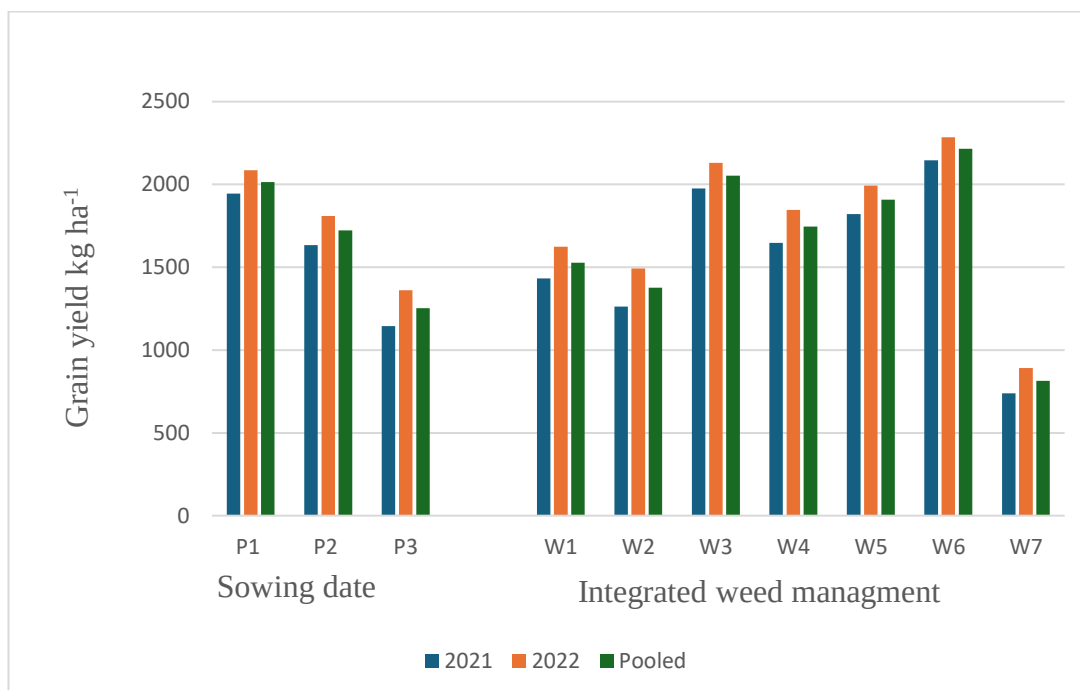


Fig. 4.1 Effect of sowing dates and integrated weed management on seed yield of soybean

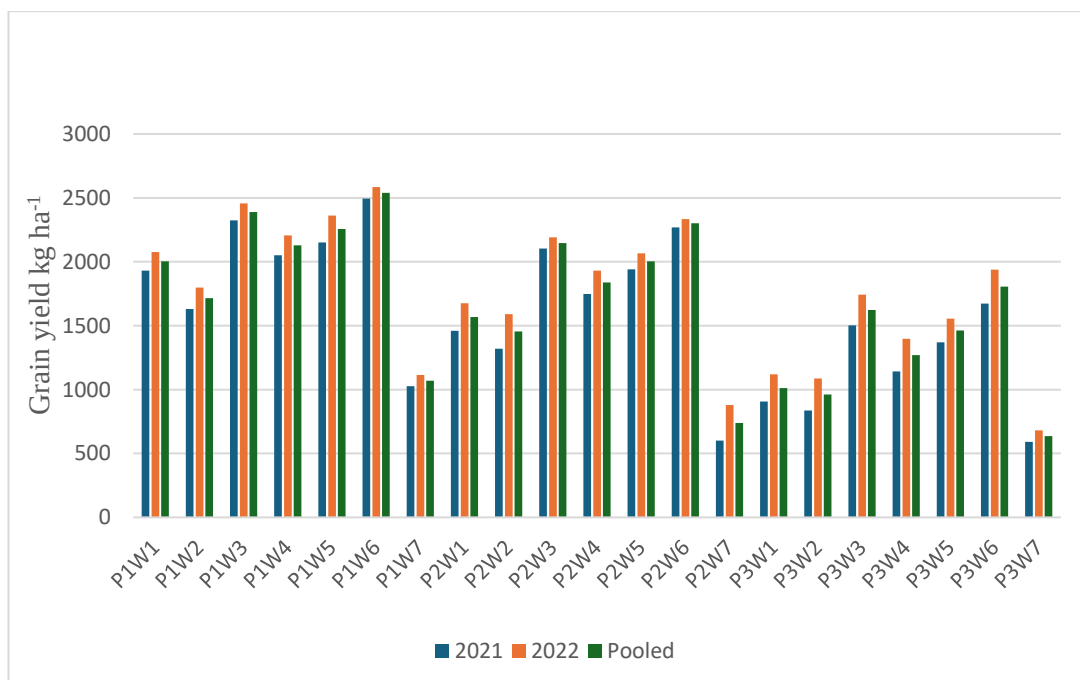


Fig 4.2 Interaction effect of sowing dates and integrated weed management on seed yield of soybean

Two-hand weeding and integrated herbicide application recorded a higher harvest index compared to the weedy check. This outcome is likely attributable to an increased coefficient of photosynthate partitioning to the sink (seed), which is facilitated by enhanced sink capacity, thereby leading to greater seed productivity. This conformed with the findings of Raj *et al.* (2020).

4.1.2.8.3 Interaction effect of sowing dates and integrated weed management on the biological yield of soybean

The interaction effect on the harvest index of soybeans was not statistically significant due to the different sowing dates and integrated weed management methods, as given in Table 4.11 (b).

4.1.3 Quality parameters

4.1.3.1 Protein content (%)

4.1.3.1.1 Effect of sowing dates on protein content of soybean

Data regarding protein content is presented in Table 4.12 (a) and Table 4.12 (b). Vollmann *et al.*, (2000) mentioned that high protein content in seeds largely depended on high temperature and moderate total rainfall over seed filling, which, however, did not observe any significant effect on the protein content of soybean in the present research in both years.

4.1.3.1.2 Effect of integrated weed management on protein content of soybean

The protein content was significantly influenced by the implementation of integrated weed management. The treatment W₆ (Hand weeding at 20 and 40 DAS) exhibited slightly higher values (38.79, 39.07 %) than other weed management treatments. Statistically, these result was at par with those treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) and W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS) in both years. Weedy check (W₇) with 33.66 and 33.92 % protein content were recorded as the lowest.

The equally higher seed protein content in W₆, W₃, and W₅ treatments by weed control measures could be attributed to better nitrogen content, resulting in equal synthesis of protein through amino acids associated with N-absorption and N-

metabolism. The presence of weeds throughout the growing season in weedy check plots contributes to reducing the protein content. The higher content of protein in weed control treatment was also mentioned in the findings of Peer *et al.* (2013) and Khalifa *et al.* (2020).

4.1.3.1.3 Interaction effect of sowing dates and integrated weed management on protein content of soybean

It can be observed from the data presented in Table 4.12 (b) that the interaction of sowing dates and integrated weed management did not exert a statistically significant effect on protein content in either of the years studied.

4.1.3.2 Protein yield (kg ha⁻¹)

4.1.3.2.1 Effect of sowing dates on protein yield of soybean

Data regarding protein yield, as presented in Table 4.12 (a) and Table 4.12 (b) revealed that the sowing dates significantly affects the protein yield of soybean. Significantly, the highest protein yield (723, 783.16 kg ha⁻¹) was observed on the 15th of June, followed by the sowing date 30th of June. The lowest yield (416.40, 500.58 kg ha⁻¹) was found on 15th of July in both years. This could be a result of optimal sowing's cumulative effect on all growth and yield attributes, resulting in the highest protein yield.

4.1.3.2.2 Effect of integrated weed management on protein yield of soybean

The implementation of Integrated Weed Management (IWM) was observed to have a significant impact on protein yield. Specifically, two hand weeding (W₆) resulted in the highest protein yields, measuring 831.06 and 893.90 kg ha⁻¹, respectively, across both years. In contrast, the weedy check (W₇) recorded the lowest protein yields, with values of 249.22 and 302.61 kg ha⁻¹ in the same period.

The substantial increase in protein yield can be attributed to the reduction in crop-weed competition for limited resources and the minimal nutrient depletion by weeds. This scenario facilitated optimal nutrient uptake by the crop, ultimately enhancing the nutrient concentration in the soybean seeds (Jadon *et al.*, 2019).

Table 4.12(a): Effect of sowing dates and integrated weed management treatments on protein content and protein yield of soybean

Treatments	Protein content (%)			Protein yield (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)						
P₁ 15th June	36.81	37.19	37.00	723.00	783.16	753.08
P₂ 30th June	36.48	36.80	36.64	605.33	673.67	639.50
P₃ 15th July	35.90	36.29	36.10	416.40	500.58	458.49
SEm±	0.79	0.46	0.46	10.32	10.30	7.29
CD at 5%	NS	NS	NS	40.51	40.44	23.77
Integrated weed Management (W)						
W₁	35.59	36.10	35.84	510.45	587.86	549.16
W₂	34.46	34.76	34.61	436.28	518.99	477.64
W₃	38.29	38.67	38.48	757.53	824.83	791.18
W₄	36.80	37.27	37.04	607.06	688.79	647.92
W₅	37.19	37.54	37.36	679.43	750.31	714.87
W₆	38.79	39.07	38.93	831.06	893.90	862.48
W₇	33.66	33.92	33.79	249.22	302.61	275.91
SEm±	0.88	0.77	0.59	20.05	18.09	13.50
CD at 5%	2.53	2.21	1.65	57.51	51.87	38.06

Table 4.12(b): Interaction effect of sowing dates and integrated weed management treatments on protein content and protein yield of soybean

Treatments	Protein content (%)			Protein yield (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	36.05	36.60	36.33	695.89	758.81	727.35
P₁W₂	34.93	35.17	35.05	569.10	632.78	600.94
P₁W₃	38.75	39.23	38.99	899.14	963.92	931.53
P₁W₄	36.94	37.67	37.30	756.86	830.73	793.79
P₁W₅	37.54	37.94	37.74	810.13	895.73	852.93
P₁W₆	39.25	39.41	39.33	979.76	1017.93	998.84
P₁W₇	34.19	34.31	34.25	350.14	382.19	366.17
P₂W₁	35.60	36.19	35.90	517.28	606.74	562.01
P₂W₂	34.42	34.69	34.55	454.69	551.37	503.03
P₂W₃	38.24	38.51	38.37	804.63	843.36	824.00
P₂W₄	37.08	37.35	37.22	648.02	721.17	684.60
P₂W₅	37.45	37.72	37.58	727.21	779.74	753.47
P₂W₆	38.91	39.18	39.05	883.08	915.13	899.10
P₂W₇	33.69	33.96	33.83	202.38	298.20	250.29
P₃W₁	35.10	35.50	35.30	318.20	398.02	358.11
P₃W₂	34.04	34.44	34.24	285.06	372.81	328.93
P₃W₃	37.88	38.27	38.07	568.82	667.20	618.01
P₃W₄	36.39	36.79	36.59	416.29	514.47	465.38
P₃W₅	36.57	36.97	36.77	500.96	575.47	538.21
P₃W₆	38.21	38.61	38.41	630.33	748.63	689.48
P₃W₇	33.09	33.49	33.29	195.12	227.45	211.29
SEm± (PxW)	1.53	1.34	1.02	34.73	31.32	23.38
SEm± (WxP)	1.49	0.97	0.89	23.22	22.21	16.07
CD at 5%	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS



Plate 1: Field layout and solarization with black polythene sheet



Plate 2: Paddy straw mulching



Plate 3: Herbicides application



Plate 4: Germination stage of soybean



Plate 5: Early growth stage of soybean



Plate 6: Root nodule of soybean



Plate 7: Flowering stage



Plate 8: Pod formation stage



Plate 9: Maturity stage of soybean



Plate 10: Harvest



Plate 11: Threshing and cleaning.



Plate 12: Soybean seed



Plate 13: Effect of 15th June and Hand weeding at 20 and 40 DAS



**Plate 14: Effect of 15th June and Pendimethalin 30 EC @ 1 kg a.i. ha⁻¹ fb
Imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS**



Plate 15: Effect of 15th July and Weedy check at 40 DAS



Plate 16: General view of the experimental field

4.1.3.2.3 Interaction effect of sowing dates and integrated weed management on protein content of soybean

The study found that there was no significant effect on protein yield due to the interaction of sowing dates and integrated weed management in both the years of experiment and the pooled value of two years as given in table 4.12 (b).

4.2 OBSERVATION OF WEED

4.2.1 Weed flora

Fourteen weed species were identified predominantly in the experimental field. The weed flora observed in the experimental field were identified and recorded as grasses, sedges, and broad-leaved weeds. The dominant species of grasses were *Digitaria sanguinalis*, *Eleusine indica*, and *Cynadon dactylon*. Among the sedges, *Cyperus iria* and *Cyperus rotundus* were prevalent, while the broadleaved weeds were primarily represented by *Ageratum conyzoides*, *Amaranthus viridis*, *Borreria latifolia*, *cleome rutidosperma*, *Mimosa pudica*, *Mollugo pentaphylla*, *Scorparia dulcis*, *Alternanthera sessilis* and *commelina benghalensis*. Similar weed species were reported in soybean field by Sangeetha *et al.* (2012), Panda *et al.* (2015) and Apon and Nongmaithem (2022).

4.2.2 Weed population (no. m⁻²) at 20, 40, 60 DAS and harvest

4.2.2.1 Weed population (no. m⁻²) of *Digitaria sanguinalis*

The data on weed population (no. m⁻²) of *Digitaria sanguinalis* at 20, 40, 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years are presented in Table 4.14 (a) and Table 4.14 (b).

Table 4.13 Weed flora of the experiment field

Sl. No.	Scientific name	Common name	Family	Ontogeny
Grasses				
1	<i>Cynadon dactylon</i>	Doob grass	Poaceae	Perennial
2	<i>Digitaria sanguinalis</i>	Crab grass	Poaceae	Annual
3	<i>Eleusine indica</i>	Goose grass	Poaceae	Annual

Sedges				
1	<i>Cyperus iria</i>	Rice flat sedge	Cyperaceae	Annual
2	<i>Cyperus rotundus</i>	Nut garss	Cyperaceae	Annual
Broad leaf weeds				
1	<i>Ageratum conyzoides</i>	Billy goat weed	Asteraceae	Annual
2	<i>Alternanthera sessilis</i>	Dwarf copperleaf	Amaranthaceae	Perennial
3	<i>Amaranthus viridis</i>	Green amaranth	Amaranthaceae	Annual
4	<i>Borreria latifolia</i>	Broadleaf buttonweed	Rubiaceae	Annual
5	<i>Cleome rutidosperma</i>	Fringed soider flower	Cleomaceae	Annual
6	<i>Commelina benghalensis</i>	Day flower	Marsileaceae	Perennial
7	<i>Mimosa pudica</i>	Touch me-not	Fabaceae	Annual
8	<i>Mollugo pentaphylla</i>	Carpet weed	Molluginaceae	Annual
9	<i>Scorparia dulcis</i>	Sweet broom	Scorophulariaceae	Annual

4.2.2.1.1 Effect of sowing dates on population (no. m⁻²) of *Digitaria sanguinalis*

An inquisition of two years' data and their pooled value on weed population of *Digitaria sanguinalis* revealed that sowing date were found to be significant at all the stages of observation except at harvest, which was non-significant. At 20, 40, and 60 DAS pooled values of two years recorded significantly lower population (3.80, 3.05 and 4.33, respectively) on sowing date 15th of June, while the highest population (5.67, 4.66 and 5.70, respectively) was observed when the crop was sown on the 15th of July.

4.2.2.1.2 Effect of integrated weed management on population (no. m⁻²) of *Digitaria sanguinalis*

Integrated weed management significantly affected the weed population of *Digitaria sanguinalis* at all stages of observation in both years and their pooled value.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly



Digitaria sanguinalis



Eleusine indica



Cynodon dactylon

Plate 17. Grasses weed observed in the experimental field



Cyperus iria



Cyperus rotundus

Plate 18. Sedges weed observed in the experimental field



Ageratum conyzoides



Amaranthus viridis



Borreria latifolia



Cleome rutidosperma

Plate 19 (a). Broadleaf weed observed in the experimental field



Mimosa pudica



Mollugo pentaphylla



Scorparia dulcis



Alternanthera sessilis



Commelina benghalensis

Plate 19 (b). Broadleaf weed observed in the experimental field

lowest weed density (3.52 and 2.67, respectively) of *Digitaria sanguinalis* in treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) which was followed by treatments W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 5.64 and 6.58 recorded the highest weed population in W₇ (Weedy check) at both stages.

At 60 DAS and harvest, W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lower population of 3.70 and 2.96, respectively, followed by the application of treatments W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). The highest pooled value (7.33 and 6.82, respectively) of weed population was recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.1.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Digitaria sanguinalis*

Results presented in Table 4.14 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect on the population of *Digitaria sanguinalis* in both years and their pooled value at all the stages of observation.

4.2.2.2 Weed population (no. m⁻²) of *Eleusine indica*

The data on weed population (no. m⁻²) of *Eleusine indica* at 20, 40, 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years are presented in Table 4.15 (a) and Table 4.15 (b).

4.2.2.2.1 Effect of sowing dates on population (no. m⁻²) of *Eleusine indica*

Results on two years' data and their pooled value on weed of *Eleusine indica* revealed that sowing dates were found to be significant at all the stages of observation except at harvest. At 20, 40, and 60 DAS pooled values of two years recorded significantly lower populations (3.12, 2.91, and 3.38, respectively) of *Eleusine indica* on the sowing date 15th of June, while the highest population (4.46, 3.79 and 4.41, respectively) was observed when the crop was sown on the 15th of July.

Table 4.14(a) Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Digitaria sanguinalis* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	3.22 (10.05)	3.02 (8.87)	3.12 (9.46)	3.11 (10.03)	2.71 (7.34)	2.91 (8.69)	3.48 (13.02)	3.29 (11.26)	3.38 (12.14)	3.07 (9.50)	3.00 (8.74)	3.03 (9.12)
P₂ 30th June	3.71 (13.60)	3.24 (10.48)	3.48 (12.04)	3.43 (12.11)	3.22 (10.36)	3.33 (11.24)	3.91 (15.99)	3.78 (14.80)	3.85 (15.40)	3.33 (10.87)	3.16 (9.73)	3.24 (10.30)
P₃ 15th July	4.58 (21.07)	4.34 (18.81)	4.46 (19.94)	3.82 (14.73)	3.76 (14.33)	3.79 (14.53)	4.59 (21.91)	4.22 (18.85)	4.41 (20.38)	3.36 (11.04)	3.17 (9.71)	3.26 (10.38)
SEm±	0.10	0.09	0.07	0.08	0.08	0.06	0.11	0.10	0.07	0.09	0.08	0.06
CD at 5%	0.40	0.37	0.23	0.31	0.31	0.18	0.44	0.38	0.24	NS	NS	NS
Integrated weed Management (W)												
W₁	4.56 (21.43)	4.20 (17.78)	4.38 (19.61)	4.02 (16.15)	3.24 (11.06)	3.63 (13.61)	5.17 (26.72)	4.97 (25.14)	5.07 (25.93)	4.50 (19.79)	4.39 (18.77)	4.44 (19.28)
W₂	4.96 (25.00)	4.29 (18.61)	4.62 (21.80)	4.10 (16.81)	3.42 (11.85)	3.76 (14.33)	5.29 (27.88)	5.19 (26.71)	5.24 (27.29)	4.78 (22.39)	4.69 (21.47)	4.73 (21.93)
W₃	3.46 (12.55)	3.58 (13.00)	3.52 (12.78)	2.89 (8.43)	2.44 (6.00)	2.67 (7.21)	4.11 (16.80)	3.97 (15.61)	4.04 (16.20)	3.25 (10.09)	2.91 (8.01)	3.08 (9.05)
W₄	3.66 (13.90)	3.72 (13.99)	3.69 (13.94)	3.38 (11.58)	2.80 (8.06)	3.09 (9.82)	4.82 (23.42)	4.64 (21.44)	4.73 (22.43)	4.09 (16.30)	4.01 (15.60)	4.05 (15.95)
W₅	5.94 (35.49)	5.04 (25.44)	5.49 (30.46)	3.11 (9.75)	2.59 (7.09)	2.85 (8.42)	4.67 (22.06)	4.43 (19.40)	4.55 (20.73)	3.49 (11.74)	3.10 (9.17)	3.30 (10.46)
W₆	5.46 (30.05)	4.74 (22.27)	5.10 (26.16)	4.48 (20.21)	3.93 (15.22)	4.21 (17.72)	3.81 (14.24)	3.60 (12.83)	3.70 (13.53)	3.14 (9.40)	2.78 (7.25)	2.96 (8.33)
W₇	6.03 (37.39)	5.25 (27.80)	5.64 (32.60)	7.19 (51.85)	5.97 (35.73)	6.58 (43.79)	7.79 (60.39)	6.87 (47.17)	7.33 (53.78)	7.18 (51.53)	6.45 (41.63)	6.82 (46.58)
SEm±	0.21	0.13	0.12	0.14	0.19	0.12	0.10	0.15	0.09	0.13	0.12	0.09
CD at 5%	0.60	0.37	0.35	0.40	0.56	0.34	0.28	0.42	0.25	0.38	0.34	0.25

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.14(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Digitaria sanguinalis* at 20,40,60 DAS and at harvest.

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	3.52 (11.90)	3.40 (11.07)	3.46 (11.49)	3.36 (10.85)	2.37 (6.50)	2.86 (8.67)	4.40 (18.85)	4.18 (18.17)	4.29 (18.51)	4.39 (18.92)	4.31 (18.15)	4.35 (18.53)
P₁W₂	3.93 (15.00)	3.49 (11.71)	3.71 (13.35)	3.41 (11.12)	2.72 (7.21)	3.06 (9.16)	4.67 (21.29)	4.63 (20.95)	4.65 (21.12)	4.66 (21.28)	4.59 (20.56)	4.63 (20.92)
P₁W₃	2.30 (4.87)	2.85 (7.63)	2.58 (6.25)	1.89 (3.09)	1.70 (2.48)	1.80 (2.78)	3.36 (10.79)	3.04 (9.00)	3.20 (9.89)	3.09 (9.14)	2.77 (7.18)	2.93 (8.16)
P₁W₄	2.56 (6.11)	2.97 (8.32)	2.77 (7.21)	2.39 (5.23)	1.87 (3.17)	2.13 (4.20)	4.05 (15.90)	3.93 (14.91)	3.99 (15.41)	3.92 (14.94)	3.87 (14.49)	3.90 (14.72)
P₁W₅	5.25 (27.04)	4.23 (17.41)	4.74 (22.22)	2.14 (4.10)	1.85 (3.16)	1.99 (3.63)	3.84 (14.23)	3.80 (13.97)	3.82 (14.10)	3.42 (11.25)	3.03 (8.73)	3.23 (9.99)
P₁W₆	4.54 (20.13)	4.18 (17.01)	4.36 (18.57)	3.76 (13.62)	3.46 (11.53)	3.61 (12.57)	3.61 (12.53)	3.38 (10.97)	3.50 (11.75)	3.12 (9.25)	2.81 (7.40)	2.97 (8.32)
P₁W₇	5.39 (29.30)	4.53 (20.07)	4.96 (24.69)	6.65 (43.80)	5.10 (25.58)	5.88 (34.69)	7.29 (52.68)	6.39 (40.70)	6.84 (46.69)	7.32 (53.20)	6.34 (39.89)	6.83 (46.55)
P₂W₁	4.33 (18.30)	3.94 (15.08)	4.14 (16.69)	3.82 (14.16)	3.24 (10.07)	3.53 (12.11)	5.07 (25.21)	4.92 (23.82)	5.00 (24.52)	4.56 (20.30)	4.42 (19.08)	4.49 (19.69)
P₂W₂	4.72 (21.79)	4.04 (15.85)	4.38 (18.82)	3.92 (14.93)	3.31 (10.89)	3.62 (12.91)	5.14 (25.89)	5.02 (24.66)	5.08 (25.27)	4.73 (21.94)	4.65 (21.08)	4.69 (21.51)
P₂W₃	3.29 (10.32)	3.29 (10.31)	3.29 (10.32)	3.07 (8.95)	2.32 (5.00)	2.70 (6.98)	3.57 (12.26)	3.50 (11.76)	3.54 (12.01)	3.23 (9.92)	2.82 (7.48)	3.02 (8.70)
P₂W₄	3.50 (11.80)	3.45 (11.44)	3.48 (11.62)	3.35 (10.75)	2.72 (6.97)	3.04 (8.86)	4.66 (21.44)	4.55 (20.24)	4.61 (20.84)	4.19 (17.05)	4.16 (16.83)	4.17 (16.94)
P₂W₅	5.82 (33.37)	4.95 (24.07)	5.39 (28.72)	3.23 (10.00)	2.38 (6.06)	2.81 (8.03)	4.47 (19.56)	4.43 (19.13)	4.45 (19.34)	3.36 (10.77)	3.03 (8.83)	3.19 (9.80)
P₂W₆	5.27 (27.30)	4.57 (20.52)	4.92 (23.91)	4.27 (17.77)	3.78 (13.84)	4.03 (15.81)	3.81 (14.21)	3.80 (13.96)	3.81 (14.09)	3.27 (10.29)	2.89 (8.00)	3.08 (9.14)

P₂W₇	5.81 (34.75)	5.17 (26.52)	5.49 (30.63)	7.34 (53.53)	6.06 (36.43)	6.70 (44.98)	7.95 (62.80)	6.75 (45.31)	7.35 (54.05)	7.13 (51.40)	6.48 (41.49)	6.81 (46.45)
P₃W₁	5.83 (34.09)	5.26 (27.19)	5.55 (30.64)	4.89 (23.46)	4.13 (16.61)	4.51 (20.03)	6.04 (36.09)	5.81 (33.43)	5.92 (34.76)	4.54 (20.16)	4.42 (19.09)	4.48 (19.62)
P₃W₂	6.22 (38.22)	5.34 (28.27)	5.78 (33.24)	4.98 (24.39)	4.24 (17.46)	4.61 (20.93)	6.07 (36.46)	5.91 (34.51)	5.99 (35.48)	4.93 (23.95)	4.82 (22.76)	4.88 (23.35)
P₃W₃	4.79 (22.47)	4.6 (21.07)	4.69 (21.77)	3.7 (13.25)	3.31 (10.51)	3.51 (11.88)	4.49 (19.67)	4.26 (17.72)	4.38 (18.70)	3.1 (9.13)	2.75 (7.10)	2.92 (8.11)
P₃W₄	4.93 (23.78)	4.75 (22.21)	4.84 (23.00)	4.38 (18.75)	3.81 (14.05)	4.1 (16.40)	5.76 (32.91)	5.44 (29.17)	5.6 (31.04)	4.17 (16.91)	4.00 (15.47)	4.08 (16.19)
P₃W₅	6.76 (46.05)	5.94 (34.84)	6.35 (40.44)	3.95 (15.17)	3.53 (12.06)	3.74 (13.62)	5.71 (32.40)	5.05 (25.09)	5.38 (28.75)	3.7 (13.21)	3.23 (9.95)	3.47 (11.58)
P₃W₆	6.56 (42.71)	5.46 (29.28)	6.01 (36.00)	5.42 (29.24)	4.56 (20.29)	4.99 (24.77)	4.91 (23.64)	4.73 (21.90)	4.82 (22.77)	3.35 (10.75)	3.02 (8.63)	3.19 (9.69)
P₃W₇	6.89 (48.12)	6.06 (36.82)	6.47 (42.47)	7.58 (58.23)	6.74 (45.19)	7.16 (51.71)	8.13 (65.68)	7.48 (55.52)	7.81 (60.60)	7.09 (50.00)	6.53 (43.49)	6.81 (46.75)
SEm± (PxW)	0.36	0.23	0.21	0.24	0.34	0.21	0.17	0.25	0.15	2.91	2.41	1.89
SEm± (WxP)	0.28	0.18	0.17	0.20	0.26	0.16	0.17	0.20	0.13	2.10	2.24	1.54
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

4.2.2.2.2 Effect of integrated weed management on population (no. m⁻²) of *Eleusine indica*

Significant result was recorded on weed population of *Eleusine indica* due to integrated weed management at all stages of observation.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest weed density (3.05 and 2.58, respectively) of *Eleusine indica* in W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) treatment which was followed by treatment W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 4.52 and 4.99 recorded the highest weed population in W₇ (Weedy check) at both stages.

At 60 DAS and harvest, W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lowest population of 2.82 and 2.49, respectively, followed by the application of W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) treatments. The highest pooled value (6.32 and 3.84, respectively) of weed population was recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.2.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Eleusine indica*

Data presented in Table 4.15 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect on the population of *Eleusine indica* in both years and their pooled value at all the stages of observation.

4.2.2.3 Weed population (no. m⁻²) of *Cynodon dactylon*

The data on weed population (no. m⁻²) of *Cynodon dactylon* at 20, 40, 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years are presented in Table 4.16 (a) and Table 4.16 (b).

4.2.2.3.1 Effect of sowing dates on population (no. m⁻²) of *Cynodon dactylon*

An examination of two years' data and their pooled value on weed of *Cynodon dactylon* revealed that sowing dates were found to be significant at all the stages of observation except at harvest. At 20, 40, and 60 DAS pooled values of two years

Table 4.15(a) Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Eleusine indica* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	3.22 (10.05)	3.02 (8.87)	3.12 (9.46)	3.11 (10.03)	2.71 (7.34)	2.91 (8.69)	3.48 (13.02)	3.29 (11.26)	3.38 (12.14)	3.07 (9.50)	3.00 (8.74)	3.03 (9.12)
P₂ 30th June	3.71 (13.60)	3.24 (10.48)	3.48 (12.04)	3.43 (12.11)	3.22 (10.36)	3.33 (11.24)	3.91 (15.99)	3.78 (14.80)	3.85 (15.40)	3.33 (10.87)	3.16 (9.73)	3.24 (10.30)
P₃ 15th July	4.58 (21.07)	4.34 (18.81)	4.46 (19.94)	3.82 (14.73)	3.76 (14.33)	3.79 (14.53)	4.59 (21.91)	4.22 (18.85)	4.41 (20.38)	3.36 (11.04)	3.17 (9.71)	3.26 (10.38)
SEm±	0.10	0.09	0.07	0.08	0.08	0.06	0.11	0.10	0.07	0.09	0.08	0.06
CD at 5%	0.40	0.37	0.23	0.31	0.31	0.18	0.44	0.38	0.24	NS	NS	NS
Integrated weed Management (W)												
W₁	3.58 (12.80)	3.25 (10.90)	3.42 (11.85)	3.22 (10.10)	3.13 (9.52)	3.17 (9.81)	3.93 (15.21)	3.73 (13.71)	3.83 (14.46)	3.49 (11.74)	3.37 (10.88)	3.43 (11.31)
W₂	3.72 (14.02)	3.41 (11.55)	3.56 (12.78)	3.41 (11.22)	3.22 (10.16)	3.32 (10.69)	4.12 (16.86)	3.80 (14.16)	3.96 (15.51)	3.65 (12.90)	3.63 (12.71)	3.64 (12.80)
W₃	3.19 (9.95)	2.91 (8.42)	3.05 (9.19)	2.61 (6.81)	2.55 (6.17)	2.58 (6.49)	3.18 (9.78)	3.08 (9.15)	3.13 (9.46)	2.74 (7.09)	2.72 (6.94)	2.73 (7.02)
W₄	3.47 (12.02)	3.10 (9.63)	3.29 (10.82)	3.05 (8.96)	2.81 (7.55)	2.93 (8.26)	3.74 (13.77)	3.48 (11.82)	3.61 (12.80)	3.24 (10.02)	3.12 (9.25)	3.18 (9.63)
W₅	4.32 (18.58)	3.89 (15.04)	4.10 (16.81)	2.82 (7.62)	2.68 (6.81)	2.75 (7.22)	3.61 (12.84)	3.36 (10.94)	3.49 (11.89)	2.97 (8.43)	2.94 (8.19)	2.96 (8.31)
W₆	3.95 (15.80)	3.77 (14.11)	3.86 (14.95)	3.75 (13.61)	3.53 (12.26)	3.64 (12.93)	2.87 (7.96)	2.78 (7.27)	2.82 (7.61)	2.52 (5.89)	2.45 (5.53)	2.49 (5.71)
W₇	4.63 (21.20)	4.42 (19.40)	4.52 (20.30)	5.30 (27.71)	4.68 (22.26)	4.99 (24.99)	6.51 (42.42)	6.13 (37.75)	6.32 (40.08)	4.13 (17.24)	3.55 (12.24)	3.84 (14.74)
SEm±	0.16	0.15	0.11	0.12	0.13	0.09	0.12	0.13	0.09	0.14	0.07	0.08
CD at 5%	0.45	0.44	0.31	0.35	0.37	0.25	0.35	0.37	0.25	0.39	0.20	0.22

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.15(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Eleusine indica* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	2.98 (8.38)	2.72 (6.90)	2.85 (7.64)	2.88 (7.86)	2.61 (6.29)	2.74 (7.08)	3.47 (11.60)	3.17 (9.57)	3.32 (10.59)	3.47 (11.58)	3.46 (11.49)	3.47 (11.53)
P₁W₂	3.08 (9.00)	2.84 (7.56)	2.96 (8.28)	3.15 (9.44)	2.69 (6.74)	2.92 (8.09)	3.53 (11.96)	3.26 (10.12)	3.39 (11.04)	3.49 (11.74)	3.69 (13.19)	3.59 (12.47)
P₁W₃	2.68 (6.69)	2.53 (5.89)	2.6 (6.29)	2.18 (4.43)	2.17 (4.28)	2.18 (4.36)	2.32 (4.90)	2.51 (5.80)	2.42 (5.35)	2.3 (4.80)	2.35 (5.05)	2.33 (4.93)
P₁W₄	2.92 (8.05)	2.61 (6.34)	2.77 (7.19)	2.65 (6.55)	2.35 (5.04)	2.5 (5.80)	3.15 (9.44)	2.96 (8.28)	3.06 (8.86)	3.08 (9.03)	3.08 (9.03)	3.08 (9.03)
P₁W₅	3.62 (12.62)	3.35 (10.71)	3.48 (11.66)	2.35 (5.08)	2.23 (4.47)	2.29 (4.77)	3.1 (9.12)	2.92 (8.03)	3.01 (8.57)	2.66 (6.60)	2.64 (6.48)	2.65 (6.54)
P₁W₆	3.22 (9.87)	3.19 (9.71)	3.21 (9.79)	3.52 (11.86)	2.95 (8.22)	3.23 (10.04)	2.66 (6.57)	2.61 (6.32)	2.63 (6.44)	2.51 (5.87)	2.53 (5.91)	2.52 (5.89)
P₁W₇	4.03 (15.71)	3.92 (14.99)	3.97 (15.35)	5.05 (25.02)	3.94 (16.31)	4.49 (20.67)	6.11 (37.57)	5.57 (30.72)	5.84 (34.15)	3.95 (16.90)	3.24 (10.00)	3.59 (13.45)
P₂W₁	3.43 (11.34)	2.96 (8.28)	3.2 (9.81)	3.11 (9.20)	3.1 (9.14)	3.1 (9.17)	3.75 (13.61)	3.68 (13.18)	3.72 (13.39)	3.5 (11.76)	3.32 (10.50)	3.41 (11.13)
P₂W₂	3.58 (12.49)	3.08 (9.02)	3.33 (10.75)	3.36 (10.82)	3.17 (9.56)	3.27 (10.19)	3.97 (15.29)	3.85 (14.44)	3.91 (14.87)	3.7 (13.34)	3.59 (12.40)	3.65 (12.87)
P₂W₃	3.03 (8.69)	2.46 (5.54)	2.74 (7.12)	2.62 (7.11)	2.48 (5.70)	2.55 (6.41)	2.91 (8.01)	2.9 (7.93)	2.91 (7.97)	2.63 (6.45)	2.45 (5.51)	2.54 (5.98)
P₂W₄	3.32 (10.52)	2.72 (6.98)	3.02 (8.75)	2.97 (8.34)	2.8 (7.37)	2.89 (7.86)	3.61 (12.56)	3.5 (11.75)	3.56 (12.16)	3.31 (10.52)	3.1 (9.16)	3.21 (9.84)
P₂W₅	4.23 (17.52)	3.59 (12.43)	3.91 (14.97)	2.91 (7.98)	2.76 (7.15)	2.83 (7.57)	3.44 (11.31)	3.39 (10.98)	3.41 (11.15)	3.13 (9.37)	3.08 (8.97)	3.11 (9.17)

P₂W₆	3.79 (13.93)	3.52 (11.89)	3.65 (12.91)	3.71 (13.32)	3.49 (11.68)	3.6 (12.50)	3.24 (10.01)	3.13 (9.29)	3.18 (9.65)	2.86 (7.69)	2.82 (7.45)	2.84 (7.57)
P₂W₇	4.6 (20.75)	4.38 (19.23)	4.49 (19.99)	5.33 (27.99)	4.73 (21.95)	5.03 (24.97)	6.45 (41.15)	6.04 (36.03)	6.25 (38.59)	4.16 (16.99)	3.78 (14.08)	3.97 (15.53)
P₃W₁	4.33 (18.69)	4.07 (17.51)	4.2 (18.10)	3.67 (13.23)	3.69 (13.14)	3.68 (13.18)	4.57 (20.43)	4.32 (18.37)	4.45 (19.40)	3.51 (11.88)	3.34 (10.65)	3.43 (11.26)
P₃W₂	4.5 (20.56)	4.31 (18.06)	4.4 (19.31)	3.73 (13.41)	3.81 (14.18)	3.77 (13.80)	4.86 (23.33)	4.29 (17.93)	4.58 (20.63)	3.76 (13.62)	3.6 (12.54)	3.68 (13.08)
P₃W₃	3.87 (14.47)	3.76 (13.83)	3.81 (14.15)	3.05 (8.89)	3 (8.54)	3.02 (8.71)	3.37 (10.97)	2.92 (8.07)	3.14 (9.52)	2.63 (6.42)	2.55 (6.02)	2.59 (6.22)
P₃W₄	4.17 (17.48)	3.98 (15.57)	4.07 (16.53)	3.53 (12.00)	3.27 (10.23)	3.4 (11.11)	4.45 (19.31)	3.99 (15.44)	4.22 (17.38)	3.32 (10.50)	3.16 (9.55)	3.24 (10.03)
P₃W₅	5.11 (25.59)	4.73 (21.99)	4.92 (23.79)	3.2 (9.81)	3.05 (8.82)	3.13 (9.31)	4.29 (18.08)	3.78 (13.81)	4.03 (15.94)	3.13 (9.32)	3.1 (9.13)	3.12 (9.22)
P₃W₆	4.85 (23.59)	4.6 (20.75)	4.72 (22.17)	4.02 (15.64)	4.15 (16.88)	4.08 (16.26)	3.64 (12.75)	3.5 (11.83)	3.57 (12.29)	2.87 (7.71)	2.82 (7.47)	2.84 (7.59)
P₃W₇	5.25 (27.15)	4.95 (23.98)	5.1 (25.56)	5.53 (30.11)	5.38 (28.53)	5.45 (29.32)	6.96 (48.54)	6.76 (46.49)	6.86 (47.51)	4.28 (17.82)	3.62 (12.63)	3.95 (15.23)
SEm± (P×W)	0.27	0.26	0.19	0.21	0.22	0.15	0.21	0.22	0.15	0.24	0.12	0.13
SEm± (W×P)	0.21	0.20	0.14	0.16	0.17	0.12	0.21	0.19	0.14	0.19	0.14	0.12
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

recorded significantly lowest population (1.77, 1.54 and 1.60, respectively) of *Cynadon dactylon* on the sowing date of 15th June, while the highest population (2.26, 2.04 and 2.18, respectively) was observed when the crop was sown on the 15th of July.

4.2.2.3.2 Effect of integrated weed management on weed population (no. m⁻²) of *Cynadon dactylon*.

The data of both years and pooled value revealed that integrated weed management significantly affected the weed population of *Cynadon dactylon* at all stages of observation in both years.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest weed density (1.49 and 1.28, respectively) of *Cynadon dactylon* in treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) which was followed by treatments W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 2.54 and 2.94 recorded the highest weed population in W₇ (Weedy check) at both stages.

At 60 DAS and harvest, W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lower population of 1.27 and 0.71, respectively, followed by the application of W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) treatments. The highest pooled value (3.17 and 2.43, respectively) of weed population was recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.3.3 Interaction effect of sowing dates and integrated weed management on population (no. m⁻²) of *Cynadon dactylon*

Results presented in Table 4.16 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect on the population of *Cynadon dactylon* in both years and their pooled value at all the stages of observation.

4.2.2.4 Weed population (no. m⁻²) of *Cyperus iria*

The data on weed population (no. m⁻²) of *Cyperus iria* at 20, 40, 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years are presented in Table 4.17 (a) and Table 4.17 (b).

Table 4.16(a) Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Cynadon dactylon* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.85 (3.15)	1.68 (2.47)	1.77 (2.81)	1.56 (2.21)	1.52 (2.07)	1.54 (2.14)	1.64 (2.60)	1.55 (2.26)	1.60 (2.43)	1.50 (2.06)	1.29 (1.36)	1.40 (1.71)
P₂ 30th June	2.01 (3.78)	1.84 (2.98)	1.93 (3.38)	1.71 (2.72)	1.68 (2.66)	1.69 (2.69)	1.79 (3.07)	1.73 (2.89)	1.76 (2.98)	1.52 (2.12)	1.31 (1.40)	1.42 (1.76)
P₃ 15th July	2.44 (5.67)	2.09 (3.93)	2.26 (4.80)	2.13 (4.31)	1.94 (3.56)	2.04 (3.94)	2.26 (4.88)	2.11 (4.30)	2.18 (4.59)	1.55 (2.21)	1.32 (1.47)	1.44 (1.84)
SEm±	0.06	0.04	0.04	0.05	0.05	0.03	0.04	0.04	0.03	0.03	0.03	0.02
CD at 5%	0.23	0.17	0.12	0.18	0.18	0.11	0.17	0.15	0.09	NS	NS	NS
Integrated weed Management (W)												
W₁	1.92 (3.26)	1.83 (2.91)	1.87 (3.08)	1.62 (2.21)	1.54 (1.94)	1.58 (2.07)	1.87 (3.09)	1.80 (2.81)	1.84 (2.95)	1.53 (1.83)	1.38 (1.40)	1.45 (1.62)
W₂	1.95 (3.39)	1.86 (3.01)	1.91 (3.20)	1.69 (2.44)	1.59 (2.08)	1.64 (2.26)	1.99 (3.53)	1.82 (2.88)	1.90 (3.21)	1.72 (2.45)	1.37 (1.39)	1.55 (1.92)
W₃	1.52 (1.88)	1.45 (1.66)	1.49 (1.77)	1.31 (1.26)	1.25 (1.06)	1.28 (1.16)	1.51 (1.91)	1.39 (1.49)	1.45 (1.70)	1.27 (1.12)	1.00 (0.51)	1.13 (0.81)
W₄	1.63 (2.24)	1.58 (2.09)	1.61 (2.17)	1.62 (2.20)	1.52 (1.86)	1.57 (2.03)	1.73 (2.56)	1.73 (2.55)	1.73 (2.55)	1.49 (1.74)	1.36 (1.36)	1.43 (1.55)
W₅	2.54 (6.13)	2.12 (4.02)	2.33 (5.08)	1.41 (1.54)	1.33 (1.30)	1.37 (1.42)	1.61 (2.17)	1.53 (1.95)	1.57 (2.06)	1.35 (1.34)	1.08 (0.67)	1.22 (1.00)
W₆	2.26 (4.71)	2.04 (3.71)	2.15 (4.21)	1.95 (3.37)	1.88 (3.07)	1.91 (3.22)	1.35 (1.40)	1.18 (0.96)	1.27 (1.18)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	2.87 (7.79)	2.21 (4.49)	2.54 (6.14)	2.99 (8.54)	2.90 (8.03)	2.94 (8.28)	3.21 (9.96)	3.13 (9.40)	3.17 (9.68)	2.63 (6.43)	2.24 (4.55)	2.43 (5.49)
SEm±	0.05	0.08	0.05	0.04	0.05	0.03	0.06	0.06	0.04	0.03	0.03	0.02
CD at 5%	0.15	0.22	0.13	0.12	0.15	0.10	0.18	0.18	0.13	0.08	0.10	0.06

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.16(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Cynodon dactylon* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.65 (2.23)	1.64 (2.31)	1.64 (2.27)	1.35 (1.32)	1.33 (1.26)	1.34 (1.29)	1.61 (2.08)	1.54 (1.88)	1.57 (1.98)	1.51 (1.79)	1.38 (1.41)	1.45 (1.60)
P₁W₂	1.68 (2.33)	1.66 (2.27)	1.67 (2.30)	1.47 (1.66)	1.39 (1.43)	1.43 (1.55)	1.74 (2.53)	1.56 (1.94)	1.65 (2.23)	1.70 (2.39)	1.38 (1.39)	1.54 (1.89)
P₁W₃	1.30 (1.20)	1.27 (1.11)	1.28 (1.15)	1.12 (0.76)	1.15 (0.81)	1.13 (0.79)	1.23 (1.02)	1.15 (0.86)	1.19 (0.94)	1.21 (0.98)	0.93 (0.38)	1.07 (0.68)
P₁W₄	1.39 (1.44)	1.37 (1.39)	1.38 (1.42)	1.30 (1.20)	1.31 (1.22)	1.31 (1.21)	1.43 (1.55)	1.46 (1.65)	1.45 (1.60)	1.45 (1.61)	1.36 (1.36)	1.41 (1.49)
P₁W₅	2.22 (4.49)	1.95 (3.34)	2.08 (3.92)	1.17 (0.88)	1.20 (0.94)	1.19 (0.91)	1.34 (1.31)	1.29 (1.15)	1.31 (1.23)	1.32 (1.25)	1.07 (0.64)	1.19 (0.94)
P₁W₆	1.98 (3.44)	1.83 (2.88)	1.91 (3.16)	1.69 (2.37)	1.64 (2.18)	1.67 (2.28)	1.08 (0.69)	0.98 (0.47)	1.03 (0.58)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	2.72 (6.90)	2.07 (4.01)	2.40 (5.46)	2.79 (7.26)	2.66 (6.61)	2.72 (6.94)	3.06 (9.04)	2.89 (7.87)	2.97 (8.45)	2.63 (6.40)	2.18 (4.32)	2.41 (5.36)
P₂W₁	1.83 (2.86)	1.79 (2.72)	1.81 (2.79)	1.48 (1.70)	1.46 (1.64)	1.47 (1.67)	1.74 (2.52)	1.72 (2.46)	1.73 (2.49)	1.51 (1.77)	1.38 (1.39)	1.44 (1.58)
P₂W₂	1.86 (2.97)	1.84 (2.89)	1.85 (2.93)	1.53 (1.86)	1.53 (1.83)	1.53 (1.84)	1.86 (2.96)	1.74 (2.52)	1.80 (2.74)	1.71 (2.42)	1.37 (1.38)	1.54 (1.90)
P₂W₃	1.45 (1.59)	1.39 (1.43)	1.42 (1.51)	1.23 (1.03)	1.20 (0.95)	1.22 (0.99)	1.35 (1.33)	1.33 (1.26)	1.34 (1.30)	1.27 (1.13)	1.01 (0.53)	1.14 (0.83)
P₂W₄	1.55 (1.91)	1.54 (2.00)	1.54 (1.95)	1.59 (2.03)	1.52 (1.82)	1.56 (1.92)	1.64 (2.21)	1.65 (2.23)	1.65 (2.22)	1.50 (1.74)	1.36 (1.34)	1.43 (1.54)
P₂W₅	2.44 (5.52)	2.09 (3.89)	2.27 (4.70)	1.30 (1.19)	1.29 (1.16)	1.29 (1.17)	1.47 (1.65)	1.45 (1.59)	1.46 (1.62)	1.35 (1.33)	1.10 (0.70)	1.22 (1.02)
P₂W₆	2.16 (4.19)	2.04 (3.69)	2.10 (3.94)	1.87 (2.99)	1.85 (2.92)	1.86 (2.96)	1.30 (1.19)	1.09 (0.71)	1.19 (0.95)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)

P₂W₇	2.80 (7.41)	2.17 (4.20)	2.48 (5.80)	2.95 (8.25)	2.92 (8.31)	2.93 (8.28)	3.16 (9.63)	3.15 (9.45)	3.15 (9.54)	2.62 (6.42)	2.23 (4.48)	2.42 (5.45)
P₃W₁	2.28 (4.68)	2.05 (3.70)	2.16 (4.19)	2.03 (3.62)	1.85 (2.91)	1.94 (3.26)	2.27 (4.66)	2.14 (4.09)	2.21 (4.38)	1.56 (1.93)	1.38 (1.40)	1.47 (1.67)
P₃W₂	2.31 (4.85)	2.09 (3.87)	2.20 (4.36)	2.08 (3.81)	1.87 (2.99)	1.97 (3.40)	2.37 (5.10)	2.16 (4.19)	2.27 (4.64)	1.74 (2.53)	1.38 (1.39)	1.56 (1.96)
P₃W₃	1.82 (2.84)	1.71 (2.43)	1.77 (2.64)	1.57 (1.99)	1.39 (1.43)	1.48 (1.71)	1.94 (3.39)	1.68 (2.36)	1.81 (2.87)	1.32 (1.24)	1.06 (0.62)	1.19 (0.93)
P₃W₄	1.96 (3.36)	1.83 (2.89)	1.90 (3.12)	1.97 (3.36)	1.74 (2.53)	1.85 (2.95)	2.10 (3.92)	2.07 (3.77)	2.08 (3.84)	1.54 (1.86)	1.36 (1.36)	1.45 (1.61)
P₃W₅	2.96 (8.39)	2.31 (4.82)	2.63 (6.61)	1.74 (2.55)	1.52 (1.82)	1.63 (2.18)	2.01 (3.55)	1.87 (3.12)	1.94 (3.33)	1.39 (1.43)	1.09 (0.68)	1.24 (1.06)
P₃W₆	2.65 (6.51)	2.25 (4.54)	2.45 (5.53)	2.29 (4.74)	2.14 (4.10)	2.22 (4.42)	1.68 (2.32)	1.48 (1.70)	1.58 (2.01)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	3.09 (9.07)	2.40 (5.27)	2.75 (7.17)	3.23 (10.10)	3.11 (9.16)	3.17 (9.63)	3.42 (11.22)	3.35 (10.89)	3.38 (11.05)	2.64 (6.46)	2.30 (4.83)	2.47 (5.64)
SEm± (PxW)	0.09	0.14	0.08	0.07	0.09	0.06	0.11	0.11	0.08	0.05	0.06	0.04
SEm± (WxP)	0.11	0.10	0.07	0.08	0.09	0.06	0.09	0.08	0.06	0.06	0.06	0.04
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

4.2.2.4.1 Effect of sowing dates on weed population (no. m⁻²) of *Cyperus iria*.

An examination of two years' data and their pooled value on weed of *Cyperus iria* revealed that sowing dates were found to be significant at all the stages of observation except at harvest. At 20, 40, and 60 DAS, pooled values of two years recorded significantly lower populations (1.73, 1.44, and 1.77, respectively) of *Cyperus iria* on the sowing date 15th of June, while the highest population (2.26, 2.01 and 2.20 respectively) was observed when the crop was sown on the 15th of July.

4.2.2.4.2 Effect of integrated weed management on weed population (no. m⁻²) of *Cyperus iria*

Integrated weed management significantly affected the weed population of *Cyperus iria* at all stages of observation in both years and their pooled value.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly the lowest weed density (1.41 and 1.32, respectively) of *Cyperus iria* in W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) treatment which was followed by treatment W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 2.62 and 2.69 recorded the highest weed population in W₇ (Weedy check) at both stages.

At 60 DAS and harvest, W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lower population of 0.81 and 0.71, respectively, followed by the application of W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) treatment. The highest pooled value (2.93 and 3.02, respectively) of weed population was recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.4.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Cyperus iria*

Results presented in Table 4.17 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect on the population of *Cyperus iria* in both years and their pooled value at all the stages of observation.

Table 4.17(a) Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Cyperus iria* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.78 (2.82)	1.69 (2.55)	1.73 (2.68)	1.50 (1.96)	1.39 (1.67)	1.44 (1.82)	1.77 (2.99)	1.76 (2.95)	1.77 (2.97)	1.69 (2.88)	1.63 (2.57)	1.66 (2.72)
P₂ 30th June	1.86 (3.13)	1.79 (2.92)	1.82 (3.03)	1.80 (2.93)	1.72 (2.67)	1.76 (2.80)	1.91 (3.52)	1.83 (3.26)	1.87 (3.39)	1.70 (2.86)	1.64 (2.62)	1.67 (2.74)
P₃ 15th July	2.37 (5.35)	2.16 (4.32)	2.26 (4.84)	2.05 (3.83)	1.97 (3.60)	2.01 (3.72)	2.24 (4.85)	2.17 (4.74)	2.20 (4.79)	1.71 (2.91)	1.66 (2.69)	1.69 (2.80)
SEm±	0.05	0.05	0.04	0.03	0.05	0.03	0.04	0.04	0.03	0.05	0.04	0.03
CD at 5%	0.19	0.21	0.12	0.14	0.18	0.10	0.16	0.15	0.09	NS	NS	NS
Integrated weed Management (W)												
W₁	1.86 (3.05)	1.69 (2.43)	1.78 (2.74)	1.68 (2.40)	1.59 (2.11)	1.64 (2.25)	2.17 (4.28)	2.15 (4.20)	2.16 (4.24)	1.86 (2.96)	1.80 (2.73)	1.83 (2.84)
W₂	1.94 (3.35)	1.74 (2.59)	1.84 (2.97)	1.70 (2.47)	1.61 (2.19)	1.66 (2.33)	2.20 (4.38)	2.17 (4.26)	2.18 (4.32)	1.96 (3.36)	1.82 (2.82)	1.89 (3.09)
W₃	1.45 (1.66)	1.36 (1.41)	1.41 (1.54)	1.40 (1.54)	1.24 (1.07)	1.32 (1.31)	1.79 (2.73)	1.77 (2.69)	1.78 (2.71)	1.31 (1.21)	1.29 (1.18)	1.30 (1.19)
W₄	1.58 (2.08)	1.45 (1.67)	1.51 (1.87)	1.63 (2.23)	1.50 (1.82)	1.56 (2.03)	1.96 (3.37)	1.91 (3.23)	1.94 (3.30)	1.63 (2.15)	1.59 (2.04)	1.61 (2.09)
W₅	2.34 (5.12)	2.22 (4.50)	2.28 (4.81)	1.47 (1.73)	1.31 (1.27)	1.39 (1.50)	1.86 (3.02)	1.81 (2.85)	1.84 (2.93)	1.35 (1.34)	1.35 (1.33)	1.35 (1.33)
W₆	2.23 (4.60)	2.06 (3.78)	2.15 (4.19)	1.93 (3.28)	1.88 (3.08)	1.90 (3.18)	0.91 (0.44)	0.71 (0.00)	0.81 (0.22)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	2.63 (6.51)	2.61 (6.45)	2.62 (6.48)	2.67 (6.72)	2.71 (6.99)	2.69 (6.86)	2.94 (8.29)	2.93 (8.33)	2.93 (8.31)	3.09 (9.17)	2.95 (8.28)	3.02 (8.72)
SEm±	0.07	0.07	0.05	0.06	0.05	0.04	0.08	0.09	0.06	0.06	0.04	0.03
CD at 5%	0.21	0.20	0.14	0.16	0.14	0.11	0.23	0.25	0.17	0.16	0.11	0.10

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.17(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Cyperus iria* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.63 (2.15)	1.47 (1.65)	1.55 (1.90)	1.38 (1.39)	1.22 (1.00)	1.30 (1.20)	1.94 (3.27)	1.95 (3.31)	1.95 (3.29)	1.83 (2.85)	1.78 (2.67)	1.80 (2.76)
P₁W₂	1.72 (2.48)	1.51 (1.78)	1.62 (2.13)	1.40 (1.45)	1.25 (1.07)	1.32 (1.26)	1.99 (3.48)	1.97 (3.38)	1.98 (3.43)	1.94 (3.27)	1.81 (2.76)	1.87 (3.01)
P₁W₃	1.25 (1.07)	1.16 (0.86)	1.21 (0.96)	1.11 (0.73)	0.99 (0.48)	1.05 (0.61)	1.57 (1.98)	1.58 (1.99)	1.58 (1.99)	1.30 (1.20)	1.27 (1.12)	1.29 (1.16)
P₁W₄	1.35 (1.32)	1.23 (1.02)	1.29 (1.17)	1.28 (1.15)	1.17 (0.86)	1.23 (1.01)	1.74 (2.55)	1.72 (2.46)	1.73 (2.51)	1.60 (2.06)	1.58 (2.01)	1.59 (2.03)
P₁W₅	2.13 (4.07)	2.05 (3.72)	2.09 (3.90)	1.16 (0.84)	1.03 (0.57)	1.09 (0.70)	1.65 (2.23)	1.63 (2.15)	1.64 (2.19)	1.32 (1.26)	1.34 (1.29)	1.33 (1.28)
P₁W₆	1.97 (3.40)	1.87 (3.00)	1.92 (3.20)	1.63 (2.16)	1.57 (1.96)	1.60 (2.06)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	2.39 (5.23)	2.51 (5.82)	2.45 (5.52)	2.54 (6.01)	2.47 (5.78)	2.51 (5.89)	2.80 (7.39)	2.80 (7.39)	2.80 (7.39)	3.12 (9.51)	2.93 (8.13)	3.02 (8.82)
P₂W₁	1.71 (2.45)	1.60 (2.06)	1.66 (2.25)	1.71 (2.43)	1.63 (2.17)	1.67 (2.30)	2.12 (3.99)	2.02 (3.59)	2.07 (3.79)	1.86 (2.96)	1.80 (2.73)	1.83 (2.84)
P₂W₂	1.81 (2.79)	1.64 (2.20)	1.73 (2.50)	1.73 (2.50)	1.66 (2.25)	1.69 (2.37)	2.15 (4.15)	2.04 (3.65)	2.10 (3.90)	1.96 (3.36)	1.82 (2.81)	1.89 (3.08)
P₂W₃	1.32 (1.25)	1.27 (1.10)	1.29 (1.17)	1.40 (1.48)	1.27 (1.11)	1.33 (1.29)	1.76 (2.60)	1.65 (2.21)	1.70 (2.41)	1.29 (1.16)	1.30 (1.18)	1.29 (1.17)
P₂W₄	1.41 (1.50)	1.34 (1.31)	1.38 (1.41)	1.66 (2.27)	1.53 (1.85)	1.60 (2.06)	1.91 (3.15)	1.78 (2.69)	1.85 (2.92)	1.63 (2.16)	1.56 (1.95)	1.59 (2.06)
P₂W₅	2.22 (4.42)	2.17 (4.24)	2.19 (4.33)	1.48 (1.70)	1.33 (1.29)	1.41 (1.50)	1.82 (2.82)	1.69 (2.36)	1.75 (2.59)	1.37 (1.38)	1.35 (1.33)	1.36 (1.35)

P₂W₆	2.08 (3.83)	1.98 (3.43)	2.03 (3.63)	1.96 (3.37)	1.90 (3.11)	1.93 (3.24)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	2.48 (5.70)	2.52 (6.09)	2.50 (5.89)	2.68 (6.79)	2.71 (6.91)	2.69 (6.85)	2.90 (7.94)	2.93 (8.35)	2.92 (8.14)	3.08 (9.02)	2.96 (8.31)	3.02 (8.67)
P₃W₁	2.24 (4.54)	2.02 (3.59)	2.13 (4.06)	1.96 (3.36)	1.91 (3.16)	1.94 (3.26)	2.44 (5.59)	2.49 (5.71)	2.47 (5.65)	1.89 (3.06)	1.82 (2.81)	1.85 (2.93)
P₃W₂	2.29 (4.77)	2.07 (3.79)	2.18 (4.28)	1.99 (3.45)	1.93 (3.25)	1.96 (3.35)	2.45 (5.52)	2.50 (5.75)	2.48 (5.64)	1.99 (3.44)	1.84 (2.90)	1.91 (3.17)
P₃W₃	1.77 (2.67)	1.66 (2.27)	1.72 (2.47)	1.70 (2.43)	1.45 (1.62)	1.57 (2.03)	2.02 (3.60)	2.09 (3.85)	2.05 (3.72)	1.33 (1.27)	1.31 (1.24)	1.32 (1.25)
P₃W₄	1.97 (3.42)	1.77 (2.67)	1.87 (3.05)	1.93 (3.28)	1.80 (2.75)	1.87 (3.01)	2.21 (4.40)	2.24 (4.53)	2.23 (4.47)	1.65 (2.22)	1.63 (2.16)	1.64 (2.19)
P₃W₅	2.66 (6.87)	2.45 (5.54)	2.55 (6.20)	1.77 (2.64)	1.56 (1.94)	1.66 (2.29)	2.11 (4.00)	2.13 (4.04)	2.12 (4.02)	1.36 (1.38)	1.36 (1.36)	1.36 (1.37)
P₃W₆	2.66 (6.58)	2.32 (4.92)	2.49 (5.75)	2.19 (4.31)	2.16 (4.17)	2.18 (4.24)	1.32 (1.31)	0.71 (0.00)	1.01 (0.65)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	3.01 (8.62)	2.79 (7.43)	2.90 (8.03)	2.79 (7.37)	2.96 (8.29)	2.88 (7.83)	3.10 (9.55)	3.05 (9.27)	3.08 (9.41)	3.07 (8.97)	2.97 (8.39)	3.02 (8.68)
SEm± (PxW)	0.13	0.12	0.09	0.10	0.08	0.07	0.14	0.15	0.10	0.10	0.07	0.06
SEm± (WxP)	0.10	0.10	0.07	0.07	0.09	0.06	0.09	0.09	0.07	0.09	0.07	0.06
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

4.2.2.5 Weed population (no. m⁻²) of *Cyperus rotundus*

The data on weed population (no. m⁻²) of *Cyperus rotundus* at 20, 40, and 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years are presented in Table 4.18 (a) and Table 4.18 (b).

4.2.2.5.1 Effect of sowing dates on weed population (no. m⁻²) of *Cyperus rotundus*.

An examination of two years' data and their pooled value on weed of *Cyperus rotundus* revealed that sowing dates were found to be significant at all the stages of observation except at harvest. At 20, 40, and 60 DAS pooled values of two years recorded significantly lower population (1.45, 1.29 and 1.45, respectively) of *Cyperus rotundus* on sowing date 15th of June, while the highest population (1.81, 1.68 and 1.97, respectively) was observed when the crop was sown on the 15th of July.

4.2.2.5.2 Effect of integrated weed management on weed population (no. m⁻²) of *Cyperus rotundus*

Significant results were recorded on weed population of *Cyperus rotundus* due to integrated weed management at all stages of observation in both years and their pooled value.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest weed density (1.27 and 1.07, respectively) of *Cyperus rotundus* in treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) which was followed by treatments W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 1.92 and 2.35, respectively recorded the highest weed population in W₇ (Weedy check) at both stages.

At 60 DAS and harvest, W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lower population of 0.83 and 0.79, respectively, followed by the application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃). The highest pooled value of weed population was recorded in W₇ (Weedy check) at 60 DAS (3.33) and harvest (2.67).

4.2.2.5.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Cyperus rotundus*

Results presented in Table 4.18 (b) revealed that the interaction of the sowing

Table 4.18(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Cyperus rotundus* at 20,40,60 DAS and at harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.49 (1.77)	1.42 (1.57)	1.45 (1.67)	1.32 (1.47)	1.25 (1.23)	1.29 (1.35)	1.50 (2.49)	1.40 (1.92)	1.45 (2.21)	1.43 (1.85)	1.40 (1.77)	1.42 (1.81)
P₂ 30th June	1.67 (2.37)	1.60 (2.15)	1.64 (2.26)	1.33 (1.47)	1.31 (1.39)	1.32 (1.43)	1.52 (2.53)	1.49 (2.18)	1.50 (2.36)	1.46 (1.93)	1.41 (1.81)	1.44 (1.87)
P₃ 15th July	1.82 (2.92)	1.79 (2.82)	1.81 (2.87)	1.69 (2.56)	1.67 (2.43)	1.68 (2.49)	2.16 (4.76)	1.77 (3.08)	1.97 (3.92)	1.48 (1.89)	1.48 (1.77)	1.48 (1.83)
SEm±	0.04	0.04	0.03	0.03	0.03	0.02	0.03	0.02	0.02	0.02	0.03	0.02
CD at 5%	0.15	0.17	0.09	0.10	0.12	0.07	0.10	0.07	0.05	NS	NS	NS
Integrated weed Management (W)												
W₁	1.67 (2.31)	1.61 (2.14)	1.64 (2.23)	1.29 (1.21)	1.26 (1.14)	1.28 (1.17)	1.63 (2.27)	1.54 (1.92)	1.59 (2.09)	1.40 (1.45)	1.39 (1.42)	1.39 (1.44)
W₂	1.68 (2.33)	1.62 (2.16)	1.65 (2.24)	1.30 (1.22)	1.28 (1.18)	1.29 (1.20)	1.67 (2.40)	1.56 (1.96)	1.61 (2.18)	1.41 (1.49)	1.41 (1.48)	1.41 (1.48)
W₃	1.31 (1.22)	1.23 (1.03)	1.27 (1.13)	1.06 (0.67)	1.07 (0.71)	1.07 (0.69)	1.37 (1.56)	1.22 (1.06)	1.30 (1.31)	1.25 (1.06)	1.18 (0.91)	1.21 (0.98)
W₄	1.33 (1.29)	1.25 (1.08)	1.29 (1.19)	1.27 (1.15)	1.24 (1.09)	1.26 (1.12)	1.53 (1.97)	1.44 (1.61)	1.48 (1.79)	1.35 (1.31)	1.33 (1.28)	1.34 (1.30)
W₅	1.90 (3.13)	1.85 (2.97)	1.88 (3.05)	1.08 (0.71)	1.09 (0.75)	1.09 (0.73)	1.39 (1.61)	1.29 (1.21)	1.34 (1.41)	1.31 (1.22)	1.29 (1.16)	1.30 (1.19)
W₆	1.83 (2.94)	1.75 (2.62)	1.79 (2.78)	1.68 (2.37)	1.64 (2.23)	1.66 (2.30)	0.87 (0.31)	0.79 (0.18)	0.83 (0.24)	0.82 (0.21)	0.76 (0.11)	0.79 (0.16)
W₇	1.93 (3.24)	1.91 (3.25)	1.92 (3.25)	2.43 (5.49)	2.27 (4.68)	2.35 (5.08)	3.62 (12.71)	3.04 (8.84)	3.33 (10.77)	2.69 (6.71)	2.66 (6.59)	2.67 (6.65)
SEm±	0.05	0.06	0.04	0.05	0.04	0.03	0.06	0.06	0.05	0.03	0.03	0.02
CD at 5%	0.13	0.17	0.11	0.13	0.12	0.09	0.18	0.18	0.13	0.09	0.09	0.06

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.18(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Cyperus rotundus* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.49 (1.72)	1.41 (1.48)	1.45 (1.60)	1.15 (0.82)	1.08 (0.68)	1.12 (0.75)	1.38 (1.41)	1.37 (1.39)	1.38 (1.40)	1.38 (1.41)	1.36 (1.36)	1.37 (1.39)
P₁W₂	1.49 (1.73)	1.42 (1.51)	1.46 (1.62)	1.16 (0.83)	1.10 (0.71)	1.13 (0.77)	1.43 (1.54)	1.39 (1.43)	1.41 (1.49)	1.39 (1.44)	1.39 (1.44)	1.39 (1.44)
P₁W₃	1.17 (0.87)	1.08 (0.66)	1.12 (0.76)	0.96 (0.44)	0.93 (0.37)	0.95 (0.41)	1.09 (0.68)	1.03 (0.56)	1.06 (0.62)	1.23 (1.02)	1.16 (0.85)	1.20 (0.94)
P₁W₄	1.18 (0.90)	1.09 (0.69)	1.14 (0.79)	1.13 (0.78)	1.07 (0.64)	1.10 (0.71)	1.27 (1.10)	1.24 (1.04)	1.25 (1.07)	1.33 (1.26)	1.30 (1.19)	1.31 (1.22)
P₁W₅	1.71 (2.43)	1.66 (2.27)	1.69 (2.35)	0.98 (0.47)	0.95 (0.40)	0.96 (0.44)	1.11 (0.74)	1.06 (0.63)	1.09 (0.68)	1.30 (1.18)	1.24 (1.04)	1.27 (1.11)
P₁W₆	1.64 (2.20)	1.57 (1.95)	1.60 (2.08)	1.55 (1.89)	1.48 (1.69)	1.51 (1.79)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.74 (2.53)	1.71 (2.44)	1.72 (2.48)	2.34 (5.02)	2.14 (4.10)	2.24 (4.56)	3.51 (11.99)	2.98 (8.41)	3.25 (10.20)	2.67 (6.66)	2.65 (6.52)	2.66 (6.59)
P₂W₁	1.69 (2.36)	1.61 (2.11)	1.65 (2.23)	1.16 (0.85)	1.16 (0.84)	1.16 (0.85)	1.40 (1.45)	1.49 (1.71)	1.44 (1.58)	1.40 (1.45)	1.38 (1.41)	1.39 (1.43)
P₂W₂	1.69 (2.37)	1.62 (2.14)	1.66 (2.25)	1.17 (0.86)	1.18 (0.88)	1.17 (0.87)	1.44 (1.59)	1.50 (1.76)	1.47 (1.67)	1.41 (1.49)	1.40 (1.46)	1.40 (1.48)
P₂W₃	1.30 (1.19)	1.24 (1.04)	1.27 (1.11)	0.96 (0.44)	0.96 (0.46)	0.96 (0.45)	1.12 (0.76)	1.13 (0.78)	1.13 (0.77)	1.23 (1.02)	1.12 (0.77)	1.18 (0.89)
P₂W₄	1.32 (1.23)	1.26 (1.08)	1.29 (1.16)	1.14 (0.81)	1.14 (0.81)	1.14 (0.81)	1.28 (1.15)	1.38 (1.41)	1.33 (1.28)	1.34 (1.29)	1.32 (1.25)	1.33 (1.27)
P₂W₅	1.92 (3.21)	1.86 (2.97)	1.89 (3.09)	0.97 (0.48)	0.98 (0.49)	0.98 (0.49)	1.15 (0.82)	1.23 (1.01)	1.19 (0.92)	1.31 (1.22)	1.30 (1.19)	1.31 (1.21)

P₂W₆	1.85 (2.96)	1.75 (2.61)	1.80 (2.79)	1.56 (1.94)	1.54 (1.89)	1.55 (1.92)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.86 (0.29)	0.71 (0.00)	0.78 (0.14)
P₂W₇	1.94 (3.28)	1.88 (3.07)	1.91 (3.17)	2.31 (4.89)	2.20 (4.36)	2.26 (4.63)	3.53 (11.95)	3.01 (8.61)	3.27 (10.28)	2.69 (6.73)	2.67 (6.61)	2.68 (6.67)
P₃W₁	1.83 (2.86)	1.81 (2.82)	1.82 (2.84)	1.56 (1.95)	1.54 (1.89)	1.55 (1.92)	2.11 (3.94)	1.77 (2.66)	1.94 (3.30)	1.41 (1.50)	1.41 (1.50)	1.41 (1.50)
P₃W₂	1.84 (2.90)	1.81 (2.82)	1.83 (2.86)	1.57 (1.97)	1.56 (1.95)	1.57 (1.96)	2.14 (4.06)	1.78 (2.70)	1.96 (3.38)	1.42 (1.53)	1.43 (1.55)	1.43 (1.54)
P₃W₃	1.45 (1.61)	1.37 (1.39)	1.41 (1.50)	1.27 (1.13)	1.33 (1.30)	1.30 (1.22)	1.91 (3.25)	1.51 (1.83)	1.71 (2.54)	1.27 (1.13)	1.27 (1.11)	1.27 (1.12)
P₃W₄	1.49 (1.74)	1.40 (1.48)	1.44 (1.61)	1.54 (1.87)	1.52 (1.83)	1.53 (1.85)	2.04 (3.67)	1.69 (2.37)	1.86 (3.02)	1.38 (1.40)	1.38 (1.40)	1.38 (1.40)
P₃W₅	2.06 (3.74)	2.04 (3.66)	2.05 (3.70)	1.30 (1.20)	1.35 (1.34)	1.32 (1.27)	1.90 (3.28)	1.57 (1.99)	1.74 (2.64)	1.33 (1.27)	1.33 (1.26)	1.33 (1.26)
P₃W₆	2.01 (3.65)	1.94 (3.28)	1.98 (3.47)	1.94 (3.26)	1.90 (3.12)	1.92 (3.19)	1.19 (0.92)	0.96 (0.54)	1.07 (0.73)	0.88 (0.34)	0.87 (0.32)	0.88 (0.33)
P₃W₇	2.10 (3.91)	2.14 (4.25)	2.12 (4.08)	2.64 (6.55)	2.45 (5.56)	2.55 (6.05)	3.83 (14.20)	3.14 (9.49)	3.49 (11.84)	2.69 (6.75)	2.67 (6.64)	2.68 (6.69)
SEm± (PxW)	0.08	0.11	0.07	0.08	0.07	0.05	0.11	0.11	0.08	0.06	0.05	0.04
SEm± (WxP)	0.07	0.09	0.06	0.06	0.06	0.04	0.07	0.06	0.04	0.05	0.05	0.03
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

dates and integrated weed management did not show any significant effect on the population of *Cyperus rotundus* in both years and their pooled value at all the stages of observation.

4.2.2.6 Weed population (no. m⁻²) of *Ageratum conyzoides*

The data on weed population (no. m⁻²) of *Ageratum conyzoides* at 20, 40, and 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years and their pooled value are presented in Table 4.19 (a) and Table 4.19 (b).

4.2.2.6.1 Effect of sowing dates on weed population (no. m⁻²) of *Ageratum conyzoides*

An examination of two years' data and their pooled value on weed of *Ageratum conyzoides* revealed that sowing dates were found to be significant at all the stages of observation except at harvest. At 20, 40, and 60 DAS pooled values of two years recorded significantly lower population (2.20, 1.81, and 2.04, respectively) of *Ageratum conyzoides* on 15th of June, while the highest population (2.83, 2.38 and 2.52, respectively) was observed when the crop was sown on the 15th of July.

4.2.2.6.2 Effect of integrated weed management on weed population (no. m⁻²) of *Ageratum conyzoides*

Integrated weed management significantly affected the weed population of *Ageratum conyzoides* at all stages of observation in both years and their pooled value.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest weed density (1.92 and 1.52, respectively) of *Ageratum conyzoides* in treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) which was followed by treatment W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 2.93 and 3.10, respectively recorded the highest weed population in W₇ (Weedy check) at both stages at 20 and 40 DAS.

At 60 DAS and harvest, treatment W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lower population of 1.80 and 0.71, respectively, followed by the application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃). The highest pooled value (3.41 and

Table 4.19(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Ageratum conyzoides* at 20,40,60 DAS and at harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	2.24 (4.72)	2.16 (4.21)	2.20 (4.47)	1.95 (3.60)	1.67 (2.58)	1.81 (3.09)	2.07 (4.10)	2.00 (3.82)	2.04 (3.96)	1.70 (2.88)	1.57 (2.41)	1.63 (2.65)
P₂ 30th June	2.37 (5.36)	2.26 (4.68)	2.31 (5.02)	1.99 (3.76)	1.86 (3.23)	1.92 (3.49)	2.15 (4.45)	2.21 (4.69)	2.18 (4.57)	1.71 (2.88)	1.59 (2.48)	1.65 (2.68)
P₃ 15th July	2.92 (8.52)	2.73 (7.09)	2.83 (7.81)	2.47 (5.89)	2.29 (4.93)	2.38 (5.41)	2.60 (6.53)	2.44 (5.71)	2.52 (6.12)	1.74 (2.98)	1.62 (2.58)	1.68 (2.78)
SEm±	0.07	0.05	0.05	0.05	0.06	0.04	0.07	0.05	0.04	0.04	0.05	0.03
CD at 5%	0.29	0.21	0.15	0.21	0.24	0.13	0.27	0.19	0.14	NS	NS	NS
Integrated weed Management (W)												
W₁	2.30 (4.88)	2.33 (5.02)	2.32 (4.95)	2.00 (3.56)	1.87 (3.07)	1.93 (3.32)	2.14 (4.19)	2.18 (4.29)	2.16 (4.24)	1.91 (3.15)	1.79 (2.71)	1.85 (2.93)
W₂	2.46 (5.63)	2.39 (5.27)	2.42 (5.45)	2.10 (3.95)	2.03 (3.66)	2.06 (3.80)	2.44 (5.53)	2.39 (5.26)	2.42 (5.39)	2.22 (4.42)	2.01 (3.54)	2.11 (3.98)
W₃	1.83 (2.89)	2.00 (3.56)	1.92 (3.23)	1.67 (2.42)	1.37 (1.65)	1.52 (2.04)	1.88 (3.12)	1.80 (2.81)	1.84 (2.96)	1.26 (1.10)	1.02 (0.58)	1.14 (0.84)
W₄	1.91 (3.18)	2.04 (3.73)	1.97 (3.46)	1.88 (3.14)	1.83 (2.91)	1.85 (3.02)	2.18 (4.30)	2.17 (4.26)	2.18 (4.28)	1.66 (2.25)	1.46 (1.63)	1.56 (1.94)
W₅	3.08 (9.21)	2.65 (6.68)	2.86 (7.94)	1.80 (2.84)	1.46 (1.75)	1.63 (2.29)	1.96 (3.44)	1.88 (3.08)	1.92 (3.26)	1.31 (1.23)	1.30 (1.20)	1.31 (1.22)
W₆	2.84 (7.78)	2.55 (6.12)	2.69 (6.95)	2.20 (4.39)	2.15 (4.18)	2.17 (4.28)	1.83 (2.94)	1.76 (2.67)	1.80 (2.81)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	3.16 (9.84)	2.71 (6.92)	2.93 (8.38)	3.32 (10.61)	2.87 (7.83)	3.10 (9.22)	3.48 (11.67)	3.34 (10.82)	3.41 (11.25)	2.93 (8.24)	2.86 (7.78)	2.90 (8.01)
SEm±	0.10	0.06	0.06	0.07	0.07	0.05	0.06	0.07	0.05	0.07	0.06	0.05
CD at 5%	0.29	0.18	0.17	0.21	0.20	0.14	0.18	0.20	0.13	0.19	0.18	0.13

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.19(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Ageratum conyzoides* at 20,40,60 DAS and at harvest.

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	2.03 (3.62)	2.09 (3.89)	2.06 (3.75)	1.77 (2.65)	1.65 (2.22)	1.71 (2.43)	1.99 (3.49)	1.97 (3.39)	1.98 (3.44)	1.90 (3.09)	1.81 (2.78)	1.85 (2.94)
P₁W₂	2.25 (4.57)	2.15 (4.10)	2.20 (4.34)	1.92 (3.20)	1.80 (2.75)	1.86 (2.97)	2.26 (4.61)	2.19 (4.29)	2.22 (4.45)	2.18 (4.26)	1.99 (3.49)	2.09 (3.87)
P₁W₃	1.66 (2.25)	1.80 (2.73)	1.73 (2.49)	1.40 (1.64)	0.99 (0.64)	1.20 (1.14)	1.62 (2.15)	1.54 (1.87)	1.58 (2.01)	1.19 (0.95)	0.93 (0.40)	1.06 (0.68)
P₁W₄	1.73 (2.48)	1.84 (2.88)	1.78 (2.68)	1.76 (2.63)	1.58 (1.99)	1.67 (2.31)	1.97 (3.42)	1.96 (3.36)	1.97 (3.39)	1.67 (2.29)	1.44 (1.59)	1.56 (1.94)
P₁W₅	2.74 (7.05)	2.40 (5.27)	2.57 (6.16)	1.61 (2.14)	1.15 (0.82)	1.38 (1.48)	1.74 (2.57)	1.64 (2.20)	1.69 (2.39)	1.27 (1.11)	1.26 (1.10)	1.27 (1.10)
P₁W₆	2.36 (5.08)	2.30 (4.77)	2.33 (4.93)	2.04 (3.67)	1.93 (3.23)	1.99 (3.45)	1.59 (2.03)	1.49 (1.74)	1.54 (1.88)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	2.91 (8.00)	2.52 (5.87)	2.71 (6.94)	3.12 (9.28)	2.62 (6.40)	2.87 (7.84)	3.31 (10.47)	3.22 (9.91)	3.26 (10.19)	2.96 (8.47)	2.83 (7.53)	2.89 (8.00)
P₂W₁	2.11 (3.97)	2.21 (4.37)	2.16 (4.17)	1.88 (3.04)	1.73 (2.52)	1.81 (2.78)	1.95 (3.40)	2.16 (4.16)	2.05 (3.78)	1.92 (3.18)	1.80 (2.73)	1.86 (2.96)
P₂W₂	2.34 (4.98)	2.26 (4.60)	2.30 (4.79)	1.95 (3.31)	1.94 (3.26)	1.94 (3.29)	2.33 (4.94)	2.39 (5.23)	2.36 (5.08)	2.23 (4.46)	2.04 (3.67)	2.13 (4.07)
P₂W₃	1.71 (2.43)	1.88 (3.02)	1.79 (2.72)	1.54 (1.90)	1.35 (1.68)	1.45 (1.79)	1.78 (2.76)	1.78 (2.68)	1.78 (2.72)	1.26 (1.09)	0.96 (0.47)	1.11 (0.78)
P₂W₄	1.78 (2.67)	1.91 (3.17)	1.85 (2.92)	1.69 (2.47)	1.72 (2.48)	1.71 (2.48)	2.10 (3.93)	2.15 (4.12)	2.13 (4.03)	1.62 (2.14)	1.44 (1.59)	1.53 (1.86)
P₂W₅	2.86 (7.72)	2.51 (5.80)	2.68 (6.76)	1.64 (2.27)	1.35 (1.36)	1.50 (1.81)	1.81 (2.87)	1.84 (2.91)	1.83 (2.89)	1.31 (1.23)	1.31 (1.22)	1.31 (1.23)

P₂W₆	2.74 (7.11)	2.41 (5.36)	2.58 (6.23)	2.05 (3.76)	2.07 (3.80)	2.06 (3.78)	1.72 (2.50)	1.74 (2.53)	1.73 (2.51)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	3.02 (8.64)	2.63 (6.42)	2.82 (7.53)	3.17 (9.55)	2.82 (7.47)	3.00 (8.51)	3.35 (10.73)	3.39 (11.18)	3.37 (10.95)	2.91 (8.08)	2.85 (7.69)	2.88 (7.88)
P₃W₁	2.75 (7.05)	2.70 (6.80)	2.72 (6.92)	2.34 (4.98)	2.23 (4.49)	2.29 (4.74)	2.49 (5.70)	2.41 (5.33)	2.45 (5.51)	1.92 (3.18)	1.76 (2.62)	1.84 (2.90)
P₃W₂	2.78 (7.33)	2.75 (7.10)	2.77 (7.22)	2.42 (5.35)	2.34 (4.96)	2.38 (5.15)	2.74 (7.03)	2.60 (6.26)	2.67 (6.65)	2.24 (4.54)	1.99 (3.45)	2.11 (3.99)
P₃W₃	2.12 (4.01)	2.33 (4.94)	2.23 (4.47)	2.06 (3.73)	1.77 (2.64)	1.91 (3.18)	2.22 (4.44)	2.09 (3.89)	2.16 (4.16)	1.32 (1.25)	1.17 (0.87)	1.24 (1.06)
P₃W₄	2.21 (4.38)	2.38 (5.15)	2.29 (4.77)	2.19 (4.31)	2.18 (4.25)	2.19 (4.28)	2.46 (5.56)	2.40 (5.29)	2.43 (5.42)	1.68 (2.34)	1.49 (1.71)	1.59 (2.03)
P₃W₅	3.64 (12.84)	3.03 (8.98)	3.33 (10.91)	2.14 (4.12)	1.89 (3.06)	2.01 (3.59)	2.32 (4.89)	2.15 (4.13)	2.23 (4.51)	1.36 (1.36)	1.34 (1.29)	1.35 (1.32)
P₃W₆	3.41 (11.15)	2.95 (8.23)	3.18 (9.69)	2.50 (5.73)	2.45 (5.51)	2.47 (5.62)	2.18 (4.31)	2.06 (3.74)	2.12 (4.02)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	3.55 (12.87)	2.99 (8.46)	3.27 (10.66)	3.67 (13.00)	3.18 (9.62)	3.43 (11.31)	3.78 (13.81)	3.40 (11.37)	3.59 (12.59)	2.93 (8.18)	2.90 (8.12)	2.91 (8.15)
SEm± (PxW)	0.15	0.10	0.09	0.11	0.12	0.08	0.12	0.10	0.08	0.08	0.09	0.06
SEm± (WxP)	0.50	0.31	0.29	0.36	0.35	0.25	0.31	0.35	0.23	0.33	0.31	0.22
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

2.90, respectively) of weed population was recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.6.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Ageratum conyzoides*

The study found no significant effect on weed population *Ageratum conyzoides* due to the interaction of sowing dates and integrated weed management in both years and their pooled value at all the stages of observation.

4.2.2.7 Weed population (no. m⁻²) of *Amaranthus viridis*

The data on weed population (no. m⁻²) of *Amaranthus viridis* at 20, 40, 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years and their pooled value are presented in Table 4.20 (a) and Table 4.20 (b).

4.2.2.7.1 Effect of sowing dates on weed population (no. m⁻²) of *Amaranthus viridis*

An examination of two years' data and their pooled value on weed of *Amaranthus viridis* revealed that sowing dates were found to be significant at all the stages of observation except at harvest. At 20, 40, and 60 DAS pooled values of two years recorded significantly lower population (1.72, 1.58, and 1.78, respectively) on sowing date 15th of June, while the highest population was observed when the crop was sown on the 15th of July.

4.2.2.7.2 Effect of integrated weed management on weed population (no. m⁻²) of *Amaranthus viridis*

Integrated weed management significantly affected the weed population of *Amaranthus viridis* at all stages of observation in both years and their pooled value.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest weed density (1.54 and 1.30, respectively) of *Amaranthus viridis* in treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) which was followed by treatments W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 2.53 and 2.76 recorded the highest weed population in W₇ (Weedy check) at both stages.

Table 4.20(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Amaranthus viridis* at 20,40,60 DAS and at harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.81 (2.93)	1.62 (2.35)	1.72 (2.64)	1.67 (2.55)	1.48 (1.89)	1.58 (2.22)	1.88 (3.33)	1.67 (2.50)	1.78 (2.92)	1.78 (3.07)	1.59 (2.38)	1.68 (2.73)
P₂ 30th June	2.04 (3.77)	1.74 (2.74)	1.89 (3.25)	1.81 (3.07)	1.58 (2.17)	1.70 (2.62)	2.12 (4.18)	2.04 (3.83)	2.08 (4.00)	1.82 (3.19)	1.60 (2.44)	1.71 (2.82)
P₃ 15th July	2.27 (4.77)	2.14 (4.20)	2.20 (4.49)	2.03 (3.82)	1.94 (3.50)	1.98 (3.66)	2.45 (5.69)	2.23 (4.67)	2.34 (5.18)	1.83 (3.25)	1.63 (2.52)	1.73 (2.88)
SEm±	0.05	0.05	0.03	0.03	0.04	0.03	0.04	0.06	0.04	0.05	0.04	0.03
CD at 5%	0.19	0.19	0.11	0.13	0.16	0.08	0.17	0.23	0.12	NS	NS	NS
Integrated weed Management (W)												
W₁	1.85 (2.96)	1.62 (2.27)	1.74 (2.62)	1.70 (2.42)	1.53 (1.88)	1.61 (2.15)	2.24 (4.55)	2.08 (3.90)	2.16 (4.22)	1.98 (3.44)	1.79 (2.72)	1.89 (3.08)
W₂	1.87 (3.05)	1.67 (2.39)	1.77 (2.72)	1.78 (2.73)	1.56 (1.98)	1.67 (2.35)	2.36 (5.09)	2.16 (4.21)	2.26 (4.65)	2.07 (3.80)	1.87 (3.01)	1.97 (3.41)
W₃	1.71 (2.47)	1.38 (1.61)	1.54 (2.04)	1.36 (1.39)	1.24 (1.09)	1.30 (1.24)	1.69 (2.45)	1.54 (1.93)	1.61 (2.19)	1.41 (1.48)	1.20 (0.94)	1.30 (1.21)
W₄	1.81 (2.83)	1.56 (2.03)	1.69 (2.43)	1.66 (2.30)	1.50 (1.79)	1.58 (2.04)	2.12 (4.05)	2.05 (3.78)	2.09 (3.92)	1.94 (3.26)	1.61 (2.10)	1.77 (2.68)
W₅	2.31 (4.96)	2.24 (4.55)	2.28 (4.75)	1.50 (1.78)	1.41 (1.52)	1.45 (1.65)	1.96 (3.43)	1.73 (2.57)	1.85 (3.00)	1.67 (2.32)	1.32 (1.25)	1.50 (1.78)
W₆	2.17 (4.26)	1.87 (3.07)	2.02 (3.66)	1.98 (3.43)	1.79 (2.74)	1.88 (3.08)	1.65 (2.32)	1.53 (1.88)	1.59 (2.10)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	2.57 (6.25)	2.50 (5.76)	2.53 (6.01)	2.89 (7.96)	2.64 (6.65)	2.76 (7.30)	3.04 (8.91)	2.77 (7.38)	2.91 (8.14)	2.89 (7.90)	2.74 (7.10)	2.82 (7.50)
SEm±	0.07	0.08	0.05	0.06	0.06	0.04	0.07	0.07	0.05	0.03	0.05	0.03
CD at 5%	0.20	0.24	0.15	0.18	0.18	0.12	0.19	0.19	0.13	0.10	0.14	0.08

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.20(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Amaranthus viridis* at 20,40,60 DAS and at harvest.

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.60 (2.07)	1.39 (1.51)	1.50 (1.79)	1.53 (1.85)	1.35 (1.35)	1.44 (1.60)	1.98 (3.41)	1.75 (2.56)	1.86 (2.98)	1.91 (3.18)	1.78 (2.69)	1.85 (2.93)
P₁W₂	1.63 (2.16)	1.43 (1.57)	1.53 (1.86)	1.57 (2.03)	1.39 (1.44)	1.48 (1.74)	2.11 (3.94)	1.84 (2.90)	1.97 (3.42)	2.07 (3.79)	1.85 (2.93)	1.96 (3.36)
P₁W₃	1.44 (1.58)	1.05 (0.68)	1.25 (1.13)	1.23 (1.01)	1.05 (0.60)	1.14 (0.80)	1.35 (1.32)	1.23 (1.02)	1.29 (1.17)	1.37 (1.39)	1.15 (0.83)	1.26 (1.11)
P₁W₄	1.56 (1.93)	1.37 (1.42)	1.46 (1.68)	1.48 (1.71)	1.33 (1.27)	1.40 (1.49)	1.85 (2.92)	1.72 (2.47)	1.79 (2.69)	1.88 (3.05)	1.61 (2.08)	1.74 (2.56)
P₁W₅	2.14 (4.06)	2.06 (3.78)	2.10 (3.92)	1.34 (1.30)	1.23 (1.02)	1.29 (1.16)	1.67 (2.30)	1.40 (1.45)	1.53 (1.88)	1.65 (2.28)	1.28 (1.13)	1.47 (1.71)
P₁W₆	1.97 (3.37)	1.68 (2.36)	1.83 (2.86)	1.80 (2.75)	1.63 (2.15)	1.71 (2.45)	1.30 (1.20)	1.22 (0.99)	1.26 (1.10)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	2.37 (5.35)	2.37 (5.14)	2.37 (5.24)	2.75 (7.16)	2.40 (5.39)	2.57 (6.28)	2.92 (8.26)	2.53 (6.12)	2.72 (7.19)	2.88 (7.82)	2.73 (7.00)	2.81 (7.41)
P₂W₁	1.84 (2.90)	1.46 (1.73)	1.65 (2.31)	1.68 (2.33)	1.45 (1.63)	1.57 (1.98)	2.21 (4.38)	2.13 (4.04)	2.17 (4.21)	2.02 (3.59)	1.79 (2.71)	1.91 (3.15)
P₂W₂	1.87 (2.99)	1.49 (1.74)	1.68 (2.36)	1.78 (2.66)	1.48 (1.71)	1.63 (2.19)	2.33 (4.92)	2.20 (4.36)	2.27 (4.64)	2.07 (3.80)	1.88 (3.03)	1.98 (3.42)
P₂W₃	1.71 (2.41)	1.35 (1.52)	1.53 (1.97)	1.26 (1.15)	1.16 (0.85)	1.21 (1.00)	1.66 (2.27)	1.61 (2.11)	1.64 (2.19)	1.39 (1.43)	1.18 (0.89)	1.28 (1.16)
P₂W₄	1.81 (2.77)	1.51 (1.81)	1.66 (2.29)	1.66 (2.25)	1.42 (1.52)	1.54 (1.89)	2.09 (3.88)	2.10 (3.93)	2.10 (3.90)	1.96 (3.35)	1.58 (1.99)	1.77 (2.67)
P₂W₅	2.32 (4.90)	2.20 (4.35)	2.26 (4.62)	1.48 (1.70)	1.33 (1.27)	1.40 (1.48)	1.94 (3.26)	1.79 (2.71)	1.86 (2.98)	1.69 (2.34)	1.31 (1.23)	1.50 (1.78)

P₂W₆	2.17 (4.21)	1.79 (2.74)	1.98 (3.47)	1.95 (3.30)	1.71 (2.43)	1.83 (2.86)	1.62 (2.15)	1.59 (2.03)	1.61 (2.09)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	2.59 (6.23)	2.40 (5.27)	2.49 (5.75)	2.90 (8.08)	2.50 (5.79)	2.70 (6.93)	2.97 (8.38)	2.85 (7.61)	2.91 (7.99)	2.88 (7.86)	2.76 (7.24)	2.82 (7.55)
P₃W₁	2.10 (3.92)	2.01 (3.58)	2.06 (3.75)	1.89 (3.09)	1.78 (2.67)	1.84 (2.88)	2.52 (5.86)	2.36 (5.10)	2.44 (5.48)	2.01 (3.56)	1.81 (2.77)	1.91 (3.16)
P₃W₂	2.12 (4.00)	2.09 (3.87)	2.10 (3.94)	2.00 (3.50)	1.81 (2.78)	1.90 (3.14)	2.63 (6.43)	2.42 (5.38)	2.53 (5.91)	2.07 (3.81)	1.89 (3.07)	1.98 (3.44)
P₃W₃	1.98 (3.43)	1.74 (2.63)	1.86 (3.03)	1.58 (1.99)	1.51 (1.81)	1.55 (1.90)	2.05 (3.61)	1.78 (2.63)	1.91 (3.12)	1.46 (1.63)	1.26 (1.10)	1.36 (1.36)
P₃W₄	2.07 (3.78)	1.81 (2.85)	1.94 (3.32)	1.86 (2.95)	1.75 (2.56)	1.80 (2.76)	2.42 (5.35)	2.33 (4.95)	2.38 (5.15)	1.97 (3.40)	1.65 (2.23)	1.81 (2.81)
P₃W₅	2.48 (5.91)	2.45 (5.51)	2.47 (5.71)	1.68 (2.33)	1.66 (2.27)	1.67 (2.30)	2.28 (4.72)	2.02 (3.56)	2.15 (4.14)	1.68 (2.33)	1.37 (1.38)	1.53 (1.86)
P₃W₆	2.39 (5.21)	2.14 (4.09)	2.27 (4.65)	2.17 (4.24)	2.03 (3.64)	2.10 (3.94)	2.01 (3.76)	1.77 (2.66)	1.89 (3.21)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	2.77 (7.18)	2.72 (6.88)	2.74 (7.03)	3.02 (8.65)	3.01 (8.76)	3.02 (8.71)	3.24 (10.08)	2.95 (8.41)	3.10 (9.25)	2.92 (8.03)	2.75 (7.08)	2.83 (7.55)
SEm± (PxW)	0.12	0.14	0.10	0.11	0.11	0.08	0.12	0.11	0.08	0.06	0.08	0.05
SEm± (WxP)	0.10	0.10	0.07	0.07	0.08	0.06	0.09	0.11	0.07	0.09	0.07	0.06
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

At 60 DAS and harvest, treatment W₆ (Hand weeding at 20 and 40 DAS) pooled value recorded a significantly lower population of 1.59 and 0.71, respectively, followed by the application of treatments W₃ (Pendimethalin 30 EC @ 1 kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). The highest pooled value (2.91 and 2.82, respectively) of weed population was recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.7.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Amaranthus viridis*

Results presented in Table 4.20 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect on the population of *Amaranthus viridis* in both years and their pooled value at all the stages of observation.

4.2.2.8 Weed population (no. m⁻²) of *Borreria latifolia*

The data on weed population (no. m⁻²) of *Borreria latifolia* at 20, 40, and 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years and their pooled value is presented in Table 4.21 (a) and Table 4.21 (b).

4.2.2.8.1 Effect of sowing dates on weed population (no. m⁻²) of *Borreria latifolia*

An examination of two years' data and their pooled value on weed of *Borreria latifolia* revealed that sowing dates were found to be significant at all the stages of observation except at harvest. At 20, 40 and 60 DAS pooled values of two years recorded significantly lower population (3.09, 2.26, and 3.06, respectively) on sowing date 15th of June, while the highest population (3.76, 3.07 and 3.56, respectively) was observed when the crop was sown on the 15th of July.

4.2.2.8.2 Effect of integrated weed management on weed population (no. m⁻²) of *Borreria latifolia*

Integrated weed management significantly affected the weed population of *Borreria latifolia* at all stages of observation in both years and their pooled value. At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest

weed density (2.87 and 1.65, respectively) in treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) which was followed by treatments W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 4.02 and 4.37 recorded the highest weed population in W₇ (Weedy check) at both stages.

At 60 DAS and harvest, W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lower population of 1.87 and 1.65 respectively, followed by the application of W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) treatments. The highest pooled value (4.87, 4.63) of weed population was recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.8.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Borreria latifolia*

Results presented in Table 4.21 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect on the population of *Borreria latifolia* in both years and their pooled value at all the stages of observation.

4.2.2.9 Weed population (no. m⁻²) of *Cleome rutidosperma*

The data on weed population (no. m⁻²) of *Cleome rutidosperma* at 20, 40, 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years and their pooled value is presented in Table 4.22 (a) and Table 4.22 (b).

4.2.2.9.1 Effect of sowing dates on weed population (no. m⁻²) of *Cleome rutidosperma*

An examination of two years' data and their pooled value on weed of *Cleome rutidosperma* revealed that sowing dates were found to be significant at all the stages of observation except at harvest, which was non-significant. At 20, 40, and 60 DAS pooled values of two years recorded significantly lower population (1.40, 1.33, and 1.67, respectively) of *Cleome rutidosperma* sowing on the 15th of June, while the highest population was observed when the crop was sown on the 15th of July.

Table 4.21(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Borreria latifolia* at 20,40,60 DAS and at harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	3.32 (10.78)	2.86 (7.96)	3.09 (9.37)	2.27 (5.44)	2.25 (5.35)	2.26 (5.40)	3.19 (10.84)	2.92 (9.15)	3.06 (10.00)	2.99 (9.57)	2.83 (8.44)	2.91 (9.01)
P₂ 30th June	3.45 (11.70)	3.32 (10.83)	3.39 (11.26)	2.82 (8.08)	2.62 (7.27)	2.72 (7.68)	3.43 (12.40)	3.17 (10.52)	3.30 (11.46)	3.01 (9.55)	2.88 (8.74)	2.95 (9.15)
P₃ 15th July	3.93 (15.16)	3.60 (12.82)	3.76 (13.99)	3.25 (10.70)	2.88 (8.65)	3.07 (9.68)	3.76 (14.54)	3.37 (11.82)	3.56 (13.18)	3.04 (9.53)	2.89 (8.87)	2.96 (9.20)
SEm±	0.10	0.09	0.07	0.08	0.07	0.05	0.07	0.06	0.04	0.06	0.07	0.05
CD at 5%	0.39	0.35	0.22	0.30	0.26	0.16	0.27	0.22	0.14	NS	NS	NS
Integrated weed Management (W)												
W₁	3.36 (10.90)	3.05 (9.01)	3.20 (9.95)	2.69 (6.92)	2.47 (5.68)	2.58 (6.30)	4.04 (15.89)	3.58 (12.38)	3.81 (14.13)	3.40 (11.11)	3.26 (10.16)	3.33 (10.64)
W₂	3.58 (12.46)	3.13 (9.46)	3.36 (10.96)	2.82 (7.64)	2.72 (7.05)	2.77 (7.35)	4.35 (18.50)	4.08 (16.23)	4.22 (17.36)	3.75 (13.61)	3.54 (12.07)	3.65 (12.84)
W₃	3.08 (9.24)	2.66 (6.68)	2.87 (7.96)	1.82 (3.03)	1.49 (1.80)	1.65 (2.42)	2.44 (5.58)	2.36 (5.19)	2.40 (5.38)	2.03 (3.66)	1.81 (2.96)	1.92 (3.31)
W₄	3.23 (10.09)	2.85 (7.73)	3.04 (8.91)	2.48 (5.98)	2.29 (4.82)	2.39 (5.40)	3.37 (10.96)	3.05 (8.94)	3.21 (9.95)	2.97 (8.34)	2.80 (7.37)	2.89 (7.86)
W₅	3.84 (14.43)	3.70 (13.38)	3.77 (13.90)	2.06 (3.97)	1.65 (2.30)	1.85 (3.14)	2.98 (8.53)	2.57 (6.19)	2.78 (7.36)	2.58 (6.14)	2.44 (5.49)	2.51 (5.82)
W₆	3.82 (14.22)	3.45 (11.55)	3.64 (12.89)	3.25 (10.19)	3.05 (8.88)	3.15 (9.54)	2.04 (3.81)	1.69 (2.50)	1.87 (3.16)	1.69 (2.39)	1.60 (2.10)	1.65 (2.24)
W₇	4.05 (16.47)	3.98 (15.94)	4.02 (16.21)	4.33 (18.79)	4.40 (19.11)	4.37 (18.95)	5.01 (24.90)	4.73 (22.06)	4.87 (23.48)	4.68 (21.58)	4.59 (20.65)	4.63 (21.11)
SEm±	0.16	0.14	0.10	0.12	0.08	0.07	0.13	0.11	0.09	0.08	0.09	0.06
CD at 5%	0.46	0.39	0.30	0.34	0.24	0.20	0.36	0.33	0.24	0.24	0.25	0.17

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.21(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Borreria latifolia* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	3.09 (9.06)	2.64 (6.66)	2.87 (7.86)	2.13 (4.03)	2.10 (3.93)	2.12 (3.98)	3.85 (14.52)	3.29 (10.37)	3.57 (12.44)	3.41 (11.21)	3.17 (9.55)	3.29 (10.38)
P₁W₂	3.34 (10.71)	2.72 (6.96)	3.03 (8.83)	2.26 (4.60)	2.20 (4.36)	2.23 (4.48)	4.17 (16.95)	3.81 (14.07)	3.99 (15.51)	3.78 (13.84)	3.55 (12.08)	3.66 (12.96)
P₁W₃	2.85 (7.61)	2.34 (5.07)	2.59 (6.34)	1.27 (1.13)	1.27 (1.26)	1.27 (1.19)	2.04 (3.71)	2.16 (4.19)	2.10 (3.95)	1.98 (3.47)	2.00 (3.51)	1.99 (3.49)
P₁W₄	2.98 (8.48)	2.43 (5.39)	2.70 (6.93)	1.86 (3.19)	2.00 (3.50)	1.93 (3.34)	3.09 (9.16)	2.80 (7.55)	2.95 (8.35)	2.97 (8.36)	2.77 (7.21)	2.87 (7.78)
P₁W₅	3.56 (12.20)	3.25 (10.07)	3.40 (11.13)	1.50 (1.75)	1.38 (1.46)	1.44 (1.60)	2.68 (6.75)	2.32 (4.91)	2.50 (5.83)	2.56 (6.08)	2.27 (4.68)	2.42 (5.38)
P₁W₆	3.57 (12.24)	3.00 (8.52)	3.29 (10.38)	2.76 (7.12)	2.70 (6.80)	2.73 (6.96)	1.73 (2.51)	1.46 (1.65)	1.60 (2.08)	1.49 (1.73)	1.45 (1.62)	1.47 (1.67)
P₁W₇	3.88 (15.15)	3.65 (13.03)	3.76 (14.09)	4.09 (16.30)	4.08 (16.19)	4.09 (16.24)	4.75 (22.30)	4.62 (21.32)	4.68 (21.81)	4.76 (22.29)	4.58 (20.47)	4.67 (21.38)
P₂W₁	3.25 (10.18)	3.03 (8.80)	3.14 (9.49)	2.69 (6.76)	2.54 (5.96)	2.62 (6.36)	4.01 (15.58)	3.65 (12.86)	3.83 (14.22)	3.41 (11.19)	3.31 (10.43)	3.36 (10.81)
P₂W₂	3.47 (11.55)	3.13 (9.33)	3.30 (10.44)	2.84 (7.55)	2.88 (7.82)	2.86 (7.68)	4.33 (18.25)	4.15 (16.71)	4.24 (17.48)	3.75 (13.64)	3.54 (12.03)	3.64 (12.84)
P₂W₃	2.96 (8.32)	2.75 (7.10)	2.85 (7.71)	1.84 (2.89)	1.44 (1.60)	1.64 (2.25)	2.43 (5.43)	2.29 (4.79)	2.36 (5.11)	1.99 (3.46)	1.80 (2.74)	1.89 (3.10)
P₂W₄	3.09 (9.16)	2.90 (7.92)	3.00 (8.54)	2.52 (5.87)	2.31 (4.85)	2.42 (5.36)	3.35 (10.76)	3.06 (8.88)	3.21 (9.82)	2.97 (8.34)	2.81 (7.41)	2.89 (7.88)
P₂W₅	3.72 (13.42)	3.74 (13.50)	3.73 (13.46)	2.07 (3.77)	1.57 (1.99)	1.82 (2.88)	2.93 (8.25)	2.59 (6.22)	2.76 (7.24)	2.56 (6.04)	2.53 (5.89)	2.54 (5.96)

P₂W₆	3.69 (13.14)	3.48 (11.62)	3.59 (12.38)	3.31 (10.47)	3.13 (9.30)	3.22 (9.89)	1.92 (3.25)	1.70 (2.42)	1.81 (2.84)	1.65 (2.22)	1.63 (2.16)	1.64 (2.19)
P₂W₇	3.96 (16.12)	4.24 (17.54)	4.10 (16.83)	4.44 (19.26)	4.45 (19.38)	4.45 (19.32)	5.06 (25.27)	4.72 (21.80)	4.89 (23.53)	4.72 (21.92)	4.58 (20.54)	4.65 (21.23)
P₃W₁	3.73 (13.47)	3.47 (11.55)	3.60 (12.51)	3.23 (9.96)	2.77 (7.16)	3.00 (8.56)	4.25 (17.56)	3.80 (13.92)	4.02 (15.74)	3.38 (10.91)	3.32 (10.51)	3.35 (10.71)
P₃W₂	3.94 (15.13)	3.55 (12.09)	3.75 (13.61)	3.36 (10.78)	3.08 (8.98)	3.22 (9.88)	4.55 (20.32)	4.29 (17.90)	4.42 (19.11)	3.72 (13.36)	3.55 (12.11)	3.64 (12.74)
P₃W₃	3.45 (11.80)	2.89 (7.88)	3.17 (9.84)	2.36 (5.08)	1.74 (2.54)	2.05 (3.81)	2.84 (7.58)	2.64 (6.59)	2.74 (7.09)	2.13 (4.05)	1.64 (2.63)	1.88 (3.34)
P₃W₄	3.61 (12.64)	3.22 (9.86)	3.41 (11.25)	3.06 (8.87)	2.57 (6.11)	2.82 (7.49)	3.67 (12.95)	3.29 (10.39)	3.48 (11.67)	2.97 (8.33)	2.83 (7.49)	2.90 (7.91)
P₃W₅	4.25 (17.67)	4.13 (16.56)	4.19 (17.12)	2.63 (6.39)	1.99 (3.46)	2.31 (4.93)	3.33 (10.58)	2.81 (7.45)	3.07 (9.01)	2.61 (6.31)	2.53 (5.91)	2.57 (6.11)
P₃W₆	4.21 (17.29)	3.87 (14.52)	4.04 (15.91)	3.67 (12.99)	3.32 (10.54)	3.50 (11.76)	2.47 (5.67)	1.91 (3.43)	2.19 (4.55)	1.93 (3.22)	1.73 (2.51)	1.83 (2.87)
P₃W₇	4.32 (18.15)	4.07 (17.25)	4.19 (17.70)	4.47 (20.82)	4.67 (21.77)	4.57 (21.30)	5.21 (27.13)	4.85 (23.05)	5.03 (25.09)	4.56 (20.52)	4.61 (20.93)	4.58 (20.72)
SEm± (PxW)	0.28	0.24	0.18	0.21	0.14	0.13	0.22	0.20	0.15	0.14	0.15	0.10
SEm± (WxP)	0.21	0.18	0.14	0.16	0.13	0.10	0.15	0.13	0.10	0.14	0.10	0.09
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

4.2.2.9.2 Effect of integrated weed management on weed population (no. m⁻²) of *Cleome rutidosperma*

Integrated weed management significantly affected the weed population of *Cleome rutidosperma* at all stages of observation in both years and their pooled value.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest weed density (1.21 and 1.12, respectively) of *Cleome rutidosperma* in treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) which was followed by treatments W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 1.83 and 2.07 recorded the highest weed population in W₇ (Weedy check) at both stages.

At 60 DAS and at harvest, W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lower population of 1.33 and 0.71, respectively followed by the application of treatments W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). The highest pooled value (2.86 and 2.74, respectively) of weed population was recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.9.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Cleome rutidosperma*

Results presented in Table 4.23 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect on the population of *Cleome rutidosperma* in both years and their pooled value at all the stage of observation.

4.2.2.10 Weed population (no. m⁻²) of *Mimosa pudica*

The data on weed population (no. m⁻²) of *Mimosa pudica* at 20, 40, 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years are presented in Table 4.22 (a) and Table 4.22 (b).

4.2.2.10.1 Effect of sowing dates on weed population (no. m⁻²) of *Mimosa pudica*

Sowing dates significantly influences the population of *Mimosa pudica* at different crop growth stages except at harvest. At 20, 40 and 60 DAS pooled values of two years recorded significantly lower population (2.02, 1.86, and 2.03, respectively)

Table 4.22(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Cleome rutidosperma* at 20,40,60 DAS and at harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.41 (1.56)	1.38 (1.45)	1.40 (1.51)	1.35 (1.39)	1.32 (1.30)	1.33 (1.34)	1.79 (2.99)	1.54 (2.15)	1.67 (2.57)	1.66 (2.64)	1.47 (2.02)	1.57 (2.36)
P₂ 30th June	1.59 (2.11)	1.51 (1.82)	1.55 (1.97)	1.48 (1.76)	1.38 (1.48)	1.43 (1.62)	1.88 (3.30)	1.74 (2.80)	1.81 (3.05)	1.71 (2.84)	1.50 (2.08)	1.61 (2.60)
P₃ 15th July	1.75 (2.64)	1.69 (2.44)	1.72 (2.54)	1.42 (2.49)	1.69 (2.04)	1.55 (2.26)	2.13 (4.22)	2.03 (3.86)	2.08 (4.04)	1.76 (3.07)	1.53 (2.14)	1.64 (2.78)
SEm±	0.04	0.04	0.03	0.03	0.04	0.03	0.05	0.04	0.03	0.04	0.05	0.03
CD at 5%	0.16	0.17	0.10	0.13	0.17	0.09	0.18	0.15	0.10	NS	NS	NS
Integrated weed Management (W)												
W₁	1.50 (1.77)	1.48 (1.70)	1.49 (1.74)	1.42 (1.54)	1.35 (1.32)	1.38 (1.43)	1.96 (3.36)	1.82 (2.86)	1.89 (3.11)	1.89 (3.07)	1.58 (2.08)	1.73 (2.58)
W₂	1.61 (2.11)	1.49 (1.75)	1.55 (1.93)	1.48 (1.71)	1.39 (1.45)	1.44 (1.58)	2.18 (4.27)	1.92 (3.26)	2.05 (3.76)	2.10 (3.91)	1.68 (2.32)	1.89 (3.11)
W₃	1.19 (0.94)	1.23 (1.04)	1.21 (0.99)	1.16 (0.86)	1.08 (0.69)	1.12 (0.78)	1.52 (1.85)	1.39 (1.48)	1.46 (1.66)	1.27 (1.15)	1.14 (0.86)	1.21 (1.00)
W₄	1.42 (1.54)	1.44 (1.59)	1.43 (1.57)	1.37 (1.41)	1.31 (1.22)	1.34 (1.31)	1.81 (2.82)	1.77 (2.67)	1.79 (2.74)	1.74 (2.54)	1.55 (1.92)	1.65 (2.23)
W₅	1.82 (2.86)	1.73 (2.54)	1.78 (2.70)	1.32 (1.26)	1.26 (1.09)	1.29 (1.18)	1.74 (2.56)	1.43 (1.60)	1.59 (2.08)	1.37 (1.39)	1.25 (1.07)	1.31 (1.23)
W₆	1.68 (2.42)	1.55 (1.93)	1.62 (2.18)	1.64 (2.27)	1.51 (1.81)	1.58 (2.04)	1.40 (1.50)	1.27 (1.12)	1.33 (1.31)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	1.88 (3.10)	1.78 (2.79)	1.83 (2.95)	2.12 (4.10)	2.02 (3.66)	2.07 (3.88)	2.92 (8.19)	2.79 (7.57)	2.86 (7.88)	2.87 (7.89)	2.61 (6.33)	2.74 (7.11)
SEm±	0.07	0.06	0.04	0.05	0.04	0.03	0.06	0.08	0.05	0.07	0.06	0.05
CD at 5%	0.19	0.17	0.13	0.14	0.12	0.09	0.19	0.23	0.15	0.20	0.18	0.13

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.22(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Cleome rutidosperma* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.36 (1.36)	1.32 (1.25)	1.34 (1.31)	1.29 (1.17)	1.29 (1.16)	1.29 (1.17)	1.81 (2.79)	1.56 (1.93)	1.68 (2.36)	1.79 (2.70)	1.50 (2.03)	1.65 (2.37)
P₁W₂	1.46 (1.64)	1.35 (1.33)	1.41 (1.48)	1.33 (1.27)	1.32 (1.24)	1.33 (1.26)	2.07 (3.81)	1.67 (2.32)	1.87 (3.06)	2.03 (3.62)	1.67 (2.29)	1.85 (2.95)
P₁W₃	1.09 (0.68)	1.02 (0.55)	1.05 (0.62)	1.06 (0.62)	0.99 (0.52)	1.02 (0.57)	1.32 (1.24)	1.20 (0.94)	1.26 (1.09)	1.25 (1.12)	1.14 (0.87)	1.20 (1.00)
P₁W₄	1.27 (1.13)	1.31 (1.23)	1.29 (1.18)	1.24 (1.03)	1.26 (1.09)	1.25 (1.06)	1.67 (2.31)	1.51 (1.77)	1.59 (2.04)	1.65 (2.21)	1.48 (1.71)	1.57 (1.96)
P₁W₅	1.67 (2.33)	1.60 (2.05)	1.63 (2.19)	1.22 (0.99)	1.21 (0.97)	1.21 (0.98)	1.59 (2.04)	1.24 (1.03)	1.41 (1.53)	1.37 (1.38)	1.21 (0.97)	1.29 (1.17)
P₁W₆	1.33 (1.32)	1.40 (1.46)	1.37 (1.39)	1.33 (1.29)	1.35 (1.33)	1.34 (1.31)	1.22 (1.00)	1.12 (0.76)	1.17 (0.88)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.73 (2.49)	1.67 (2.28)	1.70 (2.38)	1.96 (3.33)	1.81 (2.79)	1.88 (3.06)	2.84 (7.78)	2.48 (6.31)	2.66 (7.05)	2.81 (7.42)	2.60 (6.26)	2.71 (6.84)
P₂W₁	1.50 (1.76)	1.46 (1.63)	1.48 (1.69)	1.39 (1.42)	1.31 (1.23)	1.35 (1.33)	1.93 (3.21)	1.78 (2.66)	1.85 (2.94)	1.92 (3.18)	1.60 (2.08)	1.76 (2.63)
P₂W₂	1.61 (2.13)	1.47 (1.66)	1.54 (1.90)	1.44 (1.56)	1.36 (1.36)	1.40 (1.46)	2.13 (4.02)	1.88 (3.05)	2.00 (3.54)	2.11 (3.95)	1.67 (2.30)	1.89 (3.12)
P₂W₃	1.15 (0.86)	1.29 (1.16)	1.22 (1.01)	1.10 (0.70)	1.03 (0.59)	1.06 (0.65)	1.46 (1.67)	1.35 (1.32)	1.41 (1.49)	1.31 (1.21)	1.13 (0.83)	1.22 (1.02)
P₂W₄	1.43 (1.59)	1.41 (1.48)	1.42 (1.53)	1.38 (1.42)	1.28 (1.14)	1.33 (1.28)	1.75 (2.59)	1.72 (2.47)	1.74 (2.53)	1.73 (2.48)	1.57 (1.96)	1.65 (2.22)
P₂W₅	1.81 (2.79)	1.67 (2.31)	1.74 (2.55)	1.30 (1.20)	1.23 (1.01)	1.27 (1.11)	1.67 (2.29)	1.40 (1.45)	1.53 (1.87)	1.33 (1.28)	1.24 (1.04)	1.28 (1.16)
P₂W₆	1.77 (2.63)	1.53 (1.85)	1.65 (2.24)	1.69 (2.37)	1.49 (1.72)	1.59 (2.04)	1.33 (1.28)	1.22 (1.00)	1.28 (1.14)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)

P₂W₇	1.87 (3.04)	1.78 (2.67)	1.82 (2.86)	2.03 (3.61)	1.95 (3.33)	1.99 (3.47)	2.89 (8.04)	2.85 (7.65)	2.87 (7.84)	2.86 (7.77)	2.62 (6.35)	2.74 (7.06)
P₃W₁	1.64 (2.20)	1.64 (2.21)	1.64 (2.21)	1.59 (2.03)	1.44 (1.58)	1.51 (1.80)	2.14 (4.09)	2.12 (3.99)	2.13 (4.04)	1.96 (3.33)	1.62 (2.13)	1.79 (2.73)
P₃W₂	1.75 (2.56)	1.66 (2.26)	1.71 (2.41)	1.67 (2.28)	1.50 (1.75)	1.58 (2.02)	2.34 (4.97)	2.21 (4.41)	2.28 (4.69)	2.16 (4.15)	1.69 (2.37)	1.92 (3.26)
P₃W₃	1.34 (1.29)	1.38 (1.39)	1.36 (1.34)	1.32 (1.26)	1.21 (0.97)	1.27 (1.12)	1.77 (2.63)	1.63 (2.17)	1.70 (2.40)	1.26 (1.12)	1.15 (0.86)	1.20 (0.99)
P₃W₄	1.55 (1.91)	1.60 (2.06)	1.58 (1.99)	1.50 (1.77)	1.39 (1.42)	1.44 (1.60)	2.01 (3.55)	2.07 (3.78)	2.04 (3.66)	1.85 (2.93)	1.61 (2.08)	1.73 (2.50)
P₃W₅	1.98 (3.46)	1.93 (3.26)	1.96 (3.36)	1.45 (1.60)	1.34 (1.30)	1.39 (1.45)	1.96 (3.35)	1.67 (2.31)	1.81 (2.83)	1.41 (1.51)	1.30 (1.20)	1.36 (1.35)
P₃W₆	1.94 (3.31)	1.73 (2.49)	1.83 (2.90)	1.91 (3.14)	1.70 (2.39)	1.80 (2.76)	1.65 (2.22)	1.45 (1.62)	1.55 (1.92)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	2.04 (3.77)	1.91 (3.43)	1.97 (3.60)	2.37 (5.35)	2.29 (4.85)	2.33 (5.10)	3.04 (8.76)	3.04 (8.76)	3.04 (8.76)	2.94 (8.48)	2.62 (6.37)	2.78 (7.42)
SEm± (PxW)	0.39	0.41	0.28	0.38	0.28	0.24	0.11	0.14	0.09	0.12	0.11	0.08
SEm± (WxP)	0.31	0.29	0.22	0.31	0.27	0.20	0.09	0.09	0.06	0.08	0.09	0.06
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation

of *Mimosa pudica* on sowing date of 15th June, while the highest population (5.90, 4.76 and 6.54, respectively) was observed when the crop was sown on the 15th of July.

4.2.2.10.2 Effect of integrated weed management on weed population (no. m⁻²) of *Mimosa pudica*

Result revealed that population of *Mimosa pudica* was found to be significant due to integrated weed management. At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest weed density (1.72 and 1.38, respectively) of *Mimosa pudica* in treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) which was followed by treatment W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The highest weed population of *Mimosa pudica* was recorded in W₇ with pooled values of 2.63 and 3.09 at both stages.

At 60 DAS and harvest, W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lower population of 1.78 and 1.58, respectively, followed by the application of treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). The highest pooled value (3.28 and 3.04, respectively) of weed population was recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.10.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Mimosa pudica*

Results pertaining to population of *Mimosa pudica* in Table 4.23 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect in both years at all the stages of observation.

4.2.2.11 Weed population (no. m⁻²) of *Mollugo pentaphylla*

The data on weed population (no. m⁻²) of *Mollugo pentaphylla* at 20, 40, 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years and their pooled value is presented in Table 4.24 (a) and Table 4.24 (b).

4.2.2.11.1 Effect of sowing dates on weed population (no. m⁻²) of *Mollugo pentaphylla*

Table 4.23(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Mimosa pudica* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	2.21 (4.48)	1.82 (2.95)	2.02 (3.72)	1.98 (3.76)	1.75 (2.88)	1.86 (3.32)	2.13 (4.32)	1.94 (3.60)	2.03 (3.96)	2.06 (4.04)	1.90 (3.42)	1.98 (3.73)
P₂ 30th June	2.35 (5.15)	2.02 (3.73)	2.19 (4.44)	2.10 (4.35)	1.87 (3.26)	1.99 (3.81)	2.23 (4.80)	2.20 (4.69)	2.22 (4.75)	2.14 (4.32)	1.95 (3.59)	2.04 (3.96)
P₃ 15th July	2.65 (6.77)	2.31 (5.03)	2.48 (5.90)	2.33 (5.24)	2.11 (4.29)	2.22 (4.76)	2.57 (6.45)	2.62 (6.63)	2.59 (6.54)	2.17 (4.47)	1.98 (3.72)	2.08 (4.09)
SEm±	0.05	0.05	0.03	0.04	0.05	0.03	0.05	0.05	0.04	0.06	0.05	0.04
CD at 5%	0.18	0.19	0.11	0.17	0.19	0.11	0.20	0.21	0.12	NS	NS	NS
Integrated weed Management (W)												
W₁	2.36 (5.10)	1.91 (3.20)	2.13 (4.15)	2.09 (3.96)	1.84 (2.91)	1.96 (3.43)	2.58 (6.20)	2.45 (5.62)	2.52 (5.91)	2.38 (5.19)	2.08 (3.84)	2.23 (4.52)
W₂	2.41 (5.35)	2.15 (4.17)	2.28 (4.76)	2.33 (4.94)	1.98 (3.45)	2.15 (4.19)	2.62 (6.43)	2.51 (5.93)	2.57 (6.18)	2.44 (5.44)	2.17 (4.23)	2.30 (4.83)
W₃	1.90 (3.14)	1.54 (1.95)	1.72 (2.55)	1.42 (1.55)	1.35 (1.34)	1.38 (1.45)	1.66 (2.30)	1.60 (2.12)	1.63 (2.21)	1.48 (1.70)	1.37 (1.39)	1.43 (1.54)
W₄	1.97 (3.39)	1.67 (2.36)	1.82 (2.87)	1.93 (3.27)	1.59 (2.08)	1.76 (2.67)	2.20 (4.39)	2.16 (4.26)	2.18 (4.33)	2.03 (3.61)	1.81 (2.79)	1.92 (3.20)
W₅	2.73 (7.09)	2.43 (5.53)	2.58 (6.31)	1.50 (1.79)	1.49 (1.75)	1.50 (1.77)	2.02 (3.64)	2.01 (3.63)	2.01 (3.64)	1.89 (3.11)	1.60 (2.07)	1.75 (2.59)
W₆	2.69 (6.78)	2.19 (4.37)	2.44 (5.57)	2.57 (6.13)	2.08 (3.86)	2.32 (5.00)	1.78 (2.71)	1.77 (2.69)	1.78 (2.70)	1.62 (2.11)	1.54 (1.87)	1.58 (1.99)
W₇	2.79 (7.41)	2.48 (5.75)	2.63 (6.58)	3.13 (9.50)	3.05 (8.97)	3.09 (9.24)	3.30 (10.66)	3.27 (10.56)	3.28 (10.61)	3.03 (8.78)	3.04 (8.86)	3.04 (8.82)
SEm±	0.07	0.08	0.05	0.09	0.07	0.06	0.06	0.08	0.05	0.05	0.06	0.04
CD at 5%	0.19	0.24	0.15	0.27	0.20	0.16	0.19	0.23	0.15	0.14	0.16	0.10

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.23(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Mimosa pudica* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	2.17 (4.23)	1.74 (2.52)	1.96 (3.37)	1.94 (3.30)	1.71 (2.41)	1.82 (2.86)	2.40 (5.27)	2.08 (3.84)	2.24 (4.56)	2.34 (4.99)	2.06 (3.78)	2.20 (4.38)
P₁W₂	2.23 (4.49)	1.88 (3.03)	2.06 (3.76)	2.18 (4.27)	1.80 (2.74)	1.99 (3.51)	2.45 (5.54)	2.15 (4.12)	2.30 (4.83)	2.45 (5.52)	2.15 (4.13)	2.30 (4.82)
P₁W₃	1.84 (2.89)	1.36 (1.34)	1.60 (2.12)	1.26 (1.08)	1.23 (1.01)	1.24 (1.04)	1.61 (2.08)	1.48 (1.70)	1.55 (1.89)	1.55 (1.90)	1.45 (1.61)	1.50 (1.75)
P₁W₄	1.84 (2.89)	1.38 (1.39)	1.61 (2.14)	1.79 (2.74)	1.35 (1.33)	1.57 (2.04)	2.02 (3.58)	1.80 (2.75)	1.91 (3.17)	1.94 (3.26)	1.78 (2.67)	1.86 (2.97)
P₁W₅	2.45 (5.49)	2.15 (4.15)	2.30 (4.82)	1.34 (1.33)	1.28 (1.14)	1.31 (1.23)	1.84 (2.88)	1.67 (2.31)	1.76 (2.60)	1.76 (2.65)	1.60 (2.06)	1.68 (2.36)
P₁W₆	2.43 (5.41)	2.03 (3.67)	2.23 (4.54)	2.34 (5.00)	1.94 (3.27)	2.14 (4.13)	1.47 (1.67)	1.37 (1.37)	1.42 (1.52)	1.37 (1.38)	1.31 (1.23)	1.34 (1.31)
P₁W₇	2.52 (5.95)	2.24 (4.57)	2.38 (5.26)	3.00 (8.58)	2.93 (8.28)	2.97 (8.43)	3.11 (9.19)	3.00 (9.11)	3.06 (9.15)	2.99 (8.59)	2.95 (8.47)	2.97 (8.53)
P₂W₁	2.31 (4.82)	1.84 (2.89)	2.07 (3.86)	2.05 (3.87)	1.74 (2.53)	1.89 (3.20)	2.49 (5.71)	2.39 (5.19)	2.44 (5.45)	2.42 (5.37)	2.07 (3.81)	2.25 (4.59)
P₂W₂	2.35 (5.02)	2.14 (4.09)	2.24 (4.55)	2.31 (4.83)	1.95 (3.29)	2.13 (4.06)	2.52 (5.85)	2.45 (5.49)	2.48 (5.67)	2.44 (5.46)	2.20 (4.32)	2.32 (4.89)
P₂W₃	1.86 (2.98)	1.49 (1.73)	1.68 (2.35)	(1.35) (1.35)	1.32 (1.26)	1.34 (1.31)	1.72 (2.47)	1.70 (2.38)	1.71 (2.43)	1.64 (2.17)	1.56 (1.94)	1.60 (2.06)
P₂W₄	1.93 (3.23)	1.66 (2.32)	1.80 (2.77)	1.91 (3.14)	1.57 (1.99)	1.74 (2.57)	2.11 (4.00)	2.08 (3.85)	2.10 (3.92)	2.05 (3.69)	1.79 (2.73)	1.92 (3.21)
P₂W₅	2.68 (6.66)	2.42 (5.45)	2.55 (6.06)	1.46 (1.67)	1.54 (1.87)	1.50 (1.77)	1.93 (3.23)	1.94 (3.28)	1.93 (3.26)	1.89 (3.06)	1.60 (2.06)	1.74 (2.56)

P₂W₆	2.63 (6.43)	2.13 (4.06)	2.38 (5.25)	2.58 (6.19)	2.03 (3.61)	2.31 (4.90)	1.58 (1.98)	1.55 (1.91)	1.56 (1.95)	1.53 (2.17)	1.38 (1.94)	1.45 (2.06)
P₂W₇	2.72 (6.93)	2.45 (5.55)	2.59 (6.24)	3.06 (9.42)	2.96 (8.29)	3.01 (8.86)	3.27 (10.38)	3.30 (10.74)	3.29 (10.56)	3.02 (8.64)	3.05 (8.87)	3.03 (8.76)
P₃W₁	2.59 (6.24)	2.14 (4.20)	2.37 (5.22)	2.28 (4.70)	2.06 (3.78)	2.17 (4.24)	2.85 (7.61)	2.89 (7.84)	2.87 (7.73)	2.39 (5.22)	2.11 (3.94)	2.25 (4.58)
P₃W₂	2.65 (6.55)	2.42 (5.39)	2.54 (5.97)	2.49 (5.70)	2.19 (4.31)	2.34 (5.01)	2.90 (7.90)	2.95 (8.18)	2.92 (8.04)	2.41 (5.32)	2.18 (4.24)	2.29 (4.78)
P₃W₃	2.01 (3.56)	1.79 (2.76)	1.90 (3.16)	1.65 (2.23)	1.49 (1.76)	1.57 (2.00)	2.02 (3.58)	2.12 (3.98)	2.07 (3.78)	1.66 (2.27)	1.60 (2.06)	1.63 (2.16)
P₃W₄	2.13 (4.06)	1.96 (3.36)	2.05 (3.71)	2.10 (3.93)	1.84 (2.91)	1.97 (3.42)	2.47 (5.59)	2.58 (6.18)	2.53 (5.88)	2.09 (3.87)	1.86 (2.96)	1.98 (3.42)
P₃W₅	3.08 (9.13)	2.71 (7.00)	2.89 (8.06)	1.69 (2.37)	1.66 (2.25)	1.67 (2.31)	2.30 (4.81)	2.41 (5.31)	2.35 (5.06)	2.03 (3.61)	1.61 (2.10)	1.82 (2.85)
P₃W₆	2.99 (8.51)	2.42 (5.37)	2.71 (6.94)	2.77 (7.22)	2.27 (4.69)	2.52 (5.95)	1.93 (3.24)	1.89 (3.08)	1.91 (3.16)	1.54 (1.88)	1.42 (1.51)	1.48 (1.70)
P₃W₇	3.12 (9.33)	2.75 (7.12)	2.93 (8.23)	3.32 (10.50)	3.26 (10.35)	3.29 (10.43)	3.51 (12.40)	3.51 (11.82)	3.51 (12.11)	3.10 (9.12)	3.12 (9.23)	3.11 (9.17)
SEm± (PxW)	0.12	0.15	0.09	0.87	0.69	0.55	1.06	1.02	0.74	0.49	0.57	0.38
SEm± (WxP)	0.09	0.10	0.07	0.60	0.51	0.39	0.77	0.73	0.53	0.60	0.56	0.41
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Differences in population of *Mollugo pentaphylla* showed significant effect due to sowing dates in both years at all the stages of observation except at harvest. At 20, 40 and 60 DAS pooled values of two years recorded significantly lowest population (2.87, 1.88, and 2.16, respectively) of *Mollugo pentaphylla* on sowing date of 15th June, while the maximum population was observed when the crop was sown on the 15th of July.

4.2.2.11.2 Effect of integrated weed management on weed population (no. m⁻²) of *Mollugo pentaphylla*

Data presented in Table 4.24 (a) showed significant effect in population of *Mollugo pentaphylla* due to integrated weed management at all stages of observation in both years and their pooled value.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest weed density (2.44 and 1.38 respectively) of *Mollugo pentaphylla* in treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) which was followed by treatments W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 3.68 and 3.79 recorded the highest weed population in W₇ (Weedy check) at both stages.

At 60 DAS and harvest, treatment W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lowest population of 1.77 and 0.71 respectively followed by the application of treatments W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). The highest pooled value (4.01, 3.64) of weed population was recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.11.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Mollugo pentaphylla*

Data respect to population of *Mollugo pentaphylla* presented in Table 4.24 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect in both years and their pooled value at all the stages of observation.

4.2.2.12 Weed population (no. m⁻²) of *Scorparia dulcis*.

Observation on weed population (no. m⁻²) of *Scorparia dulcis* at 20, 40, 60

Table 4.24(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Mollugo pentaphylla* at 20,40,60 DAS and at harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	3.01 (8.86)	2.73 (7.39)	2.87 (8.13)	1.93 (3.86)	1.84 (3.42)	1.88 (3.64)	2.19 (4.86)	2.12 (4.47)	2.16 (4.67)	1.67 (3.24)	1.61 (2.94)	1.64 (3.09)
P₂ 30th June	3.41 (11.41)	2.96 (8.54)	3.18 (9.97)	2.19 (5.11)	1.99 (4.09)	2.09 (4.60)	2.38 (5.74)	2.33 (5.55)	2.35 (5.65)	1.72 (3.46)	1.64 (3.03)	1.68 (3.25)
P₃ 15th July	3.56 (12.50)	3.29 (10.68)	3.42 (11.59)	2.50 (6.74)	2.31 (5.53)	2.40 (6.13)	2.70 (7.33)	2.69 (7.40)	2.70 (7.36)	1.74 (3.60)	1.65 (3.10)	1.69 (3.35)
SEm±	0.08	0.08	0.06	0.06	0.03	0.04	0.06	0.04	0.03	0.05	0.03	0.03
CD at 5%	0.31	0.32	0.18	0.25	0.13	0.12	0.22	0.15	0.11	NS	NS	NS
Integrated weed Management (W)												
W₁	3.01 (8.69)	2.67 (6.89)	2.84 (7.79)	2.08 (3.97)	1.97 (3.43)	2.02 (3.70)	2.58 (6.20)	2.53 (5.98)	2.56 (6.09)	2.10 (3.90)	1.97 (3.41)	2.04 (3.65)
W₂	3.57 (12.36)	3.22 (10.06)	3.39 (11.21)	2.18 (4.37)	2.02 (3.67)	2.10 (4.02)	2.66 (6.62)	2.61 (6.37)	2.63 (6.49)	2.13 (4.05)	2.02 (3.58)	2.07 (3.81)
W₃	2.63 (6.57)	2.24 (4.65)	2.44 (5.61)	1.41 (1.50)	1.36 (1.38)	1.38 (1.44)	1.88 (3.10)	1.83 (2.91)	1.86 (3.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₄	2.94 (8.25)	2.46 (5.69)	2.70 (6.97)	1.46 (1.68)	1.43 (1.58)	1.45 (1.63)	2.04 (3.73)	1.99 (3.52)	2.02 (3.63)	1.36 (1.36)	1.34 (1.32)	1.35 (1.34)
W₅	3.69 (13.29)	3.45 (11.54)	3.57 (12.41)	1.44 (1.61)	1.40 (1.49)	1.42 (1.55)	1.99 (3.50)	1.95 (3.35)	1.97 (3.43)	1.17 (0.96)	1.15 (0.90)	1.16 (0.93)
W₆	3.63 (12.92)	3.37 (10.98)	3.50 (11.95)	2.91 (8.25)	2.50 (5.84)	2.71 (7.04)	1.79 (2.77)	1.74 (2.61)	1.77 (2.69)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	3.82 (14.37)	3.54 (12.29)	3.68 (13.33)	3.95 (15.27)	3.64 (13.03)	3.79 (14.15)	4.02 (15.92)	4.01 (15.92)	4.01 (15.92)	3.77 (13.76)	3.52 (11.96)	3.64 (12.86)
SEm±	0.15	0.14	0.10	0.08	0.09	0.06	0.06	0.08	0.05	0.06	0.07	0.05
CD at 5%	0.42	0.40	0.29	0.24	0.27	0.18	0.19	0.23	0.15	0.17	0.20	0.13

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.24(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Mollugo pentaphylla* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	2.73 (6.93)	2.37 (5.15)	2.55 (6.04)	1.76 (2.67)	1.69 (2.38)	1.73 (2.53)	2.40 (5.28)	2.32 (4.88)	2.36 (5.08)	2.03 (3.62)	1.93 (3.22)	1.98 (3.42)
P₁W₂	3.33 (10.59)	2.89 (7.85)	3.11 (9.22)	1.83 (2.85)	1.73 (2.53)	1.78 (2.69)	2.48 (5.67)	2.40 (5.25)	2.44 (5.46)	2.06 (3.74)	1.95 (3.29)	2.00 (3.52)
P₁W₃	2.20 (4.39)	1.96 (3.36)	2.08 (3.88)	1.29 (1.18)	1.23 (1.02)	1.26 (1.10)	1.64 (2.20)	1.61 (2.11)	1.63 (2.15)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₄	2.61 (6.36)	2.01 (3.58)	2.31 (4.97)	1.34 (1.31)	1.29 (1.17)	1.32 (1.24)	1.82 (2.81)	1.76 (2.60)	1.79 (2.70)	1.34 (1.30)	1.32 (1.26)	1.33 (1.28)
P₁W₅	3.38 (11.09)	3.28 (10.37)	3.33 (10.73)	1.31 (1.22)	1.25 (1.07)	1.28 (1.15)	1.77 (2.65)	1.74 (2.53)	1.76 (2.59)	1.11 (0.79)	1.12 (0.76)	1.12 (0.77)
P₁W₆	3.36 (10.81)	3.24 (10.00)	3.30 (10.41)	2.38 (5.18)	2.21 (4.41)	2.30 (4.80)	1.50 (1.78)	1.49 (1.71)	1.50 (1.75)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	3.47 (11.81)	3.38 (11.45)	3.43 (11.63)	3.62 (12.64)	3.43 (11.34)	3.53 (11.99)	3.72 (13.64)	3.54 (12.25)	3.63 (12.95)	3.70 (13.23)	3.53 (12.05)	3.62 (12.64)
P₂W₁	3.13 (9.33)	2.61 (6.32)	2.87 (7.83)	2.05 (3.72)	1.91 (3.15)	1.98 (3.44)	2.52 (5.91)	2.45 (5.49)	2.49 (5.70)	2.13 (4.02)	2.03 (3.62)	2.08 (3.82)
P₂W₂	3.62 (12.73)	3.27 (10.32)	3.44 (11.52)	2.16 (4.19)	1.98 (3.44)	2.07 (3.82)	2.61 (6.32)	2.53 (5.91)	2.57 (6.12)	2.17 (4.21)	2.05 (3.72)	2.11 (3.96)
P₂W₃	2.70 (6.82)	2.12 (4.01)	2.41 (5.41)	1.39 (1.44)	1.31 (1.22)	1.35 (1.33)	1.82 (2.82)	1.78 (2.68)	1.80 (2.75)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₄	3.06 (8.93)	2.55 (6.01)	2.81 (7.47)	1.44 (1.59)	1.35 (1.36)	1.40 (1.48)	1.96 (3.35)	1.94 (3.26)	1.95 (3.31)	1.38 (1.41)	1.37 (1.42)	1.38 (1.41)
P₂W₅	3.79 (13.99)	3.38 (11.07)	3.59 (12.53)	1.41 (1.52)	1.34 (1.31)	1.38 (1.41)	1.92 (3.21)	1.89 (3.09)	1.91 (3.15)	1.18 (0.99)	1.14 (0.91)	1.16 (0.95)
P₂W₆	3.69 (13.26)	3.29 (10.45)	3.49 (11.85)	2.88 (7.80)	2.43 (5.45)	2.66 (6.63)	1.73 (2.51)	1.67 (2.31)	1.70 (2.41)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)

P₂W₇	3.90 (14.82)	3.47 (11.57)	3.68 (13.20)	3.98 (15.51)	3.60 (12.71)	3.79 (14.11)	4.06 (16.04)	4.04 (16.13)	4.05 (16.09)	3.74 (13.58)	3.46 (11.56)	3.60 (12.57)
P₃W₁	3.18 (9.82)	3.05 (9.19)	3.11 (9.51)	2.45 (5.51)	2.29 (4.75)	2.37 (5.13)	2.81 (7.40)	2.84 (7.58)	2.82 (7.49)	2.13 (4.05)	1.97 (3.38)	2.05 (3.72)
P₃W₂	3.75 (13.77)	3.51 (12.00)	3.63 (12.88)	2.55 (6.06)	2.36 (5.06)	2.46 (5.56)	2.88 (7.87)	2.90 (7.94)	2.89 (7.90)	2.17 (4.20)	2.05 (3.72)	2.11 (3.96)
P₃W₃	3.00 (8.49)	2.64 (6.57)	2.82 (7.53)	1.54 (1.88)	1.53 (1.90)	1.54 (1.89)	2.18 (4.26)	2.10 (3.93)	2.14 (4.09)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₄	3.14 (9.47)	2.82 (7.46)	2.98 (8.47)	1.61 (2.16)	1.65 (2.22)	1.63 (2.19)	2.35 (5.03)	2.28 (4.70)	2.31 (4.87)	1.37 (1.37)	1.33 (1.28)	1.35 (1.32)
P₃W₅	3.89 (14.79)	3.67 (13.18)	3.78 (13.98)	1.61 (2.10)	1.60 (2.08)	1.61 (2.09)	2.27 (4.64)	2.22 (4.44)	2.24 (4.54)	1.22 (1.10)	1.19 (1.03)	1.21 (1.07)
P₃W₆	3.84 (14.70)	3.58 (12.48)	3.71 (13.59)	3.48 (11.78)	2.85 (7.64)	3.16 (9.71)	2.13 (4.03)	2.07 (3.81)	2.10 (3.92)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	4.09 (16.49)	3.77 (13.86)	3.93 (15.17)	4.25 (17.65)	3.88 (15.04)	4.06 (16.35)	4.28 (18.08)	4.45 (19.38)	4.36 (18.73)	3.86 (14.48)	3.56 (12.29)	3.71 (13.38)
SEm± (PxW)	1.82	1.61	1.21	0.91	1.05	0.70	0.14	0.15	0.10	0.10	0.12	0.08
SEm± (WxP)	1.31	1.25	0.90	0.76	0.65	0.50	0.11	0.09	0.07	0.10	0.07	0.06
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years and their pooled value is presented in Table 4.25 (a) and Table 4.25 (b).

4.2.2.12.1 Effect of sowing dates on weed population (no. m⁻²) of *Scorparia dulcis*

An examination of two years' data and their pooled value on weed of *Scorparia dulcis* revealed that sowing dates were found to be significant at all the stages of observation except at harvest. At 20, 40, and 60DAS pooled values of two years recorded significantly lowest populations (1.62, 1.47, and 1.76, respectively) of *Scorparia dulcis* on the sowing date 15th of June, while the highest population (1.92, 1.73 and 2.20, respectively) was observed when the crop was sown on the 15th of July.

4.2.2.12.2 Effect of integrated weed management on weed population (no. m⁻²) of *Scorparia dulcis*

Variation in weed population of *Scorparia dulcis* was found significant due to integrated weed management at all stages of observation in both years and their pooled value.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest weed density (1.33 and 1.08, respectively) of *Scorparia dulcis* in W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) treatment which was followed by treatment W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 2.06 and 2.52 recorded the highest weed population in W₇ (Weedy check) at both stages.

At 60 DAS and harvest, treatments W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lower population of 1.56 and 1.29, respectively, followed by the application of treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). The highest pooled values (2.88, 2.77, respectively) of weed population were recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.12.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Scorparia dulcis*

Results presented in Table 4.25 (b) revealed that the interaction of the sowing

Table 4.25(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Scorparia dulcis* at 20,40,60 DAS and at harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.66 (2.29)	1.59 (2.09)	1.62 (2.19)	1.53 (2.03)	1.42 (1.73)	1.47 (1.88)	1.85 (3.11)	1.68 (2.54)	1.76 (2.82)	1.75 (2.82)	1.66 (2.47)	1.71 (2.65)
P₂ 30th June	1.82 (2.94)	1.71 (2.51)	1.77 (2.72)	1.64 (2.35)	1.45 (1.81)	1.54 (2.08)	1.97 (3.57)	1.83 (3.03)	1.90 (3.30)	1.77 (2.89)	1.71 (2.67)	1.74 (2.78)
P₃ 15th July	2.00 (3.67)	1.84 (3.07)	1.92 (3.37)	1.85 (3.18)	1.61 (2.35)	1.73 (2.76)	2.27 (4.87)	2.14 (4.29)	2.20 (4.58)	1.78 (2.94)	1.73 (2.74)	1.75 (2.84)
SEm±	0.04	0.04	0.03	0.03	0.03	0.02	0.03	0.04	0.03	0.04	0.05	0.03
CD at 5%	0.17	0.15	0.09	0.10	0.12	0.06	0.13	0.16	0.09	NS	NS	NS
Integrated weed Management (W)												
W₁	1.85 (2.94)	1.68 (2.34)	1.76 (2.64)	1.58 (2.01)	1.41 (1.52)	1.50 (1.76)	2.12 (4.01)	1.95 (3.35)	2.03 (3.68)	1.87 (3.02)	1.79 (2.71)	1.83 (2.86)
W₂	1.88 (3.06)	1.77 (2.66)	1.83 (2.86)	2.18 (2.18)	2.02 (1.64)	2.10 (1.91)	2.18 (4.29)	1.99 (3.51)	2.09 (3.90)	1.95 (3.33)	1.82 (2.84)	1.89 (3.08)
W₃	1.40 (1.47)	1.26 (1.09)	1.33 (1.28)	1.21 (0.98)	0.94 (0.47)	1.08 (0.72)	1.70 (2.43)	1.56 (2.00)	1.63 (2.21)	1.36 (1.38)	1.35 (1.34)	1.35 (1.36)
W₄	1.54 (1.88)	1.36 (1.38)	1.45 (1.63)	1.50 (1.79)	1.38 (1.42)	1.44 (1.60)	1.90 (3.13)	1.73 (2.53)	1.81 (2.83)	1.68 (2.33)	1.59 (2.04)	1.63 (2.19)
W₅	2.04 (3.74)	1.96 (3.35)	2.00 (3.55)	1.39 (1.47)	1.19 (0.97)	1.29 (1.22)	1.74 (2.58)	1.61 (2.15)	1.68 (2.37)	1.38 (1.43)	1.36 (1.37)	1.37 (1.40)
W₆	2.01 (3.63)	1.92 (3.22)	1.97 (3.42)	1.84 (3.02)	1.60 (2.08)	1.72 (2.55)	1.65 (2.27)	1.48 (1.74)	1.56 (2.00)	1.31 (1.23)	1.27 (1.11)	1.29 (1.17)
W₇	2.08 (4.03)	2.04 (3.86)	2.06 (3.94)	2.56 (6.20)	2.48 (5.66)	2.52 (5.93)	2.92 (8.24)	2.84 (7.73)	2.88 (7.99)	2.81 (7.48)	2.72 (6.98)	2.77 (7.23)
SEm±	0.09	0.08	0.06	0.08	0.07	0.05	0.07	0.07	0.05	0.06	0.06	0.04
CD at 5%	0.25	0.22	0.17	0.23	0.20	0.15	0.20	0.20	0.14	0.18	0.17	0.12

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.25(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Scorparia dulcis* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.66 (2.25)	1.52 (1.81)	1.59 (2.03)	1.46 (1.63)	1.34 (1.32)	1.40 (1.47)	1.95 (3.32)	1.76 (2.62)	1.86 (2.97)	1.88 (3.07)	1.76 (2.63)	1.82 (2.85)
P₁W₂	1.69 (2.36)	1.62 (2.12)	1.65 (2.24)	1.51 (1.77)	1.39 (1.44)	1.45 (1.61)	2.02 (3.60)	1.81 (2.77)	1.92 (3.19)	1.97 (3.39)	1.81 (2.80)	1.89 (3.09)
P₁W₃	1.32 (1.25)	1.18 (0.89)	1.25 (1.07)	1.11 (0.74)	0.82 (0.19)	0.97 (0.47)	1.53 (1.84)	1.33 (1.26)	1.43 (1.55)	1.34 (1.30)	1.32 (1.25)	1.33 (1.27)
P₁W₄	1.42 (1.53)	1.27 (1.12)	1.35 (1.32)	1.33 (1.30)	1.31 (1.22)	1.32 (1.26)	1.73 (2.51)	1.51 (1.79)	1.62 (2.15)	1.69 (2.36)	1.48 (1.69)	1.58 (2.03)
P₁W₅	1.83 (2.86)	1.82 (2.82)	1.83 (2.84)	1.28 (1.13)	1.13 (0.82)	1.21 (0.97)	1.56 (1.94)	1.38 (1.42)	1.47 (1.68)	1.34 (1.31)	1.34 (1.30)	1.34 (1.31)
P₁W₆	1.82 (2.81)	1.78 (2.67)	1.80 (2.74)	1.65 (2.52)	1.53 (1.89)	1.59 (2.20)	1.53 (1.64)	1.33 (1.00)	1.43 (1.32)	1.28 (1.15)	1.23 (1.02)	1.26 (1.09)
P₁W₇	1.86 (2.95)	1.93 (3.24)	1.89 (3.10)	2.37 (5.14)	2.40 (5.24)	2.38 (5.19)	2.71 (6.93)	2.72 (6.91)	2.71 (6.92)	2.76 (7.18)	2.67 (6.63)	2.71 (6.91)
P₂W₁	1.86 (2.98)	1.66 (2.26)	1.76 (2.62)	1.54 (1.87)	1.38 (1.41)	1.46 (1.64)	2.06 (3.76)	1.90 (3.12)	1.98 (3.44)	1.86 (2.97)	1.81 (2.77)	1.83 (2.87)
P₂W₂	1.87 (3.03)	1.76 (2.60)	1.82 (2.82)	1.59 (2.03)	1.42 (1.53)	1.51 (1.78)	2.13 (4.02)	1.94 (3.27)	2.03 (3.65)	1.95 (3.31)	1.83 (2.87)	1.89 (3.09)
P₂W₃	1.40 (1.47)	1.26 (1.09)	1.33 (1.28)	1.19 (0.92)	0.87 (0.27)	1.03 (0.59)	1.64 (2.19)	1.50 (1.76)	1.57 (1.97)	1.36 (1.36)	1.36 (1.39)	1.36 (1.38)
P₂W₄	1.53 (1.85)	1.34 (1.32)	1.44 (1.58)	1.49 (1.73)	1.35 (1.32)	1.42 (1.52)	1.83 (2.86)	1.67 (2.29)	1.75 (2.58)	1.70 (2.38)	1.62 (2.14)	1.66 (2.26)
P₂W₅	2.03 (3.61)	1.95 (3.32)	1.99 (3.47)	1.35 (1.34)	1.11 (0.78)	1.23 (1.06)	1.68 (2.35)	1.55 (1.92)	1.62 (2.13)	1.40 (1.48)	1.38 (1.43)	1.39 (1.45)

P₂W₆	1.99 (3.47)	1.92 (3.19)	1.95 (3.33)	1.82 (2.80)	1.57 (1.98)	1.69 (2.39)	1.59 (2.04)	1.41 (1.50)	1.50 (1.77)	1.30 (1.20)	1.26 (1.08)	1.28 (1.14)
P₂W₇	2.09 (4.15)	2.07 (3.80)	2.08 (3.97)	2.50 (5.76)	2.43 (5.40)	2.46 (5.58)	2.85 (7.79)	2.81 (7.39)	2.83 (7.59)	2.81 (7.50)	2.72 (7.00)	2.77 (7.25)
P₃W₁	2.02 (3.59)	1.85 (2.94)	1.94 (3.27)	1.74 (2.53)	1.51 (1.82)	1.63 (2.17)	2.33 (4.94)	2.20 (4.33)	2.26 (4.63)	1.87 (3.00)	1.80 (2.73)	1.83 (2.87)
P₃W₂	2.07 (3.80)	1.94 (3.27)	2.00 (3.54)	1.80 (2.74)	1.55 (1.94)	1.68 (2.34)	2.40 (5.26)	2.23 (4.49)	2.32 (4.87)	1.94 (3.28)	1.82 (2.84)	1.88 (3.06)
P₃W₃	1.48 (1.70)	1.34 (1.30)	1.41 (1.50)	1.33 (1.26)	1.13 (0.95)	1.23 (1.11)	1.94 (3.27)	1.86 (2.97)	1.90 (3.12)	1.38 (1.47)	1.36 (1.37)	1.37 (1.42)
P₃W₄	1.65 (2.25)	1.48 (1.70)	1.57 (1.97)	1.68 (2.34)	1.48 (1.73)	1.58 (2.03)	2.12 (4.01)	2.00 (3.52)	2.06 (3.76)	1.66 (2.26)	1.66 (2.29)	1.66 (2.27)
P₃W₅	2.28 (4.75)	2.10 (3.93)	2.19 (4.34)	1.54 (1.93)	1.31 (1.30)	1.43 (1.62)	1.98 (3.46)	1.90 (3.13)	1.94 (3.29)	1.41 (1.49)	1.37 (1.39)	1.39 (1.44)
P₃W₆	2.23 (4.59)	2.07 (3.81)	2.15 (4.20)	2.05 (3.73)	1.69 (2.39)	1.87 (3.06)	1.91 (3.14)	1.79 (2.71)	1.85 (2.93)	1.36 (1.47)	1.31 (1.37)	1.33 (1.42)
P₃W₇	2.28 (4.98)	2.10 (4.53)	2.19 (4.76)	2.83 (7.71)	2.61 (6.32)	2.72 (7.02)	3.21 (10.00)	2.98 (8.89)	3.10 (9.45)	2.85 (7.75)	2.78 (7.30)	2.82 (7.53)
SEm±(PxW)	0.65	0.62	0.45	0.14	0.12	0.09	0.12	0.12	0.09	0.50	0.45	0.34
SEm± (WxP)	0.43	0.40	0.29	0.08	0.07	0.05	0.08	0.09	0.06	0.40	0.43	0.29
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

dates and integrated weed management did not show any significant effect on the population of *Scorparia dulcis* in both years and their pooled value at all the stages of observation.

4.2.2.13 Weed population (no. m⁻²) of *Alternanthera sessilis*

The data on weed population (no. m⁻²) of *Alternanthera sessilis* at 20, 40, 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years and their pooled value is presented in Table 4.26 (a) and Table 4.26 (b).

4.2.2.13.1 Effect of sowing dates on weed population (no. m⁻²) of *Alternanthera sessilis*

Variation in weed population of *Alternanthera sessilis* of two years' data and their pooled value revealed that sowing dates were found to be significant at all the stages of observation except at harvest, which was non-significant. At 20, 40, and 60 DAS pooled values of two years recorded significantly lower population (1.44, 1.26, and 1.55, respectively) of *Alternanthera sessilis* on the 15th of June, while the highest population (1.62, 1.56 and 1.87, respectively) was observed when the crop was sown on the 15th of July.

4.2.2.13.2 Effect of integrated weed management on weed population (no. m⁻²) of *Alternanthera sessilis*

Significant effects on *Alternanthera sessilis* due to integrated weed management were observed at all stages of observation in both years and their pooled value.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest weed density (1.30, 1.12) of *Alternanthera sessilis* in treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) which was followed by treatment W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled values of 1.67 and 2.03 were recorded the highest weed population in W₇ (Weedy check) at both stages.

At 60 DAS and harvest, treatment W₆ (Hand weeding at 20 and 40 DAS)

Table 4.26(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Alternanthera sessilis* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.47 (1.66)	1.42 (1.58)	1.44 (1.62)	1.31 (1.31)	1.21 (1.04)	1.26 (1.18)	1.56 (2.05)	1.54 (1.96)	1.55 (2.00)	1.19 (1.05)	1.17 (.99)	1.18 (1.02)
P₂ 30th June	1.55 (1.93)	1.52 (1.86)	1.54 (1.90)	1.50 (1.85)	1.44 (1.64)	1.47 (1.75)	1.77 (2.71)	1.73 (2.61)	1.75 (2.66)	1.20 (1.12)	1.18 (1.06)	1.19 (1.09)
P₃ 15th July	1.71 (2.47)	1.54 (1.89)	1.62 (2.18)	1.60 (2.16)	1.53 (1.92)	1.56 (2.04)	1.94 (3.39)	1.79 (2.82)	1.87 (3.10)	1.22 (1.14)	1.19 (1.06)	1.21 (1.10)
SEm±	0.03	0.02	0.02	0.04	0.04	0.03	0.03	0.03	0.02	0.03	0.02	0.02
CD at 5%	0.12	0.07	0.06	0.14	0.14	0.08	0.13	0.12	0.07	NS	NS	NS
Integrated weed Management (W)												
W₁	1.59 (2.05)	1.51 (1.79)	1.55 (1.92)	1.45 (1.62)	1.37 (1.40)	1.41 (1.51)	1.80 (2.79)	1.73 (2.54)	1.77 (2.66)	1.35 (1.31)	1.34 (1.30)	1.34 (1.30)
W₂	1.61 (2.10)	1.54 (1.88)	1.58 (1.99)	1.49 (1.72)	1.41 (1.51)	1.45 (1.61)	1.87 (3.02)	1.77 (2.64)	1.82 (2.83)	1.40 (1.46)	1.37 (1.39)	1.39 (1.42)
W₃	1.36 (1.35)	1.25 (1.06)	1.30 (1.20)	1.15 (.85)	1.08 (.69)	1.12 (0.77)	1.50 (1.82)	1.45 (1.63)	1.47 (1.72)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₄	1.44 (1.59)	1.34 (1.35)	1.39 (1.47)	1.40 (1.46)	1.32 (1.26)	1.36 (1.36)	1.76 (2.62)	1.68 (2.37)	1.72 (2.50)	1.27 (1.11)	1.27 (1.10)	1.27 (1.11)
W₅	1.66 (2.28)	1.60 (2.09)	1.63 (2.19)	1.18 (.93)	1.16 (.88)	1.17 (.90)	1.71 (2.47)	1.64 (2.22)	1.68 (2.34)	1.10 (0.72)	1.06 (0.63)	1.08 (0.68)
W₆	1.66 (2.26)	1.59 (2.05)	1.62 (2.15)	1.52 (1.82)	1.46 (1.65)	1.49 (1.73)	1.38 (1.41)	1.33 (1.26)	1.35 (1.34)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	1.71 (2.53)	1.64 (2.23)	1.67 (2.38)	2.11 (4.03)	1.95 (3.38)	2.03 (3.70)	2.27 (4.88)	2.23 (4.59)	2.25 (4.74)	1.89 (3.12)	1.82 (2.86)	1.85 (2.99)
SEm±	0.05	0.07	0.04	0.04	0.04	0.03	0.08	0.08	0.06	0.04	0.04	0.03
CD at 5%	0.15	0.20	0.12	0.12	0.12	0.08	0.23	0.22	0.16	0.12	0.12	0.08

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.26(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Alternanthera sessilis*. at 20,40,60 DAS and at harvest.

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.49 (1.72)	1.44 (1.58)	1.46 (1.65)	1.30 (1.19)	1.23 (1.00)	1.26 (1.09)	1.58 (2.01)	1.55 (1.97)	1.57 (1.99)	1.34 (1.29)	1.32 (1.25)	1.33 (1.27)
P₁W₂	1.51 (1.78)	1.47 (1.68)	1.49 (1.73)	1.35 (1.31)	1.27 (1.12)	1.31 (1.22)	1.62 (2.14)	1.58 (2.01)	1.60 (2.07)	1.39 (1.44)	1.35 (1.32)	1.37 (1.38)
P₁W₃	1.25 (1.07)	1.17 (0.87)	1.21 (0.97)	0.94 (0.39)	0.90 (0.31)	0.92 (0.35)	1.34 (1.34)	1.34 (1.30)	1.34 (1.32)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₄	1.34 (1.30)	1.26 (1.15)	1.30 (1.23)	1.26 (1.09)	1.19 (0.92)	1.23 (1.00)	1.56 (1.93)	1.51 (1.77)	1.53 (1.85)	1.26 (1.08)	1.23 (1.01)	1.24 (1.05)
P₁W₅	1.56 (1.93)	1.53 (1.87)	1.54 (1.90)	0.96 (0.42)	0.91 (0.33)	0.93 (0.37)	1.52 (1.82)	1.50 (1.81)	1.51 (1.82)	1.09 (0.70)	1.04 (0.59)	1.06 (0.64)
P₁W₆	1.55 (1.92)	1.52 (1.82)	1.54 (1.87)	1.38 (1.39)	1.29 (1.17)	1.33 (1.28)	1.23 (1.02)	1.22 (1.00)	1.23 (1.01)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.56 (1.93)	1.58 (2.07)	1.57 (2.00)	1.96 (3.39)	1.71 (2.46)	1.84 (2.92)	2.07 (4.08)	2.09 (3.88)	2.08 (3.98)	1.83 (2.85)	1.81 (2.79)	1.82 (2.82)
P₂W₁	1.57 (1.98)	1.53 (1.86)	1.55 (1.92)	1.48 (1.68)	1.41 (1.49)	1.44 (1.59)	1.81 (2.77)	1.79 (2.72)	1.80 (2.74)	1.34 (1.30)	1.34 (1.30)	1.34 (1.30)
P₂W₂	1.59 (2.03)	1.57 (1.96)	1.58 (1.99)	1.51 (1.77)	1.46 (1.64)	1.48 (1.71)	1.87 (3.02)	1.85 (2.94)	1.86 (2.98)	1.40 (1.46)	1.39 (1.42)	1.39 (1.44)
P₂W₃	1.34 (1.29)	1.28 (1.15)	1.31 (1.22)	1.22 (0.98)	1.11 (0.73)	1.16 (0.86)	1.50 (1.76)	1.49 (1.77)	1.49 (1.76)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₄	1.42 (1.53)	1.36 (1.49)	1.39 (1.51)	1.38 (1.41)	1.38 (1.40)	1.38 (1.40)	1.75 (2.57)	1.74 (2.61)	1.75 (2.59)	1.27 (1.11)	1.27 (1.11)	1.27 (1.11)
P₂W₅	1.65 (2.25)	1.63 (2.17)	1.64 (2.21)	1.25 (1.06)	1.25 (1.06)	1.25 (1.06)	1.71 (2.41)	1.69 (2.36)	1.70 (2.38)	1.09 (0.69)	1.04 (0.59)	1.06 (0.64)

P₂W₆	1.64 (2.19)	1.62 (2.13)	1.63 (2.16)	1.56 (1.93)	1.48 (1.71)	1.52 (1.82)	1.37 (1.39)	1.34 (1.30)	1.36 (1.34)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	1.66 (2.27)	1.64 (2.27)	1.65 (2.27)	2.14 (4.13)	1.99 (3.49)	2.07 (3.81)	2.35 (5.10)	2.24 (4.57)	2.29 (4.83)	1.90 (3.27)	1.84 (3.02)	1.87 (3.15)
P₃W₁	1.72 (2.44)	1.55 (1.92)	1.63 (2.18)	1.58 (1.99)	1.49 (1.72)	1.53 (1.85)	2.02 (3.60)	1.85 (2.93)	1.94 (3.26)	1.36 (1.34)	1.36 (1.34)	1.36 (1.34)
P₃W₂	1.73 (2.49)	1.59 (2.02)	1.66 (2.25)	1.60 (2.07)	1.50 (1.77)	1.55 (1.92)	2.10 (3.91)	1.86 (2.96)	1.98 (3.44)	1.40 (1.47)	1.38 (1.41)	1.39 (1.44)
P₃W₃	1.48 (1.69)	1.28 (1.15)	1.38 (1.42)	1.29 (1.17)	1.23 (1.02)	1.26 (1.09)	1.67 (2.36)	1.51 (1.82)	1.59 (2.09)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₄	1.56 (1.95)	1.38 (1.42)	1.47 (1.68)	1.55 (1.90)	1.40 (1.45)	1.47 (1.68)	1.97 (3.37)	1.79 (2.73)	1.88 (3.05)	1.28 (1.14)	1.30 (1.20)	1.29 (1.17)
P₃W₅	1.78 (2.68)	1.65 (2.22)	1.72 (2.45)	1.34 (1.30)	1.32 (1.25)	1.33 (1.27)	1.92 (3.17)	1.73 (2.49)	1.82 (2.83)	1.13 (0.78)	1.10 (0.72)	1.11 (0.75)
P₃W₆	1.78 (2.67)	1.64 (2.18)	1.71 (2.43)	1.62 (2.14)	1.60 (2.06)	1.61 (2.10)	1.53 (1.83)	1.41 (1.49)	1.47 (1.66)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	1.91 (3.39)	1.69 (2.34)	1.80 (2.87)	2.23 (4.57)	2.13 (4.20)	2.18 (4.38)	2.40 (5.47)	2.37 (5.31)	2.39 (5.39)	1.92 (3.22)	1.81 (2.76)	1.87 (2.99)
SEm± (PxW)	0.09	0.12	0.07	0.07	0.07	0.05	0.14	0.13	0.10	0.07	0.07	0.05
SEm± (WxP)	0.06	0.06	0.04	0.07	0.07	0.05	0.08	0.08	0.06	0.06	0.05	0.04
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

pooled value of two years recorded a significantly lowest population of 1.35 and 0.71 respectively followed by the application of treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). The highest pooled value (2.25, 1.85, respectively) of weed population was recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.13.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Alternanthera sessilis*

Data with respect to weed population presented in Table 4.26 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect on the population of *Alternanthera sessilis* in both years and their pooled value at all the stages of observation.

4.2.2.14 Weed population (no. m⁻²) of *Commelina benghalensis*

The data on weed population (no. m⁻²) of *Commelina benghalensis* at 20, 40, 60 DAS and harvest as influenced by sowing dates and integrated weed management treatments in both the years and their pooled value is presented in Table 4.27 (a) and Table 4.27 (b).

4.2.2.14.1 Effect of sowing dates on weed population (no. m⁻²) of *Commelina benghalensis*

An examination of two years' data and their pooled value on weed of *Commelina benghalensis* revealed that sowing dates were found to be significant at all the stages of observation except at harvest, which was non-significant. At 20, 40, and 60 DAS pooled values of two years recorded significantly lowest population (1.34, 1.24, and 1.66, respectively) on the 15th of June, while the highest population (1.57, 1.47 and 1.98, respectively) was observed when the crop was sown on the 15th of July.

4.2.2.14.2 Effect of integrated weed management on weed population (no. m⁻²) of *Commelina benghalensis*

Integrated weed management significantly affected the weed population of *Commelina benghalensis* at all stages of observation in both years and their pooled value.

At 20 and 40 DAS, the pooled value of two years' results recorded significantly lowest weed density (1.25, 1.13) of *Commelina benghalensis* in treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) which was followed by treatment W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS). The pooled value of 1.65 and 1.78 recorded highest weed population in W₇ (Weedy check) at both stages.

At 60 DAS and harvest, W₆ (Hand weeding at 20 and 40 DAS) pooled value of two years recorded a significantly lower population of 1.59 and 0.71, respectively followed by the application of W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) treatments. The highest pooled values (2.27 and 1.91, respectively) of weed population were recorded in W₇ (Weedy check) at 60 DAS and harvest.

4.2.2.14.3 Interaction effect of sowing dates and integrated weed management on the population (no. m⁻²) of *Commelina benghalensis*

Results presented in Table 4.27 (b) revealed that the interaction of the sowing dates and integrated weed management did not show any significant effect on the population of *Commelina benghalensis* in both years and their pooled value at all the stages of observation.

4.2.2.15 Weed population (no. m⁻²) of grasses

The data concerning weed density (no. m⁻²) of grasses at 20, 40, and 60 DAS and harvest as affected by sowing dates and integrated weed management approaches over both years and the pooled data of the two years, is presented in Table 4.28 (a) and Table 4.28 (b).

4.2.2.15.1 Effect of dates of sowing on population of grasses

Critical appraisal of data showed that the population of grasses due to the sowing dates was significant at 20, 40, and 60 DAS, except at harvest. The pooled value of two years revealed that sowing on the 15th of June recorded a significantly lower population (5.14, 4.40 and 5.64, respectively) of grasses at 20, 40, and 60 DAS. The highest weed population (7.52, 6.27 and 7.48, respectively) was observed on the

Table 4.27(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Commelina benghalensis* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.38 (1.42)	1.29 (1.21)	1.34 (1.31)	1.29 (1.20)	1.19 (0.98)	1.24 (1.09)	1.68 (2.34)	1.64 (2.24)	1.66 (2.29)	1.38 (1.64)	1.22 (1.12)	1.3 (1.38)
P₂ 30th June	1.54 (1.95)	1.43 (1.59)	1.49 (1.77)	1.41 (1.52)	1.34 (1.36)	1.38 (1.44)	1.74 (2.58)	1.70 (2.44)	1.72 (2.51)	1.40 (1.69)	1.23 (1.16)	1.32 (1.43)
P₃ 15th July	1.61 (2.13)	1.52 (1.86)	1.57 (1.99)	1.55 (2.00)	1.39 (1.51)	1.47 (1.75)	2.05 (3.86)	1.92 (3.30)	1.98 (3.58)	1.44 (1.85)	1.25 (1.20)	1.34 (1.53)
SEm±	0.03	0.03	0.02	0.03	0.02	0.02	0.04	0.03	0.03	0.05	0.03	0.03
CD at 5%	0.13	0.12	0.07	0.11	0.08	0.06	0.17	0.13	0.09	NS	NS	NS
Integrated weed Management (W)												
W₁	1.47 (1.69)	1.38 (1.42)	1.42 (1.55)	1.40 (1.49)	1.31 (1.22)	1.35 (1.35)	1.84 (2.93)	1.75 (2.59)	1.79 (2.76)	1.66 (2.27)	1.38 (1.43)	1.52 (1.85)
W₂	1.52 (1.86)	1.41 (1.51)	1.46 (1.69)	1.42 (1.54)	1.33 (1.27)	1.37 (1.40)	1.87 (3.05)	1.79 (2.78)	1.83 (2.91)	1.68 (2.32)	1.44 (1.61)	1.56 (1.96)
W₃	1.3 (1.19)	1.19 (0.94)	1.25 (1.07)	1.24 (1.06)	1.01 (0.54)	1.13 (0.80)	1.68 (2.34)	1.62 (2.16)	1.65 (2.25)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₄	1.34 (1.32)	1.25 (1.07)	1.30 (1.19)	1.32 (1.26)	1.24 (1.04)	1.28 (1.15)	1.73 (2.55)	1.67 (2.32)	1.70 (2.44)	1.60 (2.07)	1.35 (1.33)	1.47 (1.70)
W₅	1.64 (2.25)	1.57 (2.01)	1.61 (2.13)	1.28 (1.14)	1.13 (.80)	1.2 (.97)	1.71 (2.45)	1.66 (2.28)	1.68 (2.36)	1.42 (1.53)	1.29 (1.19)	1.36 (1.36)
W₆	1.62 (2.15)	1.49 (1.78)	1.55 (1.96)	1.47 (1.72)	1.39 (1.43)	1.43 (1.58)	1.61 (2.09)	1.58 (1.99)	1.59 (2.04)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	1.67 (2.36)	1.62 (2.14)	1.65 (2.25)	1.79 (2.77)	1.76 (2.69)	1.78 (2.73)	2.33 (5.08)	2.20 (4.50)	2.27 (4.79)	2.08 (3.91)	1.74 (2.58)	1.91 (3.24)
SEm±	0.07	0.05	0.04	0.06	0.05	0.04	0.08	0.08	0.06	0.05	0.05	0.03
CD at 5%	0.19	0.15	0.12	0.18	0.13	0.11	0.23	0.22	0.16	0.13	0.13	0.09

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.27(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of *Commelina benghalensis* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.36 (1.36)	1.33 (1.27)	1.34 (1.32)	1.29 (1.22)	1.18 (0.90)	1.24 (1.06)	1.67 (2.30)	1.62 (2.14)	1.65 (2.22)	1.67 (2.29)	1.37 (1.37)	1.52 (1.83)
P₁W₂	1.40 (1.48)	1.33 (1.28)	1.36 (1.38)	1.30 (1.20)	1.21 (0.95)	1.25 (1.08)	1.70 (2.39)	1.69 (2.43)	1.69 (2.41)	1.68 (2.31)	1.39 (1.45)	1.53 (1.88)
P₁W₃	1.21 (0.98)	1.11 (0.73)	1.16 (0.86)	1.14 (0.79)	0.90 (0.32)	1.02 (0.55)	1.55 (1.91)	1.52 (1.84)	1.54 (1.87)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₄	1.26 (1.10)	1.18 (0.89)	1.22 (0.99)	1.20 (0.94)	1.10 (0.72)	1.15 (0.83)	1.60 (2.06)	1.55 (1.90)	1.57 (1.98)	1.52 (1.82)	1.32 (1.25)	1.42 (1.53)
P₁W₅	1.47 (1.66)	1.43 (1.55)	1.45 (1.60)	1.20 (0.93)	1.00 (0.50)	1.10 (0.71)	1.58 (2.00)	1.53 (1.84)	1.56 (1.92)	1.32 (1.25)	1.23 (1.04)	1.27 (1.14)
P₁W₆	1.46 (1.64)	1.19 (0.95)	1.32 (1.30)	1.33 (1.29)	1.27 (1.10)	1.30 (1.20)	1.53 (1.85)	1.51 (1.77)	1.52 (1.81)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.49 (1.72)	1.50 (1.77)	1.50 (1.75)	1.58 (2.01)	1.69 (2.37)	1.64 (2.19)	2.09 (3.89)	2.05 (3.76)	2.07 (3.82)	2.07 (3.82)	1.79 (2.73)	1.93 (3.28)
P₂W₁	1.49 (1.79)	1.37 (1.38)	1.43 (1.58)	1.38 (1.40)	1.34 (1.30)	1.36 (1.35)	1.73 (2.51)	1.70 (2.41)	1.72 (2.46)	1.67 (2.29)	1.41 (1.50)	1.54 (1.89)
P₂W₂	1.60 (2.12)	1.42 (1.58)	1.51 (1.85)	1.39 (1.44)	1.36 (1.36)	1.38 (1.40)	1.76 (2.59)	1.73 (2.50)	1.74 (2.55)	1.69 (2.36)	1.43 (1.56)	1.56 (1.96)
P₂W₃	1.32 (1.25)	1.20 (0.95)	1.26 (1.10)	1.26 (1.08)	1.07 (0.64)	1.16 (0.86)	1.60 (2.05)	1.56 (1.94)	1.58 (1.99)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₄	1.37 (1.38)	1.25 (1.08)	1.31 (1.23)	1.34 (1.29)	1.27 (1.12)	1.30 (1.20)	1.66 (2.25)	1.61 (2.10)	1.63 (2.17)	1.64 (2.20)	1.32 (1.25)	1.48 (1.72)

P₂W₅	1.67 (2.38)	1.57 (2.04)	1.62 (2.21)	1.29 (1.20)	1.17 (0.86)	1.23 (1.03)	1.64 (2.20)	1.61 (2.10)	1.63 (2.15)	1.36 (1.36)	1.32 (1.25)	1.34 (1.30)
P₂W₆	1.62 (2.15)	1.57 (1.97)	1.59 (2.06)	1.44 (1.60)	1.41 (1.50)	1.43 (1.55)	1.59 (2.02)	1.56 (1.92)	1.57 (1.97)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	1.73 (2.59)	1.62 (2.12)	1.67 (2.36)	1.75 (2.62)	1.79 (2.78)	1.77 (2.70)	2.23 (4.47)	2.14 (4.13)	2.19 (4.30)	2.02 (3.62)	1.74 (2.57)	1.88 (3.09)
P₃W₁	1.55 (1.92)	1.45 (1.60)	1.50 (1.76)	1.52 (1.85)	1.40 (1.45)	1.46 (1.65)	2.11 (3.98)	1.92 (3.20)	2.01 (3.59)	1.65 (2.24)	1.38 (1.42)	1.51 (1.83)
P₃W₂	1.57 (1.97)	1.47 (1.68)	1.52 (1.83)	1.56 (1.96)	1.42 (1.51)	1.49 (1.73)	2.16 (4.18)	1.95 (3.39)	2.06 (3.79)	1.66 (2.28)	1.51 (1.82)	1.59 (2.05)
P₃W₃	1.36 (1.35)	1.27 (1.13)	1.32 (1.24)	1.33 (1.31)	1.07 (0.66)	1.20 (0.98)	1.88 (3.05)	1.78 (2.69)	1.83 (2.87)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₄	1.40 (1.49)	1.31 (1.23)	1.36 (1.36)	1.42 (1.56)	1.34 (1.30)	1.38 (1.43)	1.95 (3.34)	1.86 (2.98)	1.90 (3.16)	1.64 (2.19)	1.40 (1.47)	1.52 (1.83)
P₃W₅	1.78 (2.73)	1.72 (2.45)	1.75 (2.59)	1.34 (1.31)	1.24 (1.04)	1.29 (1.17)	1.90 (3.14)	1.82 (2.89)	1.86 (3.02)	1.57 (1.98)	1.33 (1.28)	1.45 (1.63)
P₃W₆	1.78 (2.67)	1.71 (2.41)	1.74 (2.54)	1.63 (2.28)	1.48 (1.68)	1.56 (1.98)	1.70 (2.40)	1.67 (2.29)	1.69 (2.35)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	1.80 (2.75)	1.73 (2.51)	1.77 (2.63)	2.04 (3.70)	1.82 (2.91)	1.93 (3.30)	2.66 (6.90)	2.42 (5.62)	2.54 (6.26)	2.15 (4.29)	1.71 (2.43)	1.93 (3.36)
SEm± (PxW)	0.12	0.09	0.07	0.11	0.08	0.07	0.11	0.13	0.09	0.08	0.08	0.06
SEm± (WxP)	0.08	0.07	0.05	0.07	0.05	0.04	0.09	0.08	0.06	0.08	0.06	0.05
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

sowing date 15th July. Early sowing might have provided crop-suppressing weeds more vigorously which led to decrease in weed density of grasses.

4.2.2.15.2 Effect of integrated weed management on the population of grasses

The data on weed density of grasses at 20, 40, and 60 DAS and harvest, as influenced by integrated weed management, revealed significant variation at all stages of observation. At 20 DAS, the two-year data revealed a significantly lower population of grassy weeds (4.86, 4.74) under treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). It was at par with treatment W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb hand weeding at 30 DAS). The highest population of grassy weeds (8.10, 7.16) were recorded in W₇ (weedy check) in both years. Zain *et al.* (2020) reported that the application of per-emergence pendimethalin significantly reduced the weed density of grasses and broad-leaf weeds over weedy checks.

At 40 DAS, treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) recorded a significantly lower weed population (4.01, 3.62) in both years and at par with W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS). The application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) might have brought down the weed population at this stage. The result is corroborated by Yadav *et al.* (2017).

However, hand weeding at 20 and 40 DAS (W₆) registered significantly the lowest grassy weed population at 60 DAS (4.86, 4.60) and harvest (3.97 and 3.64). At harvest, it was also observed that W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) was at par with W₆ (Hand weeding at 20 and 40 DAS) during 2021 only. Similar results were reported by Topo *et al.* (2019). This outcome may be attributed to the timely eradication of weeds through the treatment of herbicide at the initial stage and hand weeding twice, which effectively uprooted and eliminated the weeds.

Throughout all stages of observation, specifically at 20, 40, and 60 days after sowing (DAS) as well as at harvest, the highest weed population was consistently recorded in W₇ (Weedy check) across both years and in the pooled data.

Table 4.28(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of grasses at 20,40,60 DAS and at harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	5.34 (29.53)	4.95 (24.66)	5.14 (27.10)	4.75 (25.36)	4.05 (17.92)	4.40 (21.64)	5.81 (36.52)	5.47 (31.90)	5.64 (34.21)	5.4 (31.27)	5.05 (26.72)	5.23 (29.00)
P₂ 30th June	6.24 (39.90)	5.54 (31.14)	5.89 (35.52)	5.56 (33.42)	4.90 (25.78)	5.23 (29.60)	6.48 (44.97)	6.21 (40.39)	6.35 (42.68)	5.62 (33.23)	5.24 (28.67)	5.43 (30.95)
P₃ 15th July	7.90 (63.24)	7.14 (51.27)	7.52 (57.25)	6.57 (45.11)	5.98 (37.35)	6.27 (41.23)	7.73 (62.06)	7.22 (54.20)	7.48 (58.13)	5.68 (33.83)	5.29 (29.25)	5.49 (31.54)
SEm±	0.09	0.1	0.07	0.13	0.08	0.08	0.06	0.09	0.06	0.1	0.11	0.07
CD at 5%	0.36	0.41	0.22	0.51	0.3	0.25	0.24	0.36	0.18	NS	NS	NS
Integrated weed Management (W)												
W₁	6.03 (37.50)	5.55 (31.59)	5.79 (34.54)	5.32 (28.46)	4.71 (22.52)	5.01 (25.49)	6.69 (45.02)	6.42 (41.66)	6.55 (43.34)	5.82 (33.36)	5.62 (31.05)	5.72 (32.21)
W₂	6.44 (42.40)	5.70 (33.17)	6.07 (37.79)	5.52 (30.48)	4.88 (24.10)	5.20 (27.29)	6.93 (48.27)	6.61 (43.75)	6.77 (46.01)	6.17 (37.74)	6.00 (35.56)	6.09 (36.65)
W₃	4.86 (24.38)	4.74 (23.08)	4.8 (23.73)	4.01 (16.50)	3.62 (13.23)	3.82 (14.87)	5.33 (28.48)	5.12 (26.25)	5.22 (27.37)	4.33 (18.30)	3.99 (15.46)	4.16 (16.88)
W₄	5.23 (28.15)	5.01 (25.71)	5.12 (26.93)	4.73 (22.74)	4.15 (17.47)	4.44 (20.10)	6.26 (39.75)	5.97 (35.82)	6.12 (37.78)	5.34 (28.06)	5.16 (26.20)	5.25 (27.13)
W₅	7.72 (60.19)	6.64 (44.50)	7.18 (52.35)	4.32 (18.92)	3.87 (15.21)	4.10 (17.06)	6.04 (37.07)	5.69 (32.29)	5.86 (34.68)	4.68 (21.51)	4.30 (18.04)	4.49 (19.77)
W₆	7.05 (50.56)	6.31 (40.09)	6.68 (45.32)	6.09 (37.19)	5.52 (30.55)	5.81 (33.87)	4.86 (23.60)	4.60 (21.05)	4.73 (22.33)	3.97 (15.29)	3.64 (12.78)	3.80 (14.03)
W₇	8.10 (51.69)	7.16 (59.04)	7.63 (59.04)	9.39 (88.10)	8.09 (66.02)	8.74 (77.06)	10.62 (112.77)	9.70 (94.32)	10.16 (103.55)	8.67 (75.20)	7.65 (58.41)	8.16 (66.80)
SEm±	0.19	0.16	0.12	0.12	0.16	0.10	0.12	0.13	0.09	0.13	0.12	0.09
CD at 5%	0.54	0.45	0.35	0.34	0.47	0.29	0.35	0.37	0.25	0.38	0.34	0.25

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.28(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of grasses at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	4.80 (22.52)	4.56 (20.28)	4.68 (21.40)	4.52 (20.03)	3.76 (14.06)	4.14 (17.04)	5.74 (32.54)	5.43 (29.62)	5.58 (31.08)	5.72 (32.28)	5.61 (31.05)	5.67 (31.66)
P₁W₂	5.18 (26.33)	4.69 (21.55)	4.94 (23.94)	4.77 (22.22)	3.97 (15.38)	4.37 (18.80)	6.02 (35.77)	5.79 (33.00)	5.91 (34.39)	5.99 (35.40)	5.97 (35.14)	5.98 (35.27)
P₁W₃	3.64 (12.76)	3.89 (14.62)	3.76 (13.69)	2.94 (8.28)	2.82 (7.57)	2.88 (7.93)	4.54 (20.11)	4.32 (18.14)	4.43 (19.13)	4.07 (16.10)	3.76 (13.69)	3.92 (14.89)
P₁W₄	4.01 (15.60)	4.07 (16.05)	4.04 (15.83)	3.67 (12.98)	3.14 (9.44)	3.40 (11.21)	5.23 (26.89)	5.03 (24.84)	5.13 (25.86)	5.10 (25.58)	5.04 (24.88)	5.07 (25.23)
P₁W₅	6.68 (44.15)	5.65 (31.46)	6.17 (37.80)	3.24 (10.05)	3.00 (8.57)	3.12 (9.31)	5.02 (24.65)	4.86 (23.16)	4.94 (23.90)	4.42 (19.11)	4.04 (15.85)	4.23 (17.48)
P₁W₆	5.83 (33.45)	5.48 (29.59)	5.66 (31.52)	5.32 (27.85)	4.73 (21.93)	5.03 (24.89)	4.11 (16.38)	3.95 (15.26)	4.03 (15.82)	3.79 (13.94)	3.56 (12.23)	3.68 (13.09)
P₁W₇	7.22 (51.91)	6.29 (39.07)	6.75 (45.49)	8.75 (76.08)	6.97 (48.50)	7.86 (62.29)	9.98 (99.28)	8.91 (79.29)	9.44 (89.28)	8.74 (76.50)	7.39 (54.21)	8.07 (65.36)
P₂W₁	5.74 (32.50)	5.15 (26.07)	5.45 (29.29)	5.05 (25.06)	4.62 (20.85)	4.83 (22.95)	6.47 (41.34)	6.31 (39.47)	6.39 (40.40)	5.86 (33.84)	5.61 (30.97)	5.73 (32.41)
P₂W₂	6.14 (37.25)	5.32 (27.76)	5.73 (32.50)	5.30 (27.60)	4.75 (22.28)	5.03 (24.94)	6.68 (44.13)	6.49 (41.62)	6.58 (42.88)	6.16 (37.70)	5.95 (34.85)	6.06 (36.28)
P₂W₃	4.59 (20.61)	4.22 (17.28)	4.41 (18.95)	4.14 (17.10)	3.46 (11.65)	3.80 (14.37)	5.09 (25.55)	5.00 (24.50)	5.05 (25.03)	4.42 (19.10)	4.05 (15.98)	4.24 (17.54)
P₂W₄	4.97 (24.24)	4.57 (20.41)	4.77 (22.32)	4.65 (21.12)	4.08 (16.16)	4.36 (18.64)	6.05 (36.21)	5.89 (34.22)	5.97 (35.22)	5.45 (29.32)	5.27 (27.33)	5.36 (28.32)
P₂W₅	7.54 (56.40)	6.39 (40.39)	6.96 (48.40)	4.42 (19.17)	3.82 (14.37)	4.12 (16.77)	5.74 (32.52)	5.67 (31.70)	5.71 (32.11)	4.68 (21.47)	4.35 (18.51)	4.52 (19.99)

P₂W₆	6.77 (45.41)	6.04 (36.10)	6.41 (40.76)	5.88 (34.09)	5.38 (28.45)	5.63 (31.27)	4.69 (21.47)	4.57 (20.40)	4.63 (20.93)	4.11 (16.37)	3.67 (12.99)	3.89 (14.68)
P₂W₇	7.90 (62.90)	7.06 (49.94)	7.48 (56.42)	9.50 (89.78)	8.18 (66.69)	8.84 (78.23)	10.68 (113.59)	9.54 (90.78)	10.11 (102.19)	8.65 (74.81)	7.78 (60.06)	8.21 (67.43)
P₃W₁	7.56 (57.46)	6.94 (48.40)	7.25 (52.93)	6.38 (40.30)	5.75 (32.65)	6.06 (36.48)	7.85 (61.18)	7.51 (55.89)	7.68 (58.53)	5.87 (33.97)	5.62 (31.14)	5.75 (32.56)
P₃W₂	7.99 (63.63)	7.10 (50.20)	7.55 (56.92)	6.48 (41.61)	5.92 (34.64)	6.20 (38.12)	8.07 (64.89)	7.56 (56.62)	7.82 (60.76)	6.37 (40.10)	6.10 (36.69)	6.23 (38.40)
P₃W₃	6.35 (39.78)	6.10 (37.33)	6.23 (38.55)	4.96 (24.13)	4.57 (20.48)	4.77 (22.30)	6.34 (39.78)	6.04 (36.09)	6.19 (37.94)	4.49 (19.70)	4.15 (16.72)	4.32 (18.21)
P₃W₄	6.70 (44.62)	6.40 (40.67)	6.55 (42.64)	5.88 (34.11)	5.22 (26.81)	5.55 (30.46)	7.51 (56.14)	6.99 (48.39)	7.25 (52.26)	5.46 (29.27)	5.18 (26.38)	5.32 (27.83)
P₃W₅	8.94 (80.03)	7.88 (61.65)	8.41 (70.84)	5.29 (27.53)	4.81 (22.70)	5.05 (25.11)	7.37 (54.03)	6.52 (42.02)	6.94 (48.02)	4.94 (23.95)	4.50 (19.76)	4.72 (21.86)
P₃W₆	8.56 (72.81)	7.42 (54.57)	7.99 (63.69)	7.06 (49.62)	6.46 (41.28)	6.76 (45.45)	5.78 (32.96)	5.29 (27.49)	5.53 (30.22)	4.00 (15.55)	3.69 (13.12)	3.85 (14.33)
P₃W₇	9.19 (84.34)	8.14 (66.06)	8.66 (75.20)	9.92 (98.45)	9.11 (82.88)	9.52 (90.66)	11.21 (125.43)	10.63 (112.90)	10.92 (119.17)	8.64 (74.28)	7.79 (60.96)	8.21 (67.62)
SEm± (PxW)	0.12	0.09	0.07	0.11	0.08	0.07	0.11	0.13	0.09	0.08	0.08	0.06
SEm± (WxP)	0.08	0.07	0.05	0.07	0.05	0.04	0.09	0.08	0.06	0.08	0.06	0.05
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

4.2.2.15.3 Interaction effect of sowing dates and integrated weed management on the population of grasses

The data on grasses population, as illustrated in Table 4.28 (b), indicated that interaction between sowing dates and integrated weed management did not exert a significant effect on the grass population across both years at all the stages of observation.

4.2.2.16 Weed population (no. m⁻²) of Sedges

Observations on the population of sedges recorded at 20, 40, and 60 DAS and harvest are presented in Table 4.29 (a) and Table 4.29 (b).

4.2.2.16.1 Effect of dates of sowing on the population of sedges

A significant difference in the population of sedges was observed among the sowing dates at different crop growth stages at 20, 40, and 60 DAS, except at harvest, it was found to be non-significant. The pooled data on the population of sedges at 20 DAS (2.15), 40 DAS (1.79), and 60 DAS (2.17) were found to be significantly lower when the crop was sown on 15th June over 30th June and 15th July.

4.2.2.16.2 Effect of integrated Weed Management on a population of sedges

Results revealed that the population of sedge weeds was found to be significant due to integrated weed management. Throughout all observational stages, weedy check (W₇) consistently exhibited the highest population of sedge weeds.

At 20 DAS, the treatment involving pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded the minimum population of sedges (1.82, 1.70). This result was at par by treatment W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb hand weeding at 30 DAS). The reduction in weed population, as mentioned in the above treatments, may be due to effective control of sedges by the herbicide application at pre-emergence, which inhibited the microtubule formation in the cells. A similar result was reported by Meena *et al* (2017).

At 40 DAS, the application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) also recorded a significantly lower population (1.61, 1.48). This was at par with treatment W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS). The post-emergence application of imazethapyr

might have contributed to the reduction in weed population at this stage. Emmiganur and Hosmath (2020) reported similar findings.

Hand weeding at 20 and 40 DAS (W_6) gave significantly the lowest sedges weed population in both years at 60 DAS (1.02, 0.79) and harvest (0.82, 0.76), which was followed by W_3 (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS). The removal of weeds both at intra- and inter-row spaces by hand weeding might have caused crops to put forth a bushy canopy suppressing the emerged weeds leading to higher weed control efficiency. The results are in accordance with the findings of Jaiswal and Lakpale (2022).

4.2.2.16.3 Interaction effect of sowing dates and integrated weed management on the population of sedges

The findings related to the sedge population, as detailed in Table 4.29 (b), indicate that the interaction between sowing dates and integrated weed management did not exert a statistically significant effect on the sedge population in either year or in the pooled data across all observation stages.

4.2.2.17 Broad-leaved weeds (no. m⁻²)

Observations on the population of broad-leaved weeds recorded at 20, 40, and 60 DAS and harvest are presented in Table 4.30 (a) and Table 4.30 (b).

4.2.2.17.1 Effect of sowing dates on population of broad-leaved weeds

Differences in the population of broad-leaved weeds showed significant effects due to different sowing dates in both years. Significantly lowest weed population was observed when sowing was done on 15th June at 20, 40, and 60 DAS. However, at harvest, it was found to be non-significant due to sowing dates on the population of broad-leaved weeds.

4.2.2.17.2 Effect of integrated weed management on the population of broad-leaved weeds

The findings in Table 4.30 (a) reveal a significant influence on the population of broad-leaved weeds due to integrated weed management.

During all phases of observation, the weedy check (W_7) demonstrated the

Table 4.29(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of sedges at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	2.21 (4.59)	2.09 (4.12)	2.15 (4.35)	1.86 (3.43)	1.72 (2.90)	1.79 (3.17)	2.21 (5.48)	2.13 (4.88)	2.17 (5.18)	2.08 (4.73)	2.01 (4.34)	2.04 (4.54)
P₂ 30th June	2.4 (5.50)	2.30 (5.06)	2.35 (5.28)	2.12 (4.40)	2.04 (4.06)	2.08 (4.23)	2.33 (6.05)	2.24 (5.45)	2.29 (5.75)	2.12 (4.79)	2.03 (4.43)	2.07 (4.61)
P₃ 15th July	2.91 (8.27)	2.72 (7.13)	2.81 (7.70)	2.56 (6.40)	2.48 (6.02)	2.52 (6.21)	3.04 (9.61)	2.71 (7.82)	2.88 (8.71)	2.14 (4.89)	2.10 (4.66)	2.12 (4.78)
SEm±	0.03	0.05	0.03	0.04	0.04	0.03	0.03	0.01	0.02	0.04	0.04	0.03
CD at 5%	0.13	0.18	0.09	0.16	0.18	0.10	0.13	0.06	0.06	NS	NS	NS
Integrated weed Management (W)												
W₁	2.40 (5.36)	2.23 (4.57)	2.31 (4.97)	2.00 (3.60)	1.90 (3.25)	1.95 (3.42)	2.62 (6.55)	2.55 (6.12)	2.59 (6.33)	2.22 (4.41)	2.16 (4.16)	2.19 (4.28)
W₂	2.47 (5.68)	2.27 (4.75)	2.37 (5.22)	2.02 (3.69)	1.93 (3.37)	1.98 (3.53)	2.67 (6.78)	2.57 (6.22)	2.62 (6.50)	2.31 (4.84)	2.19 (4.30)	2.25 (4.57)
W₃	1.82 (2.88)	1.70 (2.44)	1.76 (2.66)	1.61 (2.22)	1.48 (1.78)	1.55 (2.00)	2.15 (4.29)	2.03 (3.74)	2.09 (4.02)	1.66 (2.27)	1.60 (2.09)	1.63 (2.18)
W₄	1.94 (3.37)	1.78 (2.75)	1.86 (3.06)	1.94 (3.39)	1.81 (2.91)	1.88 (3.15)	2.38 (5.34)	2.29 (4.84)	2.34 (5.09)	1.99 (3.46)	1.95 (3.32)	1.97 (3.39)
W₅	2.93 (8.25)	2.81 (7.47)	2.87 (7.86)	1.69 (2.44)	1.55 (2.01)	1.62 (2.23)	2.23 (4.63)	2.11 (4.06)	2.17 (4.34)	1.75 (2.56)	1.73 (2.49)	1.74 (2.53)
W₆	2.81 (7.54)	2.61 (6.38)	2.71 (6.96)	2.46 (5.65)	2.39 (5.31)	2.43 (5.48)	1.02 (0.74)	0.79 (0.18)	0.90 (0.46)	0.82 (0.21)	0.76 (0.11)	0.79 (0.16)
W₇	3.18 (9.75)	3.17 (9.70)	3.18 (9.73)	3.54 (12.21)	3.47 (11.67)	3.51 (11.94)	4.62 (21.01)	4.17 (17.17)	4.4 (19.09)	4.04 (15.88)	3.92 (14.87)	3.98 (15.37)
SEm±	0.07	0.07	0.05	0.06	0.05	0.04	0.08	0.09	0.06	0.05	0.04	0.03
CD at 5%	0.21	0.19	0.14	0.18	0.13	0.11	0.22	0.26	0.17	0.15	0.12	0.09

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.29(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of sedges at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	2.09 (3.88)	1.91 (3.13)	2.00 (3.51)	1.65 (2.21)	1.47 (1.67)	1.56 (1.94)	2.27 (4.68)	2.28 (4.69)	2.28 (4.68)	2.18 (4.26)	2.13 (4.02)	2.15 (4.14)
P₁W₂	2.17 (4.21)	1.95 (3.30)	2.06 (3.75)	1.67 (2.28)	1.51 (1.78)	1.59 (2.03)	2.35 (5.02)	2.30 (4.81)	2.32 (4.92)	2.28 (4.71)	2.17 (4.20)	2.22 (4.45)
P₁W₃	1.56 (1.94)	1.42 (1.51)	1.49 (1.73)	1.29 (1.17)	1.16 (0.86)	1.23 (1.02)	1.78 (2.66)	1.75 (2.55)	1.76 (2.61)	1.65 (2.22)	1.57 (1.97)	1.61 (2.09)
P₁W₄	1.65 (2.22)	1.49 (1.71)	1.57 (1.96)	1.56 (1.94)	1.41 (1.50)	1.49 (1.72)	2.04 (3.66)	2.00 (3.51)	2.02 (3.58)	1.95 (3.32)	1.92 (3.20)	1.94 (3.26)
P₁W₅	2.65 (6.51)	2.55 (6.00)	2.60 (6.25)	1.35 (1.31)	1.21 (0.97)	1.28 (1.14)	1.86 (2.97)	1.81 (2.78)	1.84 (2.88)	1.71 (2.44)	1.68 (2.33)	1.70 (2.39)
P₁W₆	2.47 (5.60)	2.33 (4.95)	2.40 (5.27)	2.13 (4.05)	2.04 (3.65)	2.09 (3.85)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	2.87 (7.76)	2.96 (8.26)	2.91 (8.01)	3.39 (11.03)	3.20 (9.88)	3.30 (10.46)	4.44 (19.39)	4.04 (15.80)	4.24 (17.59)	4.06 (16.17)	3.88 (14.65)	3.97 (15.41)
P₂W₁	2.30 (4.80)	2.16 (4.16)	2.23 (4.48)	1.94 (3.28)	1.87 (3.01)	1.91 (3.14)	2.43 (5.44)	2.41 (5.30)	2.42 (5.37)	2.22 (4.41)	2.15 (4.14)	2.19 (4.28)
P₂W₂	2.38 (5.16)	2.20 (4.34)	2.29 (4.75)	1.96 (3.36)	1.90 (3.13)	1.93 (3.25)	2.50 (5.74)	2.43 (5.41)	2.46 (5.57)	2.31 (4.85)	2.18 (4.26)	2.25 (4.56)
P₂W₃	1.71 (2.43)	1.63 (2.15)	1.67 (2.29)	1.55 (1.92)	1.44 (1.57)	1.49 (1.74)	1.96 (3.36)	1.87 (2.99)	1.92 (3.18)	1.64 (2.19)	1.56 (1.95)	1.60 (2.07)
P₂W₄	1.79 (2.73)	1.70 (2.40)	1.75 (2.56)	1.89 (3.08)	1.78 (2.65)	1.83 (2.87)	2.19 (4.29)	2.14 (4.10)	2.17 (4.20)	1.99 (3.45)	1.92 (3.20)	1.95 (3.32)
P₂W₅	2.85 (7.63)	2.77 (7.21)	2.81 (7.42)	1.63 (2.18)	1.51 (1.79)	1.57 (1.98)	2.03 (3.64)	1.97 (3.37)	2.00 (3.50)	1.76 (2.60)	1.74 (2.52)	1.75 (2.56)

P₂W₆	2.69 (6.80)	2.54 (5.98)	2.62 (6.39)	2.41 (5.31)	2.34 (5.00)	2.38 (5.15)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.86 (0.29)	0.71 (0.00)	0.79 (0.15)
P₂W₇	3.08 (8.98)	3.07 (9.16)	3.07 (9.07)	3.47 (11.68)	3.43 (11.27)	3.45 (11.47)	4.51 (19.89)	4.16 (16.96)	4.34 (18.42)	4.03 (15.75)	3.93 (14.92)	3.98 (15.34)
P₃W₁	2.81 (7.40)	2.63 (6.41)	2.72 (6.90)	2.41 (5.32)	2.36 (5.05)	2.38 (5.18)	3.16 (9.53)	2.98 (8.36)	3.07 (8.95)	2.25 (4.55)	2.19 (4.31)	2.22 (4.43)
P₃W₂	2.85 (7.67)	2.66 (6.62)	2.76 (7.14)	2.43 (5.43)	2.38 (5.20)	2.41 (5.31)	3.17 (9.58)	2.99 (8.45)	3.08 (9.02)	2.34 (4.97)	2.22 (4.45)	2.28 (4.71)
P₃W₃	2.18 (4.28)	2.04 (3.66)	2.11 (3.97)	2.00 (3.56)	1.84 (2.92)	1.92 (3.24)	2.70 (6.85)	2.48 (5.68)	2.59 (6.27)	1.70 (2.39)	1.68 (2.35)	1.69 (2.37)
P₃W₄	2.36 (5.16)	2.14 (4.15)	2.25 (4.66)	2.37 (5.15)	2.25 (4.58)	2.31 (4.86)	2.93 (8.07)	2.72 (6.90)	2.82 (7.49)	2.03 (3.62)	2.01 (3.55)	2.02 (3.59)
P₃W₅	3.29 (10.61)	3.11 (9.20)	3.20 (9.91)	2.08 (3.84)	1.94 (3.28)	2.01 (3.56)	2.78 (7.27)	2.55 (6.03)	2.67 (6.65)	1.77 (2.64)	1.77 (2.62)	1.77 (2.63)
P₃W₆	3.27 (10.23)	2.95 (8.21)	3.11 (9.22)	2.84 (7.57)	2.79 (7.29)	2.81 (7.43)	1.64 (2.22)	0.96 (0.54)	1.30 (1.38)	0.89 (0.35)	0.88 (0.32)	0.88 (0.34)
P₃W₇	3.61 (12.53)	3.47 (11.68)	3.54 (12.10)	3.78 (13.91)	3.78 (13.85)	3.78 (13.88)	4.90 (23.75)	4.32 (18.76)	4.61 (21.25)	4.03 (15.72)	3.94 (15.03)	3.98 (15.37)
SEm± (PxW)	0.12	0.09	0.07	0.11	0.08	0.07	0.11	0.13	0.09	0.08	0.08	0.06
SEm± (WxP)	0.08	0.07	0.05	0.07	0.05	0.04	0.09	0.08	0.06	0.08	0.06	0.05
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

highest prevalence of broad-leaved weeds. The pooled data revealed that sequential application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest population in both years at 20 DAS (5.09) and 40 DAS (3.42) as compared to the rest of the treatments. This outcome can be attributed to the pre-emergence application of pendimethalin, which was found most effective in controlling grasses and broad-leaf weeds by inhibiting seed germination and seedling development, particularly at the early crop augmentation period when the herbicide potency in the soil was at its peak. These results are in line with those reported by Zain *et al.* (2020) and Hasanuddin *et al.* (2022). Furthermore, Sandil *et al.* (2015) documented that the application of imazethapyr controlled both broad-leaved and grassy weeds.

However, at 60 DAS and harvest, W₆ (Hand weeding at 20 and 40 DAS) was found to reduce the population of broad-leaved and recorded significantly lowest pooled values (4.44 and 2.33) in both the years, followed by W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS).

4.2.2.17.3 Interaction effect of sowing dates and integrated weed management on the population of broad-leaved weeds

Data with respect to the population of broad-leaved weeds presented in Table 4.30 (b) revealed that the interaction of sowing dates and integrated weed management did not show any significant effect on the population of broad-leaved weeds in both the years at all the stages of observation.

4.2.2.18 Total weeds population (no. m⁻²)

Observations on the total weeds population recorded at 20, 40, and 60 DAS are presented in Table 4.31 (a) and Table 4.31 (b), Figure 4.3 and 4.4. It showed that the weed population count was higher at an earlier stage, but with the advancement of crop age, it decreased due to competition between the crop plants and the smothering effect of crop due to an increase in height.

4.2.2.18.1 Effect of sowing dates on total weeds population

The total weed population exhibited significant variations depending on the sowing dates. Observations at 20, 40, and 60 DAS, soybean sown on 15th June had the

Table 4.30(a): Effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of broad-leaved weeds at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	6.19 (38.70)	5.53 (31.20)	5.86 (34.95)	4.79 (25.14)	4.36 (21.17)	4.58 (23.16)	5.95 (37.96)	5.48 (32.44)	5.72 (35.20)	5.20 (30.96)	4.77 (26.21)	4.98 (28.58)
P₂ 30th June	6.77 (46.33)	6.15 (38.29)	6.46 (42.31)	5.45 (31.85)	4.92 (26.33)	5.18 (29.09)	6.43 (43.73)	6.15 (40.17)	6.29 (41.95)	5.31 (31.94)	4.89 (27.27)	5.10 (29.60)
P₃ 15th July	7.62 (58.64)	6.97 (49.09)	7.29 (53.86)	6.33 (42.21)	5.70 (34.73)	6.02 (38.47)	7.40 (56.88)	6.96 (50.50)	7.18 (53.69)	5.42 (32.83)	4.96 (27.93)	5.19 (30.38)
SEm±	0.09	0.08	0.06	0.03	0.05	0.03	0.05	0.04	0.03	0.06	0.05	0.04
CD at 5%	0.36	0.30	0.20	0.12	0.18	0.09	0.18	0.15	0.10	NS	NS	NS
Integrated weed Management (W)												
W₁	6.41 (40.99)	5.80 (33.62)	6.11 (37.31)	5.25 (27.48)	4.76 (22.43)	5.00 (24.96)	7.09 (50.11)	6.60 (43.52)	6.85 (46.82)	6.08 (36.46)	5.55 (30.36)	5.81 (33.41)
W₂	6.94 (47.99)	6.26 (39.16)	6.60 (43.57)	5.55 (30.77)	5.08 (25.68)	5.32 (28.23)	7.55 (56.81)	7.09 (50.18)	7.32 (53.50)	6.54 (42.33)	5.92 (34.58)	6.23 (38.45)
W₃	5.43 (29.28)	4.76 (22.57)	5.09 (25.93)	3.71 (13.64)	3.13 (9.65)	3.42 (11.65)	5.04 (25.39)	4.78 (22.78)	4.91 (24.09)	3.69 (13.13)	3.29 (10.37)	3.49 (11.75)
W₄	5.85 (34.08)	5.19 (26.92)	5.52 (30.50)	4.73 (22.29)	4.28 (18.12)	4.51 (20.20)	6.22 (38.54)	5.89 (34.66)	6.05 (36.60)	5.23 (26.87)	4.70 (21.60)	4.96 (24.24)
W₅	7.75 (60.11)	7.19 (51.67)	7.47 (55.89)	4.11 (16.80)	3.57 (12.55)	3.84 (14.67)	5.71 (32.59)	5.21 (27.08)	5.46 (29.84)	4.13 (16.58)	3.72 (13.36)	3.92 (14.97)
W₆	7.51 (56.43)	6.72 (45.06)	7.11 (50.74)	6.42 (41.23)	5.71 (32.46)	6.07 (36.84)	4.63 (21.42)	4.24 (17.90)	4.44 (19.66)	2.41 (5.34)	2.25 (4.59)	2.33 (4.96)
W₇	8.14 (66.35)	7.60 (57.68)	7.87 (62.01)	8.91 (79.24)	8.43 (70.97)	8.67 (75.11)	9.91 (98.46)	9.56 (91.13)	9.74 (94.79)	9.11 (82.66)	8.69 (75.09)	8.90 (78.88)
SEm±	0.13	0.12	0.09	0.08	0.07	0.05	0.12	0.07	0.07	0.07	0.07	0.05
CD at 5%	0.37	0.35	0.25	0.23	0.19	0.14	0.34	0.21	0.20	0.19	0.19	0.13

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.30(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of Broad-leaved at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	5.75 (32.60)	5.10 (25.64)	5.43 (29.12)	4.49 (19.70)	4.14 (16.66)	4.32 (18.18)	6.55 (42.38)	5.84 (33.69)	6.19 (38.04)	5.99 (35.44)	5.45 (29.30)	5.72 (32.37)
P₁W₂	6.34 (39.77)	5.51 (29.92)	5.93 (34.85)	4.80 (22.52)	4.37 (18.58)	4.58 (20.55)	7.01 (48.65)	6.37 (40.16)	6.69 (44.40)	6.51 (41.90)	5.85 (33.79)	6.18 (37.84)
P₁W₃	4.82 (22.71)	4.08 (16.24)	4.45 (19.47)	3.01 (8.58)	2.52 (5.86)	2.76 (7.22)	4.28 (17.80)	4.09 (16.21)	4.18 (17.01)	3.54 (12.08)	3.25 (10.10)	3.40 (11.09)
P₁W₄	5.26 (27.20)	4.42 (19.05)	4.84 (23.13)	4.04 (15.94)	3.70 (13.21)	3.87 (14.57)	5.58 (30.69)	5.14 (25.96)	5.36 (28.33)	5.12 (25.73)	4.58 (20.47)	4.85 (23.10)
P₁W₅	7.01 (48.67)	6.51 (41.92)	6.76 (45.30)	3.42 (11.21)	2.93 (8.11)	3.18 (9.66)	5.04 (24.94)	4.47 (19.52)	4.76 (22.23)	4.01 (15.60)	3.53 (11.99)	3.77 (13.80)
P₁W₆	6.72 (44.61)	6.06 (36.21)	6.39 (40.41)	5.54 (30.22)	5.08 (25.34)	5.31 (27.78)	3.89 (14.68)	3.53 (11.99)	3.71 (13.34)	2.18 (4.27)	2.09 (3.87)	2.14 (4.07)
P₁W₇	7.46 (55.37)	7.05 (49.42)	7.25 (52.39)	8.26 (67.82)	7.80 (60.46)	8.03 (64.14)	9.31 (86.55)	8.94 (79.58)	9.13 (83.06)	9.06 (81.67)	8.62 (73.94)	8.84 (77.81)
P₂W₁	6.33 (39.72)	5.63 (31.24)	5.98 (35.48)	5.16 (26.10)	4.66 (21.22)	4.91 (23.66)	6.91 (47.22)	6.57 (42.65)	6.74 (44.93)	6.13 (37.09)	5.61 (30.94)	5.87 (34.02)
P₂W₂	6.86 (46.58)	6.19 (37.88)	6.52 (42.23)	5.46 (29.36)	5.09 (25.41)	5.28 (27.38)	7.38 (53.93)	7.07 (49.47)	7.22 (51.70)	6.57 (42.66)	5.95 (34.92)	6.26 (38.79)
P₂W₃	5.32 (27.82)	4.71 (21.73)	5.01 (24.77)	3.59 (12.43)	3.03 (8.83)	3.31 (10.63)	4.89 (23.42)	4.68 (21.44)	4.79 (22.43)	3.64 (12.79)	3.25 (10.12)	3.45 (11.45)
P₂W₄	5.79 (33.10)	5.20 (26.59)	5.49 (29.84)	4.65 (21.16)	4.21 (17.19)	4.43 (19.17)	6.06 (36.19)	5.83 (33.52)	5.94 (34.85)	5.25 (27.08)	4.70 (21.61)	4.98 (24.35)

P₂W₅	7.63 (57.72)	7.10 (50.01)	7.37 (53.86)	4.03 (15.73)	3.46 (11.51)	3.74 (13.62)	5.53 (30.07)	5.15 (26.03)	5.34 (28.05)	4.11 (16.43)	3.78 (13.77)	3.94 (15.10)
P₂W₆	7.42 (54.59)	6.62 (43.36)	7.02 (48.98)	6.38 (40.22)	5.66 (31.49)	6.02 (35.85)	4.43 (19.12)	4.17 (16.91)	4.30 (18.02)	2.40 (5.27)	2.27 (4.66)	2.34 (4.97)
P₂W₇	8.05 (64.78)	7.59 (57.22)	7.82 (61.00)	8.85 (77.93)	8.31 (68.64)	8.58 (73.28)	9.83 (96.19)	9.58 (91.19)	9.70 (93.69)	9.09 (82.24)	8.68 (74.84)	8.89 (78.54)
P₃W₁	7.14 (50.65)	6.67 (43.99)	6.90 (47.32)	6.09 (36.65)	5.47 (29.42)	5.78 (33.04)	7.82 (60.74)	7.40 (54.22)	7.61 (57.48)	6.11 (36.84)	5.60 (30.84)	5.85 (33.84)
P₃W₂	7.61 (57.61)	7.08 (49.69)	7.35 (53.65)	6.40 (40.44)	5.79 (33.06)	6.09 (36.75)	8.26 (67.87)	7.84 (60.92)	8.05 (64.39)	6.55 (42.41)	5.96 (35.03)	6.25 (38.72)
P₃W₃	6.14 (37.32)	5.49 (29.75)	5.82 (33.53)	4.52 (19.92)	3.84 (14.25)	4.18 (17.09)	5.95 (34.94)	5.58 (30.70)	5.77 (32.82)	3.87 (14.53)	3.37 (10.89)	3.62 (12.71)
P₃W₄	6.51 (41.93)	5.96 (35.10)	6.24 (38.52)	5.50 (29.78)	4.94 (23.95)	5.22 (26.87)	7.02 (48.75)	6.70 (44.52)	6.86 (46.63)	5.32 (27.81)	4.82 (22.71)	5.07 (25.26)
P₃W₅	8.61 (73.95)	7.95 (63.09)	8.28 (68.52)	4.89 (23.45)	4.30 (18.02)	4.60 (20.74)	6.57 (42.74)	6.02 (35.71)	6.30 (39.22)	4.26 (17.70)	3.85 (14.30)	4.05 (16.00)
P₃W₆	8.39 (70.10)	7.48 (55.59)	7.94 (62.84)	7.33 (53.25)	6.41 (40.55)	6.87 (46.90)	5.56 (30.46)	5.03 (24.80)	5.29 (27.63)	2.64 (6.46)	2.39 (5.25)	2.52 (5.86)
P₃W₇	8.90 (78.92)	8.17 (66.39)	8.53 (72.65)	9.60 (91.96)	9.17 (83.82)	9.39 (87.89)	10.60 (112.65)	10.15 (102.62)	10.38 (107.63)	9.19 (84.07)	8.77 (76.50)	8.98 (80.28)
SEm± (PxW)	0.12	0.09	0.07	0.11	0.08	0.07	0.11	0.13	0.09	0.08	0.08	0.06
SEm± (WxP)	0.08	0.07	0.05	0.07	0.05	0.04	0.09	0.08	0.06	0.08	0.06	0.05
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

least total weed density, while the highest was noted for the July 15th sowing date, which could be due to the availability of higher moisture with the onset of monsoon. However, at harvest, it was found to be non-significant in both years and pooled data.

Early sowing of soybean may have facilitated more favorable environmental conditions for crop establishment, thereby enhancing its growth and competitive ability against weeds. This, in turn, led to a reduction in the utilization of resources such as moisture, nutrients, light, and space by weeds, ultimately resulting in a decreased weed population. Silva *et al.* (2009), Marangoni *et al.* (2013) and Sahu *et al.* (2019) also stated that the sowing dates affected the soybean weed population; earlier sowing reduced weed interference.

4.2.2.18.2 Effect of integrated weed management on total weed population

Significant effects on the total weed population due to integrated weed management were observed in both the years and pooled value. Throughout all observations period, the weedy check (W₇) consistently exhibits the highest overall weed population, attributable to the uninterrupted growth of weeds. These findings corroborate the results reported by Patil *et al.* (2018).

At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest total weed population (7.46, 6.87) in both the years, which was followed by W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS) in both years and pooled values. The application of herbicide at pre-emergence reduced weed density, and weed dry matter was also mentioned by Subbulakshmi (2021).

With the application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃), the significantly lowest total weed population (5.62, 4.91) was recorded at 40 DAS during both the years which was followed by W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS). Imazethapyr inhibited acetolactate synthase (ALS), a key enzyme in the biosynthesis of the branched-chain amino acid (isoleucine, leucine, and valine), the secondary effect may include disruption of photosynthate translocation, hormone imbalance due to interruption of source/ sink relationship and interference in DNA synthesis and cell growth. Similar finding with the application of post-emergence herbicide in the

Table 4.31(a): Effect of sowing dates and integrated weed management treatments on total weed density (no. m⁻²) at 20,40,60 DAS and at harvest.

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	8.42 (72.82)	7.65 (59.98)	8.03 (66.40)	6.92 (53.93)	6.13 (42.00)	6.52 (47.96)	8.56 (79.96)	7.98 (69.22)	8.27 (74.59)	7.75 (66.96)	7.19 (57.27)	7.47 (62.12)
P₂ 30th June	9.47 (91.73)	8.54 (74.48)	9.00 (83.11)	8.01 (69.66)	7.17 (56.16)	7.59 (62.91)	9.39 (94.76)	8.98 (86.00)	9.19 (90.38)	7.98 (69.96)	7.41 (60.36)	7.70 (65.16)
P₃ 15th July	11.32 (130.15)	10.31 (107.49)	10.81 (118.82)	9.43 (93.71)	8.57 (78.10)	9.00 (85.90)	11.09 (128.55)	10.36 (112.52)	10.72 (120.53)	8.10 (71.56)	7.51 (61.85)	7.8 (66.70)
SEm±	0.09	0.11	0.07	0.11	0.05	0.06	0.03	0.05	0.03	0.07	0.11	0.07
CD at 5%	0.35	0.42	0.23	0.44	0.18	0.2	0.11	0.19	0.09	NS	NS	NS
Integrated weed Management (W)												
W₁	9.08 (83.85)	8.28 (69.78)	8.68 (76.81)	7.67 (59.55)	6.90 (48.20)	7.28 (53.87)	10.05 (101.68)	9.51 (91.30)	9.78 (96.49)	8.64 (74.23)	8.13 (65.57)	8.38 (69.90)
W₂	9.75 (96.07)	8.72 (77.09)	9.23 (86.58)	8.02 (64.94)	7.25 (53.15)	7.63 (59.04)	10.55 (111.86)	9.98 (100.15)	10.26 (106.01)	9.24 (84.91)	8.66 (74.45)	8.95 (79.68)
W₃	7.46 (56.55)	6.87 (48.09)	7.16 (52.32)	5.62 (32.36)	4.91 (24.67)	5.27 (28.51)	7.58 (58.16)	7.23 (52.77)	7.40 (55.47)	5.84 (33.70)	5.33 (27.92)	5.58 (30.81)
W₄	8.04 (65.60)	7.38 (55.38)	7.71 (60.49)	6.90 (48.42)	6.16 (38.49)	6.53 (43.46)	9.09 (83.63)	8.64 (75.32)	8.87 (79.47)	7.67 (58.39)	7.18 (51.11)	7.43 (54.75)
W₅	11.29 (128.56)	10.14 (103.64)	10.71 (116.10)	6.12 (38.16)	5.41 (29.77)	5.76 (33.96)	8.56 (74.28)	7.93 (63.44)	8.25 (68.86)	6.41 (40.65)	5.86 (33.89)	6.13 (37.27)
W₆	10.64 (114.53)	9.53 (91.52)	10.09 (103.02)	9.13 (84.06)	8.24 (68.33)	8.69 (76.19)	6.72 (45.77)	6.24 (39.13)	6.48 (42.45)	4.61 (20.84)	4.24 (17.48)	4.42 (19.16)
W₇	11.89 (142.49)	10.89 (119.06)	11.39 (130.78)	13.39 (179.55)	12.16 (148.66)	12.77 (164.10)	15.22 (232.23)	14.22 (202.62)	14.72 (217.43)	13.19 (173.74)	12.19 (148.37)	12.69 (161.05)
SEm±	0.19	0.13	0.11	0.10	0.13	0.08	0.15	0.11	0.09	0.08	0.07	0.05
CD at 5%	0.54	0.37	0.32	0.29	0.37	0.23	0.43	0.32	0.24	0.23	0.20	0.15

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.31(b): Interaction effect of sowing dates and integrated weed management treatments on weed density (no. m⁻²) of total weeds population at 20,40,60 DAS and at harvest.

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	7.71 (59.00)	7.04 (49.06)	7.37 (54.03)	6.51 (41.94)	5.72 (32.39)	6.12 (37.16)	8.95 (79.60)	8.25 (68.00)	8.60 (73.80)	8.51 (71.98)	8.05 (64.37)	8.28 (68.18)
P₁W₂	8.41 (70.31)	7.43 (54.76)	7.92 (62.54)	6.89 (47.02)	6.01 (35.74)	6.45 (41.38)	9.48 (89.44)	8.86 (77.97)	9.17 (83.70)	9.08 (82.01)	8.58 (73.13)	8.83 (77.57)
P₁W₃	6.16 (37.41)	5.73 (32.37)	5.94 (34.89)	4.29 (18.04)	3.85 (14.30)	4.07 (16.17)	6.41 (40.57)	6.12 (36.91)	6.26 (38.74)	5.56 (30.39)	5.12 (25.75)	5.34 (28.07)
P₁W₄	6.75 (45.02)	6.11 (36.81)	6.43 (40.91)	5.60 (30.86)	4.96 (24.14)	5.28 (27.50)	7.85 (61.24)	7.40 (54.30)	7.63 (57.77)	7.42 (54.62)	7.00 (48.55)	7.21 (51.59)
P₁W₅	9.99 (99.33)	8.94 (79.37)	9.46 (89.35)	4.80 (22.58)	4.26 (17.65)	4.53 (20.12)	7.28 (52.57)	6.78 (45.45)	7.03 (49.01)	6.13 (37.15)	5.54 (30.17)	5.84 (33.66)
P₁W₆	9.17 (83.65)	8.44 (70.75)	8.81 (77.20)	7.91 (62.11)	7.17 (50.93)	7.54 (56.52)	5.62 (31.06)	5.26 (27.25)	5.44 (29.16)	4.32 (18.22)	4.07 (16.11)	4.20 (17.16)
P₁W₇	10.74 (115.03)	9.85 (96.75)	10.30 (105.89)	12.47 (154.94)	10.91 (118.84)	11.69 (136.89)	14.32 (205.22)	13.23 (174.66)	13.78 (189.94)	13.22 (174.35)	11.97 (142.80)	12.59 (158.57)
P₂W₁	8.80 (77.02)	7.87 (61.48)	8.34 (69.25)	7.41 (54.43)	6.75 (45.09)	7.08 (49.76)	9.72 (93.99)	9.37 (87.42)	9.55 (90.70)	8.71 (75.34)	8.16 (66.05)	8.43 (70.70)
P₂W₂	9.46 (88.98)	8.39 (69.99)	8.93 (79.49)	7.80 (60.33)	7.16 (50.82)	7.48 (55.57)	10.21 (103.80)	9.85 (96.50)	10.03 (100.15)	9.26 (85.22)	8.63 (74.04)	8.94 (79.63)
P₂W₃	7.17 (50.86)	6.45 (41.16)	6.81 (46.01)	5.63 (31.44)	4.72 (22.04)	5.18 (26.74)	7.27 (52.33)	7.03 (48.93)	7.15 (50.63)	5.88 (34.08)	5.34 (28.05)	5.61 (31.06)
P₂W₄	7.78 (60.07)	7.06 (49.40)	7.42 (54.73)	6.77 (45.36)	6.04 (36.00)	6.41 (40.68)	8.78 (76.69)	8.50 (71.84)	8.64 (74.27)	7.77 (59.85)	7.25 (52.14)	7.51 (55.99)
P₂W₅	11.06 (121.75)	9.90 (97.60)	10.48 (109.68)	6.13 (37.07)	5.29 (27.66)	5.71 (32.36)	8.17 (66.24)	7.85 (61.10)	8.01 (63.67)	6.40 (40.51)	5.94 (34.80)	6.17 (37.65)

P₂W₆	10.36 (106.80)	9.26 (85.44)	9.81 (96.12)	8.95 (79.62)	8.09 (64.93)	8.52 (72.27)	6.41 (40.59)	6.15 (37.31)	6.28 (38.95)	4.74 (21.93)	4.26 (17.65)	4.50 (19.79)
P₂W₇	11.66 (136.66)	10.81 (116.32)	11.23 (126.49)	13.41 (179.38)	12.12 (146.60)	12.76 (162.99)	15.17 (229.66)	14.12 (198.93)	14.64 (214.29)	13.15 (172.80)	12.26 (149.83)	12.71 (161.31)
P₃W₁	10.74 (115.52)	9.95 (98.80)	10.34 (107.16)	9.09 (82.27)	8.22 (67.12)	8.66 (74.70)	11.48 (131.45)	10.90 (118.47)	11.19 (124.96)	8.71 (75.37)	8.17 (66.29)	8.44 (70.83)
P₃W₂	11.37 (128.91)	10.34 (106.51)	10.85 (117.71)	9.38 (87.47)	8.56 (72.89)	8.97 (80.18)	11.95 (142.34)	11.25 (125.99)	11.60 (134.17)	9.38 (87.49)	8.75 (76.17)	9.07 (81.83)
P₃W₃	9.05 (81.38)	8.42 (70.74)	8.73 (76.06)	6.93 (47.61)	6.17 (37.65)	6.55 (42.63)	9.05 (81.57)	8.54 (72.47)	8.80 (77.02)	6.09 (36.62)	5.51 (29.96)	5.80 (33.29)
P₃W₄	9.60 (91.72)	8.95 (79.92)	9.28 (85.82)	8.34 (69.04)	7.47 (55.33)	7.90 (62.19)	10.65 (112.96)	10.01 (99.81)	10.33 (106.38)	7.82 (60.71)	7.29 (52.65)	7.56 (56.68)
P₃W₅	12.82 (164.59)	11.58 (133.95)	12.20 (149.27)	7.43 (54.81)	6.67 (44.01)	7.05 (49.41)	10.22 (104.04)	9.18 (83.76)	9.70 (93.90)	6.69 (44.30)	6.10 (36.69)	6.39 (40.49)
P₃W₆	12.38 (153.14)	10.90 (118.37)	11.64 (135.75)	10.53 (110.44)	9.47 (89.12)	10.00 (99.78)	8.13 (65.64)	7.30 (52.83)	7.71 (59.23)	4.78 (22.36)	4.38 (18.69)	4.58 (20.52)
P₃W₇	13.26 (175.78)	12.02 (144.13)	12.64 (159.95)	14.30 (204.32)	13.44 (180.55)	13.87 (192.43)	16.16 (261.82)	15.31 (234.27)	15.74 (248.05)	13.21 (174.07)	12.35 (152.48)	12.78 (163.28)
SEm± (PxW)	0.12	0.09	0.07	0.11	0.08	0.07	0.11	0.13	0.09	0.08	0.08	0.06
SEm± (WxP)	0.08	0.07	0.05	0.07	0.05	0.04	0.09	0.08	0.06	0.08	0.06	0.05
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

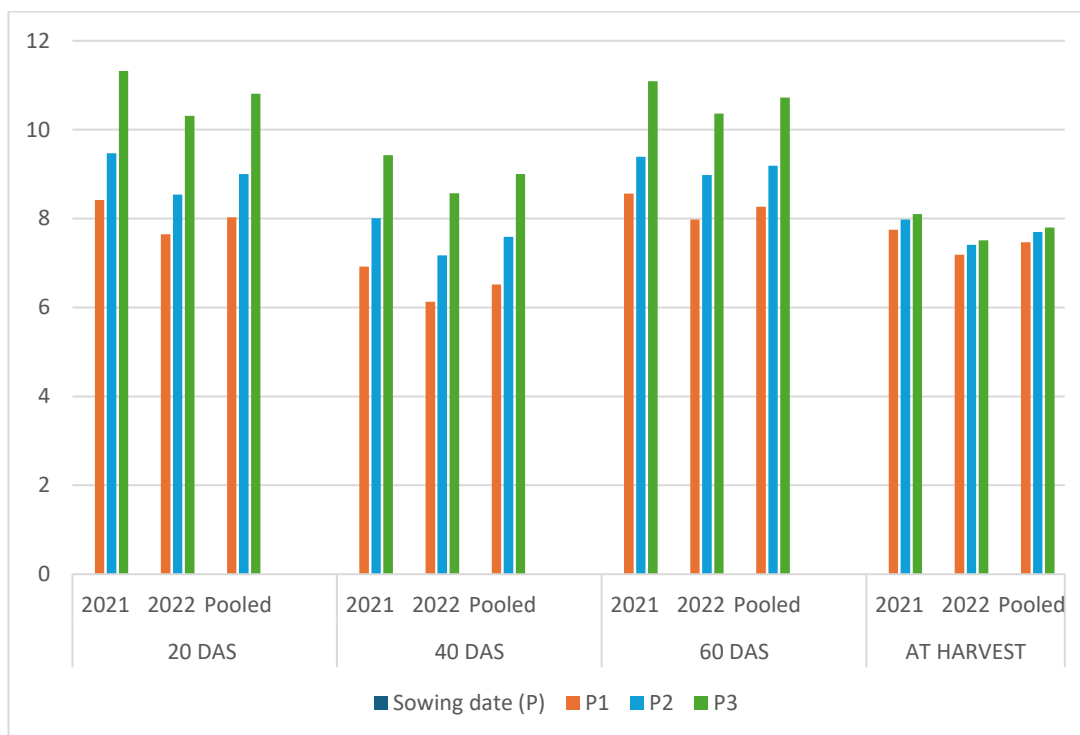


Fig 4.3 Effect of sowing dates on weed density of total weed population

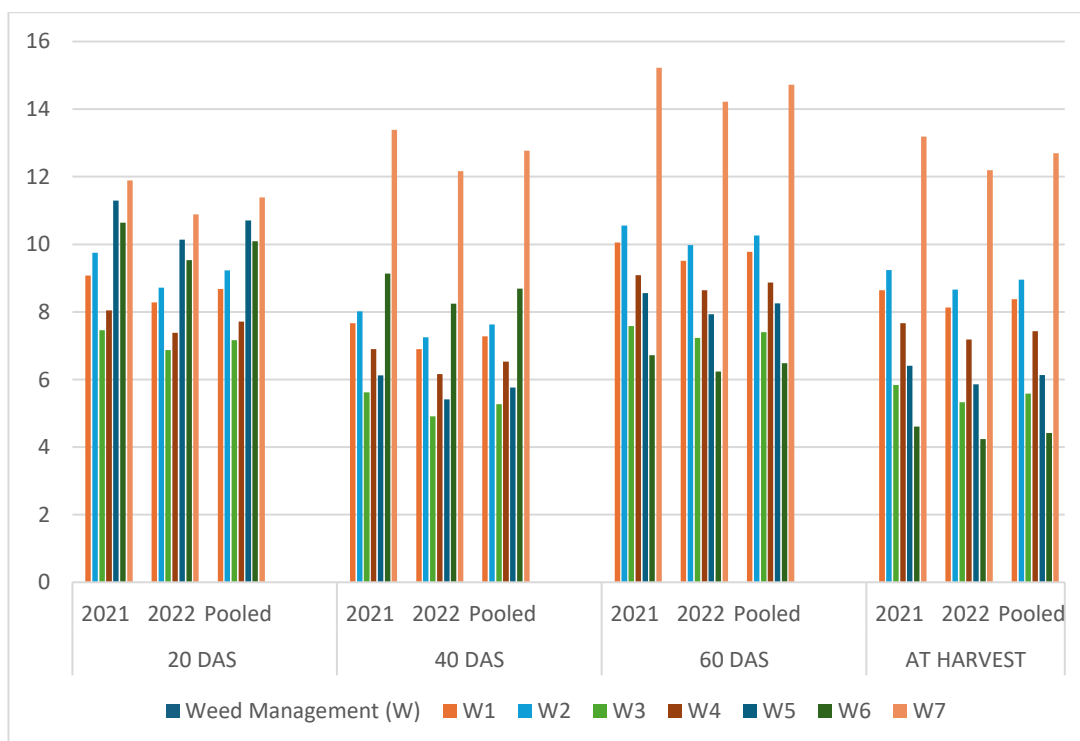


Fig 4.4 Effect of integrated weed management on total weed population

reduction of weed density was also reported by Emmiganur and Hosmath (2020).

However, at 60 DAS and harvest, treatment W₆ (Hand weeding at 20 and 40 DAS) recorded significantly lowest total weeds population (6.72, 6.24) (4.61, 4.24) in both years followed by application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃). Similar result was endorsed by Roy *et al.* (2023).

This might be due to efficient control and extermination of diverse weed flora through hand weeding at 20 and 40 DAS (W₆) from inter and intra row space and application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₆) during initial period which inhibits cell division of meristems and causes death of the weeds rapidly. In addition, the higher and denser plants might have a smothering effect on weed growth. The higher density in the weedy check plot in all the stages of observations could be attributable to the previous season's weed seed deposition, which could have resulted in an increased weed seed bank in the soil that is undisturbed by any activity, and also due to no weed management measures taken in these plots.

4.2.2.18.3 Interaction effect of sowing dates and integrated weed management on total weed population

The findings detailed in Table 4.31 (b) indicate that the interaction between sowing dates and IWM did not exert a significant effect on the over-all weed population across both years and pooled values at all observation stages.

4.2.3 WEED DRY WEIGHT (g m⁻²) at 20, 40, 60 DAS and harvest

4.2.3.1 Weed dry weight (g m⁻²) of *Digitaria sanguinalis*.

The data on dry weight of *Digitaria sanguinalis* as influenced by sowing dates and integrated weed management recorded at 20, 40, 60 DAS and harvest are presented in Table 4.32 (a) and Table 4.32 (b).

4.2.3.1.1 Effect of sowing dates on dry weight of *Digitaria sanguinalis*

An examination of two years' data and pooled values on weed biomass of *Digitaria sanguinalis* revealed significant variation among sowing dates at various stages of observations except at harvest.

The pooled values of two years at 20 and 40 DAS recorded significantly lowest

dry weight (1.96 and 1.91 g m⁻², respectively) on 15th June while sowing on 15th July recorded significantly highest dry weight (3.00 and 2.87 g m⁻² respectively). At 60 DAS, sowing on 15th June recorded the least dry weight (3.31, 3.13 g m⁻²) in both years and was at par with the sowing date of 30th June during the first year only. The significantly highest dry weight was observed on the late sowing date of 15th July in both years.

4.2.3.1.2 Effect of integrated weed management on dry weight of *Digitaria sanguinalis*

Significant results were recorded on dry weight of *Digitaria sanguinalis* due to integrated weed management. Weedy check (W₇) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded lowest weed dry weight (1.95, 1.71 gm⁻²). It was at par with treatment W₄ (Pendimethalin 30 EC @ 1kg ha⁻¹ fb interculture at 30 DAS) in both years and pooled values.

Application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest dry weight (1.76, 1.56 g m⁻²) and was at par with treatments W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS) and W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS) at 40 DAS in both years and pooled values.

However, at 60 DAS, treatment W₆ (Hand weeding at 20 and 40 DAS) recorded significantly the lowest pooled value on dry weight of 2.77 g m⁻². It was at par with W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) during the first year only. At harvest, hand weeding at 20 and 40 DAS (W₆) recorded the lowest dry weight (2.77 g m⁻², 1.97 g m⁻²) in both years and pooled values. It was at par with treatments W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both years and pooled values.

4.2.3.1.3 Interaction effect of sowing dates and integrated weed management on the dry weight (g m⁻²) of *Digitaria sanguinalis*

The study on the dry weight of *Digitaria sanguinalis* presented in Table 4.32 (b) shows that the interaction effect of sowing dates and integrated weed management

Table 4.32(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Digitaria sanguinalis* at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	2.18 (4.58)	1.75 (2.70)	1.96 (3.64)	2.09 (4.75)	1.74 (3.17)	1.91 (3.96)	3.31 (11.30)	3.13 (10.11)	3.22 (10.71)	3.03 (9.55)	2.77 (7.84)	2.9 (8.69)
P₂ 30th June	2.58 (6.45)	2.07 (3.97)	2.32 (5.21)	2.55 (6.87)	2.03 (4.16)	2.29 (5.52)	3.68 (14.03)	3.52 (12.47)	3.60 (13.25)	3.08 (9.80)	2.84 (8.27)	2.96 (9.03)
P₃ 15th July	3.27 (10.47)	2.74 (7.14)	3.00 (8.80)	3.11 (9.85)	2.63 (6.79)	2.87 (8.32)	4.34 (18.99)	4.10 (16.77)	4.22 (17.88)	3.12 (9.96)	2.87 (8.54)	3.00 (9.25)
SEm±	0.07	0.05	0.04	0.07	0.07	0.05	0.06	0.10	0.06	0.07	0.07	0.05
CD at 5%	0.29	0.20	0.14	0.28	0.26	0.16	0.25	0.4	0.2	NS	NS	NS
Integrated weed Management (W)												
W₁	2.51 (6.13)	2.07 (3.99)	2.29 (5.06)	2.47 (5.80)	1.95 (3.59)	2.21 (4.70)	3.80 (14.14)	3.64 (13.20)	3.72 (13.67)	3.17 (9.59)	3.06 (8.85)	3.11 (9.22)
W₂	2.72 (7.13)	2.12 (4.24)	2.42 (5.69)	2.57 (6.31)	2.03 (3.83)	2.30 (5.07)	3.93 (15.11)	3.87 (14.65)	3.90 (14.88)	3.36 (10.82)	3.26 (10.12)	3.31 (10.47)
W₃	1.95 (3.58)	1.71 (2.67)	1.83 (3.13)	1.76 (2.82)	1.56 (2.10)	1.66 (2.46)	3.06 (9.06)	2.98 (8.60)	3.02 (8.83)	2.34 (4.99)	2.06 (3.75)	2.20 (4.37)
W₄	2.05 (3.97)	1.78 (2.90)	1.92 (3.43)	2.04 (3.90)	1.71 (2.64)	1.87 (3.27)	3.58 (12.67)	3.48 (11.78)	3.53 (12.23)	2.90 (7.93)	2.80 (7.35)	2.85 (7.64)
W₅	3.20 (9.96)	2.56 (6.21)	2.88 (8.09)	1.89 (3.30)	1.64 (2.47)	1.77 (2.89)	3.47 (11.93)	3.32 (10.67)	3.39 (11.30)	2.50 (5.77)	2.18 (4.30)	2.34 (5.04)
W₆	2.98 (8.57)	2.39 (5.29)	2.68 (6.93)	2.85 (7.83)	2.36 (5.17)	2.60 (6.50)	2.83 (7.67)	2.70 (7.08)	2.77 (7.37)	2.27 (4.66)	1.97 (3.40)	2.12 (4.03)
W₇	3.29 (10.81)	2.68 (6.91)	2.99 (8.86)	4.50 (20.12)	3.68 (13.15)	4.09 (16.63)	5.77 (32.84)	5.11 (25.82)	5.44 (29.33)	4.99 (24.62)	4.47 (19.72)	4.73 (22.17)
SEm±	0.12	0.07	0.07	0.10	0.10	0.07	0.07	0.11	0.07	0.09	0.08	0.06
CD at 5%	0.33	0.21	0.19	0.28	0.27	0.19	0.20	0.32	0.18	0.26	0.24	0.17

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.32(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Digitaria sanguinalis*. at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.97 (3.40)	1.60 (2.05)	1.78 (2.72)	1.96 (3.33)	1.47 (1.94)	1.71 (2.64)	3.27 (10.18)	3.19 (10.49)	3.23 (10.34)	3.10 (9.17)	3.01 (8.56)	3.05 (8.87)
P₁W₂	2.19 (4.28)	1.65 (2.23)	1.92 (3.26)	2.14 (4.09)	1.60 (2.15)	1.87 (3.12)	3.47 (11.51)	3.47 (11.55)	3.47 (11.53)	3.28 (10.29)	3.19 (9.70)	3.24 (9.99)
P₁W₃	1.37 (1.39)	1.25 (1.05)	1.31 (1.22)	1.20 (0.94)	1.14 (0.81)	1.17 (0.88)	2.69 (6.73)	2.48 (5.68)	2.59 (6.21)	2.26 (4.59)	1.99 (3.46)	2.12 (4.03)
P₁W₄	1.49 (1.74)	1.32 (1.25)	1.41 (1.50)	1.49 (1.71)	1.23 (1.07)	1.36 (1.39)	3.01 (8.57)	3.01 (8.55)	3.01 (8.56)	2.78 (7.29)	2.71 (6.82)	2.75 (7.06)
P₁W₅	2.76 (7.10)	2.09 (3.89)	2.42 (5.49)	1.35 (1.34)	1.22 (1.05)	1.29 (1.19)	2.86 (7.66)	2.85 (7.62)	2.85 (7.64)	2.45 (5.54)	2.14 (4.10)	2.30 (4.82)
P₁W₆	2.50 (5.74)	2.07 (3.77)	2.28 (4.76)	2.36 (5.06)	2.03 (3.64)	2.19 (4.35)	2.51 (5.78)	2.16 (4.30)	2.33 (5.04)	2.23 (4.54)	1.96 (3.36)	2.10 (3.95)
P₁W₇	2.95 (8.42)	2.27 (4.66)	2.61 (6.54)	4.16 (16.82)	3.47 (11.52)	3.81 (14.17)	5.40 (28.63)	4.78 (22.59)	5.09 (25.61)	5.09 (25.41)	4.39 (18.87)	4.74 (22.14)
P₂W₁	2.39 (5.22)	1.92 (3.21)	2.16 (4.22)	2.38 (5.19)	1.89 (3.10)	2.13 (4.15)	3.76 (13.65)	3.68 (13.07)	3.72 (13.36)	3.21 (9.83)	3.08 (8.99)	3.15 (9.41)
P₂W₂	2.59 (6.22)	1.98 (3.43)	2.29 (4.83)	2.46 (5.59)	1.93 (3.34)	2.20 (4.46)	3.81 (14.02)	3.78 (13.80)	3.80 (13.91)	3.33 (10.60)	3.23 (9.95)	3.28 (10.28)
P₂W₃	1.86 (2.95)	1.52 (1.83)	1.69 (2.39)	1.78 (2.71)	1.44 (1.60)	1.61 (2.15)	2.84 (7.65)	2.88 (7.82)	2.86 (7.73)	2.36 (5.08)	2.04 (3.75)	2.20 (4.42)
P₂W₄	1.97 (3.37)	1.63 (2.15)	1.80 (2.76)	1.94 (3.28)	1.58 (2.03)	1.76 (2.65)	3.46 (11.59)	3.40 (11.07)	3.43 (11.33)	2.96 (8.29)	2.90 (7.93)	2.93 (8.11)
P₂W₅	3.16 (9.51)	2.51 (5.82)	2.84 (7.67)	1.85 (2.92)	1.48 (1.94)	1.67 (2.43)	3.32 (10.57)	3.26 (10.11)	3.29 (10.34)	2.41 (5.31)	2.14 (4.14)	2.28 (4.73)

P₂W₆	2.88 (7.79)	2.29 (4.79)	2.58 (6.29)	2.79 (7.31)	2.26 (4.61)	2.53 (5.96)	2.66 (6.59)	2.63 (6.39)	2.64 (6.49)	2.33 (4.91)	2.00 (3.50)	2.16 (4.21)
P₂W₇	3.18 (10.09)	2.63 (6.53)	2.91 (8.31)	4.62 (21.08)	3.61 (12.53)	4.11 (16.80)	5.89 (34.16)	5.03 (25.00)	5.46 (29.58)	4.96 (24.56)	4.48 (19.60)	4.72 (22.08)
P₃W₁	3.18 (9.77)	2.69 (6.72)	2.93 (8.25)	3.06 (8.89)	2.49 (5.74)	2.78 (7.31)	4.37 (18.59)	4.06 (16.04)	4.21 (17.31)	3.20 (9.76)	3.08 (9.00)	3.14 (9.38)
P₃W₂	3.38 (10.90)	2.73 (7.04)	3.05 (8.97)	3.12 (9.25)	2.55 (5.99)	2.83 (7.62)	4.50 (19.79)	4.37 (18.61)	4.43 (19.20)	3.46 (11.55)	3.35 (10.73)	3.41 (11.14)
P₃W₃	2.63 (6.41)	2.35 (5.13)	2.49 (5.77)	2.30 (4.82)	2.09 (3.89)	2.20 (4.36)	3.65 (12.80)	3.57 (12.30)	3.61 (12.55)	2.41 (5.30)	2.13 (4.05)	2.27 (4.68)
P₃W₄	2.70 (6.79)	2.40 (5.28)	2.55 (6.03)	2.68 (6.71)	2.31 (4.83)	2.50 (5.77)	4.27 (17.85)	4.02 (15.73)	4.14 (16.79)	2.95 (8.22)	2.79 (7.29)	2.87 (7.75)
P₃W₅	3.68 (13.28)	3.07 (8.94)	3.37 (11.11)	2.48 (5.65)	2.21 (4.41)	2.34 (5.03)	4.24 (17.57)	3.84 (14.27)	4.04 (15.92)	2.64 (6.47)	2.27 (4.67)	2.46 (5.57)
P₃W₆	3.56 (12.19)	2.80 (7.32)	3.18 (9.76)	3.39 (11.12)	2.78 (7.26)	3.09 (9.19)	3.33 (10.63)	3.32 (10.56)	3.33 (10.59)	2.24 (4.53)	1.95 (3.32)	2.10 (3.93)
P₃W₇	3.75 (13.93)	3.14 (9.54)	3.44 (11.74)	4.74 (22.47)	3.98 (15.38)	4.36 (18.93)	6.02 (35.73)	5.51 (29.86)	5.76 (32.79)	4.93 (23.90)	4.53 (20.69)	4.73 (22.29)
SEm± (PxW)	0.20	0.13	0.12	0.17	0.17	0.12	0.12	0.19	0.11	0.15	0.15	0.11
SEm± (WxP)	0.15	0.10	0.09	0.14	0.13	0.10	0.12	0.19	0.11	0.13	0.13	0.09
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

were found to be non-significant during both years.

4.2.3.2 Weed dry weight (g m^{-2}) of *Eleusine indica*

The data on the dry weight (g m^{-2}) of *Eleusine indica* as influenced by sowing dates and integrated weed management recorded at 20, 40, 60 DAS and harvest are presented in Table 4.33 (a) and Table 4.33 (b).

4.2.3.2.1 Effect of sowing dates on dry weight (g m^{-2}) of *Eleusine indica*

An inquisition of two years' data and pooled values on weed biomass of *Eleusine indica* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly, the highest dry weight at all stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, the significantly lowest pooled dry weight (1.97 g m^{-2}) was recorded on 15th June and was at par with 30th June in both years. At 40 DAS, the pooled values revealed that sowing on 15th June recorded the least dry weight (1.88 g m^{-2}) and was at par with the sowing date of 30th June during the second year. At 60 DAS, the pooled values revealed that sowing on 15th June recorded the least dry weight (2.65 g m^{-2}) and was at par with the sowing date of 30th June during the second year.

4.2.3.2.2 Effect of integrated weed management on the dry weight (g m^{-2}) of *Eleusine indica*

The data on dry weight of *Eleusine indica* due to integrated weed management were also found to be significant. Weedy check (W_7) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @ 1 kg ha^{-1} fb imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS (W_3) recorded the lowest weed dry weight ($1.69, 1.54 \text{ g m}^{-2}$) in both years and pooled values. It was at par with W_4 (Pendimethalin 30EC @ 1 kg ha^{-1} fb interculture at 30 DAS) in both years and pooled values.

Application of pendimethalin 30 EC @ 1 kg ha^{-1} fb imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS (W_3) recorded significantly lowest dry weight ($1.52, 1.47 \text{ gm}^2$) and was at par with treatments W_4 (Pendimethalin 30 EC @ 1 kg ha^{-1} fb interculture at 30 DAS) and W_5 (Imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS fb interculture at 30 DAS)

Table 4.33(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Eleusine indica* at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	2.01 (3.79)	1.92 (3.42)	1.97 (3.61)	1.91 (3.93)	1.85 (3.67)	1.88 (3.80)	2.7 (7.61)	2.61 (7.01)	2.65 (7.31)	2.36 (5.43)	2.35 (5.15)	2.35 (5.29)
P₂ 30th June	2.22 (4.73)	2.07 (4.11)	2.15 (4.42)	2.17 (4.98)	2.00 (4.21)	2.08 (4.60)	3.00 (9.22)	2.88 (8.54)	2.94 (8.88)	2.61 (6.46)	2.39 (5.33)	2.50 (5.89)
P₃ 15th July	2.76 (7.41)	2.53 (6.16)	2.65 (6.78)	2.54 (6.56)	2.45 (6.10)	2.49 (6.33)	3.54 (13.09)	3.23 (10.69)	3.38 (11.89)	2.64 (6.62)	2.41 (5.42)	2.53 (6.02)
SEm±	0.07	0.05	0.04	0.05	0.05	0.04	0.07	0.07	0.05	0.07	0.06	0.05
CD at 5%	0.28	0.20	0.14	0.20	0.20	0.12	0.27	0.28	0.16	NS	NS	NS
Integrated weed Management (W)												
W₁	2.11 (4.15)	2.04 (3.97)	2.07 (4.06)	1.95 (3.49)	1.92 (3.26)	1.94 (3.37)	3.08 (9.14)	2.90 (8.03)	2.99 (8.58)	2.72 (6.92)	2.57 (6.13)	2.65 (6.53)
W₂	2.24 (4.74)	2.07 (3.88)	2.16 (4.31)	2.07 (3.84)	1.96 (3.42)	2.01 (3.63)	3.23 (10.20)	2.95 (8.30)	3.09 (9.25)	2.84 (7.62)	2.78 (7.28)	2.81 (7.45)
W₃	1.69 (2.49)	1.54 (1.96)	1.62 (2.23)	1.52 (2.05)	1.47 (1.78)	1.50 (1.92)	2.31 (4.87)	2.25 (4.60)	2.28 (4.74)	2.14 (4.13)	2.11 (3.96)	2.13 (4.05)
W₄	1.83 (2.93)	1.63 (2.28)	1.73 (2.60)	1.75 (2.68)	1.61 (2.17)	1.68 (2.43)	2.93 (8.30)	2.69 (6.81)	2.81 (7.56)	2.52 (5.89)	2.40 (5.29)	2.46 (5.59)
W₅	2.75 (7.22)	2.53 (5.94)	2.64 (6.58)	1.65 (2.35)	1.53 (1.93)	1.59 (2.14)	2.83 (7.71)	2.63 (6.53)	2.73 (7.12)	2.32 (4.94)	2.27 (4.67)	2.29 (4.81)
W₆	2.67 (6.81)	2.46 (5.60)	2.56 (6.21)	2.38 (5.20)	2.26 (4.67)	2.32 (4.93)	2.15 (4.20)	2.13 (4.07)	2.14 (4.14)	1.97 (3.41)	1.92 (3.21)	1.95 (3.31)
W₇	3.04 (8.83)	2.95 (8.31)	2.99 (8.57)	4.11 (16.50)	3.95 (15.40)	4.03 (15.95)	5.03 (25.37)	4.80 (22.89)	4.91 (24.13)	3.22 (10.28)	2.65 (6.55)	2.93 (8.42)
SEm±	0.09	0.10	0.06	0.09	0.09	0.06	0.13	0.10	0.08	0.11	0.06	0.06
CD at 5%	0.25	0.27	0.18	0.25	0.25	0.17	0.36	0.29	0.23	0.30	0.18	0.17

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.33(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m²) of *Eleusine indica* at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.75 (2.64)	1.71 (2.44)	1.73 (2.54)	1.56 (2.02)	1.68 (2.34)	1.62 (2.18)	2.70 (6.80)	2.55 (6.01)	2.62 (6.40)	2.67 (6.65)	2.55 (6.03)	2.61 (6.34)
P₁W₂	2.01 (3.55)	1.77 (2.63)	1.89 (3.09)	1.76 (2.61)	1.73 (2.50)	1.75 (2.55)	2.74 (7.02)	2.59 (6.22)	2.67 (6.62)	2.69 (6.74)	2.78 (7.31)	2.73 (7.03)
P₁W₃	1.36 (1.36)	1.31 (1.22)	1.34 (1.29)	1.23 (1.14)	1.23 (1.03)	1.23 (1.08)	2.10 (3.89)	2.05 (3.71)	2.07 (3.80)	1.92 (3.22)	2.03 (3.64)	1.97 (3.43)
P₁W₄	1.57 (1.98)	1.36 (1.34)	1.46 (1.66)	1.42 (1.53)	1.34 (1.30)	1.38 (1.41)	2.46 (5.57)	2.32 (4.90)	2.39 (5.23)	2.37 (5.12)	2.38 (5.15)	2.37 (5.14)
P₁W₅	2.34 (4.97)	2.29 (4.72)	2.31 (4.85)	1.32 (1.24)	1.26 (1.10)	1.29 (1.17)	2.43 (5.39)	2.28 (4.71)	2.35 (5.05)	2.03 (3.66)	2.23 (4.49)	2.13 (4.08)
P₁W₆	2.26 (4.64)	2.22 (4.45)	2.24 (4.54)	2.24 (4.51)	1.98 (3.44)	2.11 (3.98)	1.85 (2.92)	1.90 (3.12)	1.87 (3.02)	1.75 (2.58)	1.87 (3.02)	1.81 (2.80)
P₁W₇	2.81 (7.44)	2.75 (7.12)	2.78 (7.28)	3.87 (14.50)	3.73 (13.96)	3.80 (14.23)	4.63 (21.64)	4.55 (20.42)	4.59 (21.03)	3.07 (10.02)	2.62 (6.38)	2.85 (8.20)
P₂W₁	1.99 (3.47)	1.89 (3.07)	1.94 (3.27)	1.98 (3.44)	1.83 (2.85)	1.90 (3.15)	2.92 (8.07)	2.92 (8.07)	2.92 (8.07)	2.74 (7.00)	2.58 (6.17)	2.66 (6.58)
P₂W₂	2.09 (3.93)	1.94 (3.28)	2.01 (3.60)	2.07 (3.80)	1.87 (3.00)	1.97 (3.40)	3.09 (9.05)	2.98 (8.45)	3.04 (8.75)	2.89 (7.94)	2.78 (7.25)	2.84 (7.60)
P₂W₃	1.56 (1.92)	1.35 (1.32)	1.45 (1.62)	1.38 (1.62)	1.28 (1.17)	1.33 (1.39)	2.28 (4.73)	2.17 (4.22)	2.23 (4.47)	2.25 (4.55)	2.15 (4.11)	2.20 (4.33)
P₂W₄	1.69 (2.35)	1.48 (1.72)	1.59 (2.03)	1.66 (2.26)	1.46 (1.63)	1.56 (1.94)	2.82 (7.45)	2.66 (6.60)	2.74 (7.03)	2.59 (6.25)	2.41 (5.33)	2.50 (5.79)
P₂W₅	2.71 (6.92)	2.48 (5.65)	2.60 (6.29)	1.59 (2.05)	1.39 (1.45)	1.49 (1.75)	2.69 (6.72)	2.59 (6.20)	2.64 (6.46)	2.46 (5.56)	2.29 (4.74)	2.37 (5.15)

P₂W₆	2.60 (6.30)	2.40 (5.25)	2.50 (5.78)	2.35 (5.06)	2.25 (4.55)	2.30 (4.80)	2.23 (4.45)	2.08 (3.85)	2.15 (4.15)	2.07 (3.81)	1.93 (3.22)	2.00 (3.52)
P₂W₇	2.94 (8.19)	2.95 (8.47)	2.95 (8.33)	4.13 (16.64)	3.91 (14.86)	4.02 (15.75)	4.95 (24.05)	4.77 (22.41)	4.86 (23.23)	3.25 (10.13)	2.62 (6.45)	2.93 (8.29)
P₃W₁	2.58 (6.33)	2.51 (6.39)	2.54 (6.36)	2.31 (5.01)	2.25 (4.58)	2.28 (4.80)	3.61 (12.54)	3.24 (10.01)	3.42 (11.27)	2.76 (7.13)	2.58 (6.20)	2.67 (6.66)
P₃W₂	2.64 (6.73)	2.50 (5.73)	2.57 (6.23)	2.36 (5.10)	2.29 (4.77)	2.33 (4.93)	3.85 (14.53)	3.28 (10.24)	3.56 (12.39)	2.94 (8.17)	2.78 (7.28)	2.86 (7.73)
P₃W₃	2.17 (4.19)	1.95 (3.34)	2.06 (3.77)	1.96 (3.39)	1.90 (3.14)	1.93 (3.27)	2.55 (6.00)	2.53 (5.88)	2.54 (5.94)	2.26 (4.63)	2.15 (4.12)	2.21 (4.38)
P₃W₄	2.22 (4.47)	2.06 (3.77)	2.14 (4.12)	2.18 (4.27)	2.02 (3.59)	2.10 (3.93)	3.52 (11.88)	3.07 (8.93)	3.29 (10.41)	2.61 (6.30)	2.41 (5.38)	2.51 (5.84)
P₃W₅	3.20 (9.76)	2.81 (7.44)	3.01 (8.60)	2.05 (3.75)	1.93 (3.23)	1.99 (3.49)	3.38 (11.01)	3.03 (8.68)	3.20 (9.84)	2.47 (5.59)	2.29 (4.78)	2.38 (5.19)
P₃W₆	3.15 (9.51)	2.75 (7.11)	2.95 (8.31)	2.55 (6.02)	2.54 (6.03)	2.55 (6.02)	2.39 (5.23)	2.39 (5.26)	2.39 (5.24)	2.09 (3.85)	1.97 (3.38)	2.03 (3.61)
P₃W₇	3.37 (10.86)	3.13 (9.33)	3.25 (10.10)	4.34 (18.37)	4.21 (17.39)	4.28 (17.88)	5.50 (30.43)	5.06 (25.85)	5.28 (28.14)	3.35 (10.69)	2.70 (6.83)	3.02 (8.76)
SEm± (PxW)	0.15	0.16	0.11	0.15	0.15	0.11	0.22	0.18	0.14	0.18	0.11	0.11
SEm± (WxP)	0.14	0.11	0.09	0.11	0.11	0.08	0.15	0.14	0.10	0.14	0.11	0.09
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

at 40 DAS in both years and pooled values.

However, at 60 DAS treatment, W₆ (Hand weeding at 20 and 40 DAS) recorded significantly the lowest dry weight (2.15, 2.13 g m⁻²) in both years and pooled values. This was at par with W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both years. At harvest, hand weeding at 20 and 40 DAS (W₆) recorded the lowest dry weight (1.97, 1.92 g m⁻²) in both years and pooled values. It was at par with treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both years.

4.2.3.2.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Eleusine indica*

The study found no significant effect on the dry weight of *Eleusine indica* due to the interaction effect of sowing dates and integrated weed management in all the stages of observation.

4.2.3.3 Weed dry weight (g m⁻²) of *Cynodon dactylon*

The data on the dry weight of *Cynodon dactylon* as influenced by sowing dates and integrated weed management recorded at 20, 40, 60 DAS and harvest are presented in Table 4.34 (a) and Table 4.34 (b).

4.2.3.3.1 Effect of sowing dates on dry weight of *Cynodon dactylon*

The effect of sowing dates on weed dry weight of *Cynodon dactylon* revealed significant variation at various stages of observations except at harvest. Significantly, the highest dry weight at all stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, the significantly lowest dry weight (0.99, 0.95 g m⁻²) was recorded on 15th June and was at par with 30th June in both years. At 40 DAS, the pooled values revealed that sowing on 15th June recorded the least dry weight (0.93 g m⁻²) and was at par with the sowing date of 30th June during the second year. At 60 DAS, the pooled values revealed that sowing on 15th June recorded the least dry weight (1.31 g m⁻²) and was at par with the sowing date of 30th June in both years and pooled values.

4.2.3.3.2 Effect of integrated weed management on the dry weight of *Cynodon dactylon*

Variations in the dry weight of *Cynodon dactylon* due to integrated weed management were also found to be significant. Weedy check (W_7) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W_3) recorded lowest weed dry weight (0.96, 0.89 g m⁻²). It was at par with W_4 (Pendimethalin 30EC @ 1kg ha⁻¹ fb interculture at 30 DAS) in both years and pooled values.

Application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W_3) recorded significantly lowest dry weight (0.82, 0.83 g m⁻²) in both years, and pooled values, and was at par with treatments W_4 (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS) and W_5 (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS) at 40 DAS in both years and pooled values.

However, at 60 DAS treatment, W_6 (Hand weeding at 20 and 40 DAS) recorded significantly the lowest dry weight (1.40, 1.19 g m⁻²) in both years and pooled values. It was at par with W_3 (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both years and pooled values. At harvest, hand weeding at 20 and 40 DAS (W_6) recorded the lowest dry weight (0.71, 0.71 g m⁻²) in both years and pooled values followed by W_3 (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both years.

4.2.3.3.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Cynodon dactylon*

The data on the dry weight of *Cynodon dactylon* presented in Table 4.34 (b) showed that the interaction effect of sowing dates and integrated weed management were found to be non-significant during both years.

4.2.3.4 Weed dry weight (g m⁻²) of *Cyperus iria*

The data on dry weight of *Cyperus iria* as influenced by sowing dates and integrated weed management recorded at 20, 40, 60 DAS and harvest are presented in Table 4.35 (a) and Table 4.35 (b).

Table 4.34(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Cynadon dactylon* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	0.99 (0.50)	0.95 (0.41)	0.97 (0.45)	0.97 (0.51)	0.89 (0.31)	0.93 (0.41)	1.40 (1.51)	1.22 (1.02)	1.31 (1.26)	1.12 (0.85)	0.99 (0.54)	1.06 (0.70)
P₂ 30th June	1.10 (0.72)	1.03 (0.59)	1.07 (0.65)	1.01 (0.63)	1.01 (0.63)	1.01 (0.63)	1.42 (1.57)	1.31 (1.24)	1.36 (1.41)	1.14 (0.90)	1.01 (0.57)	1.07 (0.73)
P₃ 15th July	1.19 (0.93)	1.09 (0.70)	1.14 (0.81)	1.15 (0.94)	1.1 (0.73)	1.12 (0.84)	1.76 (2.66)	1.43 (1.60)	1.59 (2.13)	1.15 (0.90)	1.02 (0.59)	1.08 (0.75)
SEm±	0.03	0.02	0.02	0.02	0.02	0.02	0.04	0.03	0.02	0.03	0.02	0.02
CD at 5%	0.11	0.09	0.06	0.10	0.08	0.05	0.14	0.12	0.08	NS	NS	NS
Integrated weed Management (W)												
W₁	1.09 (0.69)	0.99 (0.49)	1.04 (0.59)	0.95 (0.40)	0.95 (0.42)	0.95 (0.41)	1.48 (1.73)	1.29 (1.18)	1.39 (1.45)	1.13 (0.77)	1.03 (0.57)	1.08 (0.67)
W₂	1.09 (0.70)	1.04 (0.60)	1.07 (0.65)	0.95 (0.42)	0.96 (0.44)	0.96 (0.43)	1.5 (1.79)	1.31 (1.24)	1.41 (1.51)	1.23 (1.00)	1.03 (0.56)	1.13 (.78)
W₃	0.96 (0.42)	0.89 (0.29)	0.92 (0.36)	0.82 (0.19)	0.83 (0.20)	0.83 (0.19)	1.43 (1.57)	1.22 (1.01)	1.33 (1.29)	1.00 (.50)	0.85 (0.22)	0.92 (0.36)
W₄	1.00 (0.52)	0.91 (0.34)	0.96 (0.43)	0.92 (0.35)	0.93 (0.38)	0.92 (0.36)	1.46 (1.65)	1.28 (1.14)	1.37 (1.40)	1.11 (0.74)	1.03 (0.55)	1.07 (0.64)
W₅	1.16 (0.86)	1.11 (0.73)	1.13 (0.80)	0.85 (0.24)	0.87 (0.27)	0.86 (0.26)	1.44 (1.60)	1.25 (1.07)	1.34 (1.34)	1.04 (0.59)	0.89 (0.28)	0.96 (0.44)
W₆	1.16 (0.86)	1.08 (0.68)	1.12 (0.77)	1.03 (0.57)	1.04 (0.60)	1.04 (0.59)	1.4 (1.48)	1.19 (0.92)	1.29 (1.20)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	1.19 (0.95)	1.14 (0.81)	1.17 (0.88)	1.77 (2.70)	1.39 (1.57)	1.58 (2.13)	1.98 (3.57)	1.68 (2.45)	1.83 (3.01)	1.74 (2.57)	1.51 (1.79)	1.62 (2.18)
SEm±	0.04	0.04	0.03	0.04	0.05	0.03	0.06	0.05	0.04	0.03	0.02	0.02
CD at 5%	0.11	0.10	0.07	0.11	0.13	0.08	0.18	0.15	0.11	0.09	0.05	0.05

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.34(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Cynodon dactylon* at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	0.98 (0.46)	0.91 (0.34)	0.94 (0.40)	0.88 (0.27)	0.85 (0.22)	0.86 (0.25)	1.35 (1.33)	1.18 (0.89)	1.27 (1.11)	1.12 (0.76)	1.03 (0.57)	1.08 (0.66)
P₁W₂	0.99 (0.48)	0.97 (0.45)	0.98 (0.47)	0.89 (0.29)	0.87 (0.25)	0.88 (0.27)	1.37 (1.38)	1.19 (0.92)	1.28 (1.15)	1.22 (0.98)	1.03 (0.57)	1.13 (0.77)
P₁W₃	0.87 (0.26)	0.81 (0.16)	0.84 (0.21)	0.77 (0.10)	0.75 (0.07)	0.76 (0.08)	1.30 (1.20)	1.13 (0.77)	1.22 (0.98)	0.97 (0.45)	0.82 (0.17)	0.89 (0.31)
P₁W₄	0.91 (0.33)	0.84 (0.21)	0.87 (0.27)	0.85 (0.22)	0.82 (0.18)	0.84 (0.20)	1.33 (1.26)	1.17 (0.87)	1.25 (1.07)	1.09 (0.69)	1.03 (0.56)	1.06 (0.62)
P₁W₅	1.06 (0.64)	1.03 (0.57)	1.05 (0.60)	0.80 (0.14)	0.77 (0.09)	0.78 (0.12)	1.31 (1.23)	1.15 (0.81)	1.23 (1.02)	1.03 (0.55)	0.88 (0.27)	0.95 (0.41)
P₁W₆	1.05 (0.61)	1.00 (0.52)	1.02 (0.57)	0.96 (0.42)	0.96 (0.41)	0.96 (0.42)	1.28 (1.14)	1.10 (0.72)	1.19 (0.93)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.09 (0.69)	1.07 (0.65)	1.08 (0.67)	1.61 (2.15)	1.19 (0.91)	1.40 (1.53)	1.84 (3.05)	1.62 (2.13)	1.73 (2.59)	1.73 (2.50)	1.47 (1.67)	1.60 (2.09)
P₂W₁	1.09 (0.68)	1.00 (0.50)	1.04 (0.59)	0.92 (0.34)	0.92 (0.34)	0.92 (0.34)	1.38 (1.40)	1.26 (1.10)	1.32 (1.25)	1.12 (0.75)	1.03 (0.57)	1.07 (0.66)
P₂W₂	1.10 (0.71)	1.05 (0.62)	1.08 (0.66)	0.93 (0.36)	0.93 (0.36)	0.93 (0.36)	1.40 (1.45)	1.28 (1.13)	1.34 (1.29)	1.22 (0.99)	1.03 (0.56)	1.13 (0.78)
P₂W₃	0.95 (0.41)	0.90 (0.32)	0.93 (0.36)	0.78 (0.11)	0.78 (0.11)	0.78 (0.11)	1.33 (1.26)	1.20 (0.93)	1.26 (1.10)	1.00 (0.51)	0.85 (0.23)	0.93 (0.37)
P₂W₄	1.00 (0.51)	0.92 (0.36)	0.96 (0.44)	0.89 (0.29)	0.89 (0.29)	0.89 (0.29)	1.36 (1.34)	1.25 (1.07)	1.30 (1.20)	1.11 (0.74)	1.02 (0.55)	1.07 (0.64)
P₂W₅	1.17 (0.87)	1.12 (0.76)	1.14 (0.81)	0.81 (0.16)	0.81 (0.16)	0.81 (0.16)	1.34 (1.29)	1.22 (0.99)	1.28 (1.14)	1.04 (0.58)	0.89 (0.30)	0.97 (0.44)

P₂W₆	1.17 (0.90)	1.09 (0.71)	1.13 (0.80)	1.00 (0.52)	1.00 (0.52)	1.00 (0.52)	1.31 (1.21)	1.17 (0.86)	1.24 (1.04)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	1.19 (0.93)	1.15 (0.84)	1.17 (0.88)	1.75 (2.62)	1.75 (2.62)	1.75 (2.62)	1.87 (3.03)	1.76 (2.62)	1.82 (2.83)	1.76 (2.70)	1.51 (1.78)	1.63 (2.24)
P₃W₁	1.19 (0.92)	1.06 (0.64)	1.12 (0.78)	1.04 (0.59)	1.09 (0.69)	1.07 (0.64)	1.72 (2.46)	1.43 (1.55)	1.58 (2.01)	1.14 (0.81)	1.03 (0.57)	1.09 (0.69)
P₃W₂	1.19 (0.92)	1.11 (0.72)	1.15 (0.82)	1.05 (0.60)	1.10 (0.71)	1.07 (0.66)	1.74 (2.54)	1.47 (1.66)	1.61 (2.10)	1.24 (1.04)	1.03 (0.57)	1.14 (0.80)
P₃W₃	1.04 (0.59)	0.95 (0.41)	1.00 (0.50)	0.92 (0.35)	0.96 (0.43)	0.94 (0.39)	1.65 (2.25)	1.35 (1.32)	1.50 (1.78)	1.02 (0.55)	0.87 (0.26)	0.95 (0.41)
P₃W₄	1.09 (0.71)	0.97 (0.46)	1.03 (0.58)	1.01 (0.53)	1.09 (0.68)	1.05 (0.61)	1.69 (2.35)	1.41 (1.49)	1.55 (1.92)	1.13 (0.78)	1.03 (0.55)	1.08 (0.67)
P₃W₅	1.26 (1.09)	1.16 (0.87)	1.21 (0.98)	0.95 (0.41)	1.03 (0.57)	0.99 (0.49)	1.67 (2.28)	1.38 (1.42)	1.53 (1.85)	1.06 (0.62)	0.89 (0.29)	0.97 (0.45)
P₃W₆	1.25 (1.08)	1.15 (0.82)	1.20 (0.95)	1.13 (0.77)	1.17 (0.88)	1.15 (0.82)	1.61 (2.09)	1.30 (1.18)	1.45 (1.64)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	1.29 (1.22)	1.21 (0.96)	1.25 (1.09)	1.95 (3.33)	1.24 (1.17)	1.59 (2.25)	2.22 (4.64)	1.67 (2.60)	1.94 (3.62)	1.74 (2.52)	1.55 (1.92)	1.64 (2.22)
SEm± (PxW)	0.07	0.06	0.05	0.07	0.08	0.05	0.11	0.09	0.07	0.06	0.03	0.03
SEm± (WxP)	0.05	0.05	0.04	0.05	0.05	0.04	0.08	0.07	0.05	0.05	0.03	0.03
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

4.2.3.4.1 Effect of sowing dates on dry weight of *Cyperus iria*

A scrutiny of two years' data and pooled values on weed biomass of *Cyperus iria* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly, the highest dry weight at all stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, the significantly lowest dry weight (1.21, 1.12 g m⁻²) was recorded on 15th June and was at par with 30th June in both the years and pooled values. At 40 DAS, the pooled values revealed that sowing on 15th June recorded the least dry weight (1.04 g m⁻²) and was at par with the sowing date of 30th June during the first year. At 60 DAS, the pooled values revealed that sowing on 15th June recorded the least dry weight (1.12 g m⁻²) and was at par with the sowing date of 30th June in the first year.

4.2.3.4.2 Effect of integrated weed management on the dry weight of *Cyperus iria*

Differences in dry weight of *Cyperus iria* due to integrated weed management were also found to be significant. Weedy check (W₇) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded the lowest weed dry weight (1.07, 1.01 g m⁻²). It was at par with W₄ (Pendimethalin 30EC @ 1kg ha⁻¹ fb interculture at 30 DAS) in both years and pooled values.

Application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest dry weight (0.97, 0.95 g m⁻²) in both years and pooled values and was at par with treatments W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS) and W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS) at 40 DAS in both years and pooled values.

At 60 DAS and harvest, hand weeding at 20 and 40 DAS treatment (W₆) recorded significantly lowest pooled values of weeds dry weight (0.77, 0.71 g m⁻², respectively) in both years.

4.2.3.4.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Cyperus iria*

The study found no significant effect on the dry weight of *Cyperus iria* due to

Table 4.35(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Cyperus iria* at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.21 (1.00)	1.12 (.77)	1.17 (0.88)	1.10 (0.75)	0.99 (0.52)	1.04 (0.64)	1.16 (0.96)	1.09 (0.86)	1.12 (0.91)	1.15 (0.91)	1.13 (0.83)	1.14 (0.87)
P₂ 30th June	1.27 (1.15)	1.19 (0.95)	1.23 (1.05)	1.13 (0.81)	1.17 (0.94)	1.15 (0.87)	1.19 (1.04)	1.23 (1.19)	1.21 (1.11)	1.18 (0.97)	1.15 (0.88)	1.16 (0.92)
P₃ 15th July	1.42 (1.58)	1.34 (1.37)	1.38 (1.47)	1.30 (1.28)	1.26 (1.13)	1.28 (1.20)	1.42 (1.63)	1.37 (1.58)	1.40 (1.60)	1.19 (1.00)	1.17 (0.93)	1.18 (0.97)
SEm±	0.03	0.03	0.02	0.03	0.03	0.02	0.03	0.03	0.02	0.03	0.03	0.02
CD at 5%	0.12	0.12	0.07	0.11	0.10	0.06	0.12	0.10	0.07	NS	NS	NS
Integrated weed Management (W)												
W₁	1.26 (1.10)	1.17 (0.88)	1.22 (0.99)	1.13 (0.79)	1.11 (0.73)	1.12 (0.76)	1.35 (1.36)	1.34 (1.36)	1.35 (1.36)	1.32 (1.24)	1.31 (1.21)	1.31 (1.22)
W₂	1.28 (1.15)	1.20 (0.96)	1.24 (1.05)	1.15 (0.83)	1.11 (0.76)	1.13 (0.79)	1.41 (1.51)	1.35 (1.37)	1.38 (1.44)	1.38 (1.39)	1.32 (1.24)	1.35 (1.32)
W₃	1.07 (0.64)	1.01 (0.52)	1.04 (0.58)	0.97 (0.44)	0.95 (0.42)	0.96 (0.43)	1.04 (0.59)	0.97 (0.47)	1.00 (0.53)	1.00 (0.50)	1.00 (0.49)	1.00 (0.50)
W₄	1.11 (0.75)	1.04 (0.60)	1.08 (0.67)	1.10 (0.71)	1.01 (0.53)	1.05 (0.62)	1.18 (0.92)	1.13 (0.82)	1.16 (0.87)	1.17 (0.87)	1.16 (0.85)	1.16 (0.86)
W₅	1.44 (1.60)	1.35 (1.41)	1.40 (1.51)	1.01 (0.52)	0.98 (0.48)	0.99 (0.50)	1.09 (0.70)	1.00 (0.55)	1.04 (0.63)	1.04 (0.59)	1.04 (0.57)	1.04 (0.58)
W₆	1.40 (1.48)	1.31 (1.23)	1.35 (1.36)	1.28 (1.16)	1.23 (1.03)	1.26 (1.09)	0.83 (0.21)	0.71 (0.00)	0.77 (0.11)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	1.54 (1.97)	1.43 (1.61)	1.49 (1.79)	1.61 (2.20)	1.58 (2.08)	1.6 (2.14)	1.89 (3.16)	2.09 (3.88)	1.99 (3.52)	1.61 (2.11)	1.51 (1.82)	1.56 (1.97)
SEm±	0.06	0.05	0.04	0.04	0.04	0.03	0.05	0.06	0.04	0.02	0.04	0.02
CD at 5%	0.16	0.15	0.11	0.13	0.12	0.09	0.15	0.17	0.11	0.06	0.10	0.06

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.35(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Cyperus iria* at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.16 (0.86)	1.09 (0.69)	1.13 (0.77)	1.05 (0.61)	0.96 (0.42)	1.00 (0.51)	1.24 (1.03)	1.16 (0.85)	1.20 (0.94)	1.30 (1.19)	1.29 (1.17)	1.30 (1.18)
P₁W₂	1.18 (0.90)	1.12 (0.77)	1.15 (0.83)	1.07 (0.64)	0.92 (0.35)	0.99 (0.49)	1.29 (1.16)	1.17 (0.90)	1.23 (1.03)	1.36 (1.35)	1.31 (1.21)	1.33 (1.28)
P₁W₃	1.01 (0.51)	0.97 (0.44)	0.99 (0.47)	0.92 (0.34)	0.83 (0.19)	0.88 (0.27)	0.95 (0.40)	0.78 (0.12)	0.87 (0.26)	0.96 (0.43)	0.96 (0.41)	0.96 (0.42)
P₁W₄	1.05 (0.59)	1.00 (0.50)	1.02 (0.55)	1.02 (0.55)	0.87 (0.25)	0.94 (0.40)	1.08 (0.67)	0.96 (0.45)	1.02 (0.56)	1.14 (0.80)	1.14 (0.79)	1.14 (0.80)
P₁W₅	1.35 (1.31)	1.22 (0.98)	1.28 (1.15)	0.95 (0.40)	0.84 (0.21)	0.89 (0.30)	0.99 (0.49)	0.82 (0.21)	0.91 (0.35)	1.03 (0.56)	1.02 (0.54)	1.02 (0.55)
P₁W₆	1.31 (1.22)	1.20 (0.96)	1.26 (1.09)	1.19 (0.92)	1.05 (0.61)	1.12 (0.76)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.44 (1.58)	1.25 (1.06)	1.35 (1.32)	1.52 (1.83)	1.45 (1.65)	1.48 (1.74)	1.83 (2.95)	2.00 (3.51)	1.92 (3.23)	1.58 (2.03)	1.46 (1.70)	1.52 (1.87)
P₂W₁	1.23 (1.01)	1.15 (0.83)	1.19 (0.92)	1.09 (0.70)	1.14 (0.79)	1.11 (0.74)	1.30 (1.19)	1.33 (1.30)	1.31 (1.25)	1.32 (1.24)	1.30 (1.20)	1.31 (1.22)
P₂W₂	1.25 (1.05)	1.19 (0.91)	1.22 (0.98)	1.11 (0.73)	1.17 (0.87)	1.14 (0.80)	1.34 (1.32)	1.33 (1.29)	1.34 (1.31)	1.38 (1.40)	1.32 (1.23)	1.35 (1.31)
P₂W₃	1.05 (0.61)	1.01 (0.52)	1.03 (0.56)	0.95 (0.40)	0.98 (0.46)	0.97 (0.43)	0.99 (0.49)	0.97 (0.45)	0.98 (0.47)	1.01 (0.52)	1.01 (0.51)	1.01 (0.51)
P₂W₄	1.09 (0.69)	1.04 (0.59)	1.07 (0.64)	1.06 (0.63)	1.04 (0.58)	1.05 (0.61)	1.13 (0.79)	1.18 (0.90)	1.16 (0.84)	1.17 (0.88)	1.16 (0.85)	1.17 (0.86)
P₂W₅	1.41 (1.49)	1.30 (1.21)	1.36 (1.35)	0.98 (0.47)	1.02 (0.54)	1.00 (0.50)	1.05 (0.61)	0.98 (0.51)	1.02 (0.56)	1.05 (0.60)	1.04 (0.58)	1.04 (0.59)

P₂W₆	1.37 (1.41)	1.28 (1.14)	1.33 (1.28)	1.23 (1.02)	1.28 (1.14)	1.26 (1.08)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	1.50 (1.76)	1.37 (1.43)	1.44 (1.60)	1.49 (1.73)	1.60 (2.17)	1.54 (1.95)	1.79 (2.86)	2.08 (3.85)	1.93 (3.36)	1.62 (2.13)	1.50 (1.81)	1.56 (1.97)
P₃W₁	1.39 (1.42)	1.28 (1.13)	1.33 (1.28)	1.25 (1.07)	1.22 (0.99)	1.24 (1.03)	1.53 (1.87)	1.54 (1.92)	1.53 (1.89)	1.33 (1.28)	1.32 (1.24)	1.33 (1.26)
P₃W₂	1.41 (1.49)	1.30 (1.19)	1.35 (1.34)	1.27 (1.12)	1.24 (1.05)	1.26 (1.09)	1.59 (2.04)	1.56 (1.93)	1.57 (1.98)	1.39 (1.44)	1.34 (1.28)	1.36 (1.36)
P₃W₃	1.14 (0.80)	1.05 (0.60)	1.09 (0.70)	1.04 (0.57)	1.05 (0.61)	1.04 (0.59)	1.18 (0.89)	1.15 (0.84)	1.17 (0.87)	1.03 (0.55)	1.03 (0.56)	1.03 (0.56)
P₃W₄	1.21 (0.97)	1.09 (0.69)	1.15 (0.83)	1.21 (0.96)	1.12 (0.76)	1.17 (0.86)	1.34 (1.30)	1.27 (1.12)	1.30 (1.21)	1.19 (0.92)	1.19 (0.91)	1.19 (0.91)
P₃W₅	1.57 (2.01)	1.54 (2.03)	1.56 (2.02)	1.09 (0.69)	1.09 (0.70)	1.09 (0.69)	1.22 (1.01)	1.18 (0.93)	1.20 (0.97)	1.05 (0.61)	1.05 (0.60)	1.05 (0.60)
P₃W₆	1.52 (1.81)	1.45 (1.61)	1.48 (1.71)	1.43 (1.55)	1.35 (1.33)	1.39 (1.44)	1.07 (0.64)	0.71 (0.00)	0.89 (0.32)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	1.68 (2.55)	1.67 (2.33)	1.67 (2.44)	1.84 (3.02)	1.71 (2.43)	1.77 (2.73)	2.04 (3.67)	2.19 (4.29)	2.11 (3.98)	1.63 (2.18)	1.56 (1.95)	1.60 (2.06)
SEm± (PxW)	0.10	0.09	0.07	0.08	0.07	0.05	0.09	0.10	0.07	0.04	0.06	0.04
SEm± (WxP)	0.07	0.07	0.05	0.06	0.05	0.04	0.07	0.06	0.05	0.06	0.06	0.04
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

the interaction effect of sowing dates and integrated weed management during both years, as presented in Table 4.35 (b).

4.2.3.5 Weed dry weight (g m^{-2}) of *Cyperus rotundus*

The data on the dry weight of *Cyperus rotundus* as influenced by sowing dates and integrated weed management recorded at 20, 40, and 60 DAS and harvest are presented in Table 4.36 (a) and Table 4.36 (b).

4.2.3.5.1 Effect of sowing dates on dry weight of *Cyperus rotundus*

An inquisition of two years' data and pooled values on weed biomass of *Cyperus rotundus* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly, the highest dry weight at all stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, the significantly lowest dry weight ($1.03, 1.05 \text{ g m}^{-2}$) was recorded on 15th June and was at par with 30th June in the first years. At 40 DAS, the sowing date of 15th June recorded the least dry weight ($0.91, 0.90 \text{ g m}^{-2}$) and was at par with the sowing date of 30th June in both years and pooled values. At 60 DAS, the pooled values revealed that sowing on 15th June recorded the least dry weight ($1.03, 0.99 \text{ g m}^{-2}$) and was at par with the sowing date of 30th June in the first year.

4.2.3.5.2 Effect of integrated weed management on the dry weight of *Cyperus rotundus*

Significant results were observed on the dry weight of *Cyperus rotundus* due to integrated weed management. Weedy check (W_7) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @ 1kg ha^{-1} fb imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS (W_3) recorded lowest weed dry weight ($0.97, 0.95 \text{ g m}^{-2}$). It was at par with W_4 (Pendimethalin 30EC @ 1kg ha^{-1} fb interculture at 30 DAS) in both years and pooled values.

Application of pendimethalin 30 EC @ 1kg ha^{-1} fb imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS (W_3) recorded significantly lowest dry weight ($0.88, 0.83 \text{ g m}^{-2}$) and was at par with treatments W_4 (Pendimethalin 30 EC @ 1kg ha^{-1} fb interculture at 30

Table 4.36(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m^{-2}) of *Cyperus rotundus* at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.03 (0.58)	1.05 (0.61)	1.04 (0.59)	0.91 (0.36)	0.90 (0.33)	0.90 (0.34)	1.03 (0.80)	0.99 (0.58)	1.01 (0.69)	0.97 (0.51)	0.93 (0.42)	0.95 (0.47)
P₂ 30th June	1.15 (0.84)	1.09 (0.69)	1.12 (0.76)	0.94 (0.42)	0.92 (0.37)	0.93 (0.40)	1.12 (1.00)	1.07 (0.77)	1.10 (0.89)	0.98 (0.52)	0.94 (0.43)	0.96 (0.48)
P₃ 15th July	1.22 (1.03)	1.16 (.089)	1.19 (0.96)	1.20 (0.96)	1.08 (0.72)	1.14 (0.84)	1.36 (1.51)	1.27 (1.28)	1.32 (1.39)	1.04 (0.63)	0.97 (0.48)	1.00 (0.56)
SEm$\pm$	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.01
CD at 5%	0.10	0.08	0.05	0.11	0.08	0.06	0.13	0.06	0.06	NS	NS	NS
Integrated weed Management (W)												
W₁	1.14 (0.80)	1.12 (0.75)	1.13 (0.77)	0.97 (0.46)	0.89 (0.31)	0.93 (0.38)	1.09 (0.78)	1.09 (0.71)	1.09 (0.74)	0.96 (0.42)	0.91 (0.33)	0.94 (0.38)
W₂	1.14 (0.80)	1.12 (0.76)	1.13 (0.78)	0.97 (0.48)	0.90 (0.32)	0.94 (0.40)	1.09 (0.72)	1.10 (0.72)	1.09 (0.72)	0.96 (0.43)	0.92 (0.35)	0.94 (0.39)
W₃	0.97 (0.44)	0.95 (0.40)	0.96 (0.42)	0.88 (0.29)	0.83 (0.19)	0.85 (0.24)	0.97 (0.47)	0.94 (0.40)	0.95 (0.43)	0.90 (0.31)	0.84 (0.21)	0.87 (0.26)
W₄	0.97 (0.45)	0.95 (0.41)	0.96 (0.43)	0.94 (0.41)	0.89 (0.29)	0.91 (0.35)	1.03 (0.59)	1.04 (0.60)	1.03 (0.59)	0.94 (0.38)	0.89 (0.30)	0.92 (0.34)
W₅	1.23 (1.09)	1.19 (0.93)	1.21 (1.01)	0.90 (0.32)	0.83 (0.20)	0.87 (0.26)	0.98 (0.49)	0.97 (0.45)	0.97 (0.47)	0.93 (0.36)	0.88 (0.27)	0.90 (0.31)
W₆	1.21 (0.98)	1.16 (0.85)	1.19 (0.92)	1.11 (0.76)	1.05 (0.60)	1.08 (0.68)	0.80 (0.17)	0.75 (0.07)	0.78 (0.12)	0.76 (0.09)	0.74 (0.05)	0.75 (0.07)
W₇	1.27 (1.13)	1.21 (1.01)	1.24 (1.07)	1.35 (1.35)	1.35 (1.40)	1.35 (1.38)	2.23 (4.52)	1.91 (3.19)	2.07 (3.86)	1.54 (1.90)	1.45 (1.61)	1.5 (1.76)
SEm$\pm$	0.05	0.06	0.04	0.03	0.04	0.03	0.05	0.04	0.03	0.03	0.03	0.02
CD at 5%	0.13	0.17	0.11	0.09	0.11	0.07	0.15	0.11	0.09	0.07	0.08	0.05

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.36(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Cyperus rotundus* at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.03 (0.57)	1.06 (0.62)	1.05 (0.59)	0.86 (0.24)	0.83 (0.18)	0.84 (0.21)	0.90 (0.32)	0.96 (0.42)	0.93 (0.37)	0.94 (0.38)	0.90 (0.32)	0.92 (0.35)
P₁W₂	1.03 (0.57)	1.06 (0.63)	1.05 (0.60)	0.86 (0.24)	0.83 (0.19)	0.85 (0.22)	0.93 (0.38)	0.97 (0.43)	0.95 (0.41)	0.94 (0.39)	0.92 (0.34)	0.93 (0.36)
P₁W₃	0.90 (0.32)	0.90 (0.32)	0.90 (0.32)	0.79 (0.12)	0.77 (0.10)	0.78 (0.11)	0.81 (0.16)	0.82 (0.17)	0.82 (0.17)	0.88 (0.27)	0.83 (0.19)	0.85 (0.23)
P₁W₄	0.91 (0.33)	0.91 (0.33)	0.91 (0.33)	0.83 (0.19)	0.82 (0.17)	0.83 (0.18)	0.87 (0.26)	0.90 (0.32)	0.89 (0.29)	0.91 (0.34)	0.88 (0.28)	0.90 (0.31)
P₁W₅	1.11 (0.74)	1.13 (0.79)	1.12 (0.76)	0.81 (0.15)	0.78 (0.11)	0.79 (0.13)	0.84 (0.21)	0.83 (0.19)	0.84 (0.20)	0.90 (0.31)	0.86 (0.24)	0.88 (0.28)
P₁W₆	1.10 (0.70)	1.11 (0.73)	1.10 (0.72)	1.01 (0.53)	0.98 (0.45)	1.00 (0.49)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.14 (0.81)	1.16 (0.85)	1.15 (0.83)	1.24 (1.03)	1.26 (1.09)	1.25 (1.06)	2.19 (4.29)	1.75 (2.55)	1.97 (3.42)	1.54 (1.91)	1.44 (1.59)	1.49 (1.75)
P₂W₁	1.16 (0.84)	1.10 (0.72)	1.13 (0.78)	0.87 (0.26)	0.85 (0.23)	0.86 (0.24)	1.05 (0.76)	1.05 (0.60)	1.05 (0.68)	0.94 (0.39)	0.91 (0.33)	0.93 (0.36)
P₂W₂	1.16 (0.84)	1.11 (0.73)	1.13 (0.78)	0.87 (0.26)	0.86 (0.24)	0.87 (0.25)	1.06 (0.63)	1.05 (0.61)	1.06 (0.62)	0.95 (0.40)	0.91 (0.34)	0.93 (0.37)
P₂W₃	0.97 (0.45)	0.94 (0.38)	0.95 (0.41)	0.80 (0.14)	0.79 (0.12)	0.79 (0.13)	0.92 (0.34)	0.88 (0.27)	0.90 (0.31)	0.88 (0.27)	0.82 (0.18)	0.85 (0.23)
P₂W₄	0.98 (0.46)	0.94 (0.39)	0.96 (0.43)	0.85 (0.22)	0.85 (0.22)	0.85 (0.22)	0.99 (0.48)	0.99 (0.49)	0.99 (0.49)	0.92 (0.34)	0.89 (0.29)	0.90 (0.32)
P₂W₅	1.25 (1.07)	1.17 (0.89)	1.21 (0.98)	0.81 (0.16)	0.79 (0.13)	0.80 (0.15)	0.93 (0.36)	0.92 (0.35)	0.92 (0.36)	0.91 (0.32)	0.88 (0.28)	0.89 (0.30)

P₂W₆	1.24 (1.04)	1.14 (0.81)	1.19 (0.92)	1.02 (0.55)	1.00 (0.51)	1.01 (0.53)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.76 (0.07)	0.71 (0.00)	0.73 (0.04)
P₂W₇	1.28 (1.15)	1.20 (0.94)	1.24 (1.04)	1.36 (1.38)	1.29 (1.17)	1.32 (1.27)	2.21 (4.43)	1.88 (3.08)	2.04 (3.76)	1.54 (1.88)	1.45 (1.61)	1.50 (1.75)
P₃W₁	1.22 (0.99)	1.19 (0.91)	1.20 (0.95)	1.18 (0.89)	1.00 (0.51)	1.09 (0.70)	1.33 (1.27)	1.26 (1.10)	1.30 (1.19)	1.00 (0.50)	0.92 (0.35)	0.96 (0.42)
P₃W₂	1.22 (0.99)	1.19 (0.92)	1.21 (0.96)	1.19 (0.92)	1.01 (0.52)	1.10 (0.72)	1.29 (1.16)	1.27 (1.11)	1.28 (1.14)	1.00 (0.50)	0.93 (0.36)	0.97 (0.43)
P₃W₃	1.02 (0.54)	1.00 (0.50)	1.01 (0.52)	1.04 (0.60)	0.92 (0.35)	0.98 (0.48)	1.17 (0.89)	1.11 (0.75)	1.14 (0.82)	0.95 (0.41)	0.87 (0.26)	0.91 (0.33)
P₃W₄	1.03 (0.57)	1.01 (0.52)	1.02 (0.54)	1.14 (0.81)	0.99 (0.49)	1.07 (0.65)	1.23 (1.02)	1.21 (0.98)	1.22 (1.00)	0.98 (0.46)	0.91 (0.33)	0.95 (0.40)
P₃W₅	1.33 (1.44)	1.26 (1.10)	1.30 (1.27)	1.07 (0.66)	0.93 (0.36)	1.00 (0.51)	1.17 (0.90)	1.15 (0.82)	1.16 (0.86)	0.97 (0.44)	0.89 (0.29)	0.93 (0.37)
P₃W₆	1.30 (1.20)	1.23 (1.01)	1.27 (1.11)	1.31 (1.21)	1.16 (0.84)	1.23 (1.03)	1.00 (0.50)	0.83 (0.22)	0.92 (0.36)	0.83 (0.19)	0.79 (0.15)	0.81 (0.17)
P₃W₇	1.39 (1.44)	1.27 (1.25)	1.33 (1.34)	1.45 (1.65)	1.51 (1.94)	1.48 (1.79)	2.31 (4.84)	2.09 (3.95)	2.20 (4.39)	1.54 (1.92)	1.45 (1.62)	1.50 (1.77)
SEm± (PxW)	0.08	0.07	0.05	0.06	0.07	0.04	0.09	0.07	0.06	0.04	0.05	0.03
SEm± (WxP)	0.05	0.05	0.04	0.05	0.05	0.04	0.07	0.04	0.04	0.05	0.04	0.03
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

DAS) and W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS *fb* interculture at 30 DAS) at 40 DAS in both years and pooled values.

But at 60 DAS and harvest, treatment W₆ (Hand weeding at 20 and 40 DAS) recorded significantly lowest dry weight (0.80, 0.75 g m⁻²), (0.76, 0.74 g m⁻²) in both years and pooled values followed by W₃ (Pendimethalin 30 EC @1kg ha⁻¹ *fb* imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both years.

4.2.3.5.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Cyperus rotundus*

The data on the dry weight of *Cyperus rotundus* presented in Table 4.36 (b) shows that the interaction effect of sowing dates and integrated weed management were found to be non-significant during both years.

4.2.3.6 Weed dry weight (g m⁻²) of *Ageratum conyzoides*

The data on dry weight of *Ageratum conyzoides* as influenced by sowing dates and integrated weed management recorded at 20, 40, and 60 DAS and harvest are presented in Table 4.37 (a) and Table 4.37 (b).

4.2.3.6.1 Effect of sowing dates on dry weight of *Ageratum conyzoides*

An examination of two years' data and pooled values on weed biomass of *Ageratum conyzoides* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly, the highest dry weight at all stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, the significantly lowest dry weight (0.97, 0.92 g m⁻²) was recorded on 15th June and was at par with 30th June in both years. At 40 DAS, the sowing date of 15th June recorded the least dry weight (0.89, 0.87 g m⁻²) and was at par with the sowing date of 30th June in both years. At 60 DAS, data revealed that sowing on 15th June recorded the least dry weight (1.09, 1.05 g m⁻²) and was at par with 30th June in both years.

4.2.3.6.2 Effect of integrated weed management on dry weight of *Ageratum conyzoides*

Table 4.37(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Ageratum conyzoides*. at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	0.97 (0.46)	0.92 (0.37)	0.95 (0.41)	0.89 (0.34)	0.87 (0.30)	3.20 (11.98)	5.55 (33.45)	5.12 (28.28)	5.34 (30.87)	4.69 (23.97)	4.39 (20.53)	4.54 (22.25)
P₂ 30th June	1.02 (0.56)	0.94 (0.40)	0.98 (0.48)	0.92 (0.39)	0.9 (0.36)	0.91 (0.37)	1.12 (0.81)	1.1 (0.77)	1.11 (0.79)	1.02 (0.50)	0.94 (0.44)	0.98 (0.47)
P₃ 15th July	1.13 (0.81)	1.11 (0.76)	1.12 (0.78)	1.03 (0.61)	0.98 (0.51)	1.01 (0.56)	1.28 (1.18)	1.23 (1.05)	1.25 (1.12)	0.99 (0.53)	0.95 (0.48)	0.97 (0.50)
SEm±	0.03	0.02	0.02	0.02	0.01	0.01	0.03	0.02	0.02	0.03	0.02	0.02
CD at 5%	0.10	0.09	0.06	0.09	0.05	0.04	0.11	0.09	0.06	NS	NS	NS
Integrated weed Management (W)												
W₁	0.98 (0.48)	0.95 (0.41)	0.97 (0.44)	0.88 (0.27)	0.84 (0.21)	0.86 (0.24)	1.13 (0.78)	1.11 (0.73)	1.12 (0.75)	1.00 (0.51)	0.96 (0.43)	0.98 (0.47)
W₂	1.03 (0.57)	0.97 (0.45)	1.00 (0.51)	0.89 (0.30)	0.85 (0.23)	0.87 (0.26)	1.22 (0.99)	1.18 (0.89)	1.20 (0.94)	1.10 (0.72)	1.03 (0.55)	1.06 (0.64)
W₃	0.85 (0.25)	0.86 (0.25)	0.86 (0.24)	0.83 (0.19)	0.80 (0.14)	0.81 (0.17)	1.02 (0.55)	0.99 (0.48)	1.00 (0.52)	0.81 (0.16)	0.77 (0.09)	0.79 (0.13)
W₄	0.87 (0.26)	0.88 (0.28)	0.87 (0.27)	0.86 (0.26)	0.83 (0.19)	0.85 (0.23)	1.11 (0.75)	1.10 (0.72)	1.11 (0.74)	0.92 (0.36)	0.87 (0.26)	0.90 (0.31)
W₅	1.19 (0.93)	1.07 (0.67)	1.13 (0.80)	0.85 (0.23)	0.82 (0.17)	0.83 (0.20)	1.05 (0.62)	1.01 (0.52)	1.03 (0.57)	0.83 (0.18)	0.83 (0.19)	0.83 (0.19)
W₆	1.12 (0.77)	1.02 (0.54)	1.07 (0.66)	0.91 (0.34)	0.88 (0.28)	0.90 (0.31)	0.99 (0.48)	0.97 (0.46)	0.98 (0.457)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	1.21 (1.01)	1.19 (0.95)	1.20 (0.98)	1.42 (1.54)	1.40 (1.47)	1.41 (1.51)	1.62 (2.17)	1.55 (1.96)	1.59 (2.06)	1.41 (1.52)	1.40 (1.50)	1.40 (1.51)
SEm±	0.04	0.03	0.03	0.04	0.02	0.02	0.04	0.04	0.03	0.03	0.03	0.02
CD at 5%	0.11	0.10	0.07	0.10	0.06	0.06	0.10	0.11	0.07	0.08	0.10	0.06

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.37(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Ageratum conyzoides* at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	0.91 (0.32)	0.88 (0.28)	0.90 (0.30)	0.96 (0.43)	0.89 (0.29)	0.93 (0.36)	1.06 (0.62)	1.04 (0.57)	1.05 (0.60)	0.98 (0.47)	0.97 (0.44)	0.98 (0.45)
P₁W₂	0.97 (0.44)	0.91 (0.32)	0.94 (0.38)	0.97 (0.44)	0.91 (0.32)	0.94 (0.38)	1.15 (0.82)	1.11 (0.73)	1.13 (0.77)	1.09 (0.68)	1.02 (0.55)	1.05 (0.61)
P₁W₃	0.80 (0.15)	0.79 (0.12)	0.80 (0.13)	0.90 (0.31)	0.85 (0.23)	0.88 (0.27)	0.93 (0.37)	0.90 (0.32)	0.92 (0.34)	0.80 (0.13)	0.75 (0.06)	0.77 (0.10)
P₁W₄	0.82 (0.18)	0.81 (0.16)	0.82 (0.17)	0.94 (0.41)	0.89 (0.29)	0.91 (0.35)	1.05 (0.61)	1.03 (0.57)	1.04 (0.59)	0.89 (0.30)	0.87 (0.25)	0.88 (0.28)
P₁W₅	1.12 (0.75)	0.99 (0.48)	1.05 (0.61)	0.93 (0.37)	0.88 (0.27)	0.90 (0.32)	0.97 (0.45)	0.93 (0.37)	0.95 (0.41)	0.81 (0.15)	0.82 (0.17)	0.81 (0.16)
P₁W₆	1.01 (0.52)	0.95 (0.41)	0.98 (0.47)	1.00 (0.49)	0.95 (0.41)	0.97 (0.45)	0.92 (0.35)	0.89 (0.30)	0.91 (0.32)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.16 (0.86)	1.14 (0.79)	1.15 (0.83)	1.53 (1.83)	1.49 (1.73)	1.51 (1.78)	1.55 (1.92)	1.47 (1.68)	1.51 (1.80)	1.36 (1.37)	1.29 (1.18)	1.33 (1.27)
P₂W₁	0.94 (0.39)	0.90 (0.31)	0.92 (0.35)	0.85 (0.22)	0.83 (0.19)	0.84 (0.21)	1.09 (0.70)	1.08 (0.66)	1.08 (0.68)	0.99 (0.48)	0.96 (0.43)	0.98 (0.45)
P₂W₂	1.00 (0.51)	0.91 (0.34)	0.96 (0.42)	0.86 (0.24)	0.84 (0.21)	0.85 (0.23)	1.18 (0.89)	1.15 (0.83)	1.16 (0.86)	1.08 (0.66)	1.04 (0.57)	1.06 (0.62)
P₂W₃	0.83 (0.20)	0.83 (0.19)	0.83 (0.19)	0.80 (0.13)	0.79 (0.13)	0.79 (0.13)	0.99 (0.50)	0.96 (0.43)	0.98 (0.46)	0.80 (0.15)	0.76 (0.08)	0.78 (0.11)
P₂W₄	0.85 (0.23)	0.84 (0.20)	0.85 (0.21)	0.83 (0.19)	0.82 (0.17)	0.82 (0.18)	1.06 (0.63)	1.07 (0.65)	1.06 (0.64)	0.92 (0.35)	0.87 (0.25)	0.90 (0.30)
P₂W₅	1.16 (0.85)	1.00 (0.49)	1.08 (0.67)	0.82 (0.17)	0.80 (0.14)	0.81 (0.15)	1.00 (0.52)	0.98 (0.46)	0.99 (0.49)	0.82 (0.17)	0.83 (0.19)	0.83 (0.18)

P₂W₆	1.12 (0.76)	0.96 (0.42)	1.04 (0.59)	0.88 (0.29)	0.87 (0.25)	0.87 (0.27)	0.95 (0.41)	0.95 (0.40)	0.95 (0.41)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	1.20 (0.96)	1.17 (0.88)	1.19 (0.92)	1.38 (1.45)	1.37 (1.40)	1.38 (1.43)	1.57 (2.01)	1.54 (1.95)	1.55 (1.98)	1.47 (1.71)	1.41 (1.54)	1.44 (1.62)
P₃W₁	1.10 (0.72)	1.06 (0.63)	1.08 (0.68)	0.82 (0.17)	0.80 (0.14)	0.81 (0.15)	1.23 (1.02)	1.21 (0.95)	1.22 (0.99)	1.03 (0.57)	0.95 (0.41)	0.99 (0.49)
P₃W₂	1.11 (0.76)	1.10 (0.70)	1.10 (0.73)	0.84 (0.20)	0.81 (0.15)	0.82 (0.18)	1.33 (1.27)	1.27 (1.12)	1.30 (1.19)	1.15 (0.82)	1.02 (0.54)	1.08 (0.68)
P₃W₃	0.92 (0.35)	0.97 (0.45)	0.95 (0.40)	0.78 (0.11)	0.76 (0.08)	0.77 (0.09)	1.14 (0.79)	1.09 (0.70)	1.11 (0.74)	0.84 (0.20)	0.80 (0.14)	0.82 (0.17)
P₃W₄	0.93 (0.38)	0.98 (0.47)	0.96 (0.42)	0.81 (0.16)	0.79 (0.12)	0.80 (0.14)	1.23 (1.01)	1.20 (0.95)	1.21 (0.98)	0.95 (0.41)	0.88 (0.27)	0.92 (0.34)
P₃W₅	1.30 (1.20)	1.23 (1.05)	1.26 (1.13)	0.80 (0.14)	0.78 (0.10)	0.79 (0.12)	1.17 (0.88)	1.11 (0.74)	1.14 (0.81)	0.85 (0.22)	0.84 (0.20)	0.84 (0.21)
P₃W₆	1.24 (1.04)	1.14 (0.79)	1.19 (0.92)	0.86 (0.23)	0.83 (0.19)	0.84 (0.21)	1.09 (0.69)	1.08 (0.67)	1.09 (0.68)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	1.27 (1.21)	1.26 (1.19)	1.27 (1.20)	1.34 (1.34)	1.34 (1.29)	1.34 (1.32)	1.75 (2.59)	1.63 (2.24)	1.69 (2.42)	1.40 (1.49)	1.48 (1.77)	1.44 (1.63)
SEm± (PxW)	0.06	0.06	0.04	0.06	0.04	0.04	0.06	0.07	0.05	0.05	0.06	0.04
SEm± (WxP)	0.05	0.05	0.03	0.05	0.03	0.03	0.05	0.05	0.04	0.05	0.05	0.03
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Variations in the dry weight of *Ageratum conyzoides* due to integrated weed management were also found to be significant. Weedy check (W₇) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded the lowest pooled value on weed dry weight of 0.85, 0.86 g m⁻². It was at par with W₄ (Pendimethalin 30EC @ 1kg ha⁻¹ fb interculture at 30 DAS) both years and pooled values followed by W₁ (Soil solarization with black polythene 25 DAS fb hand weeding at 30 DAS) during the second year.

At 40 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest pooled value of dry weight (0.83, 0.80 g m⁻²) and was at par with other treatments except W₆ (Hand weeding at 20 and 40 DAS) and W₇ (weedy check) in both year and pooled values.

At 60 DAS and harvest, W₆ (hand weeding at 20 and 40 DAS) recorded the lowest dry weight significantly. It was at par with W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) and W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS) in both years and pooled values.

4.2.3.6.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Ageratum conyzoides*

The data on the dry weight of *Ageratum conyzoides* presented in Table 4.37 (b) showed that the interaction effect of sowing dates and integrated weed management were found to be non-significant during both years.

4.2.3.7 Weed dry weight (g m⁻²) of *Amaranthus viridis*

The data on the dry weight of *Amaranthus viridis* influenced by sowing dates and integrated weed management recorded at 20, 40, and 60 DAS and harvest are presented in Table 4.38 (a) and Table 4.38 (b).

4.2.3.7.1 Effect of sowing dates on dry weight of *Amaranthus viridis*

An examination of two years' data and pooled values on weed biomass of *Amaranthus viridis* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly, the highest dry weight at all

stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, the significantly lowest dry weight (1.05, 1.01 g m⁻²) was recorded on 15th June and was at par with 30th June in both years. At 40 DAS, the sowing date of 15th June recorded the least dry weight (0.95, 0.93 g m⁻²) and was at par with the sowing date of 30th June in both years. At 60 DAS, data revealed that sowing on 15th June recorded the least dry weight (1.16, 1.07 g m⁻²).

4.2.3.7.2 Effect of integrated weed management on the dry weight of *Amaranthus viridis*

Significant results were observed on the dry weight of *Amaranthus viridis* due to integrated weed management. Weedy check (W₇) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded lowest weed dry weight (1.00, 0.95 g m⁻²). It was at par with W₄ (Pendimethalin 30EC @ 1kg ha⁻¹ fb interculture at 30 DAS) followed by W₁ (Soil solarization with black polythene 25 DAS fb hand weeding at 30 DAS) and W₂ (Mulching with paddy straw 5 t ha⁻¹ fb hand weeding at 30 DAS) in both years and pooled values.

At 40 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest dry weight (0.88, 0.85 g m⁻²) and was at par with treatment W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS) in both year and pooled values and W₁ (Soil solarization with black polythene 25 DAS fb hand weeding at 30 DAS) in both years.

At 60 DAS, hand weeding at 20 and 40 DAS (W₆) recorded significantly lowest dry weight (1.06, 1.00 g m⁻²) and was at par with W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both years and pooled values. At harvest, treatment W₆ (Hand weeding at 20 and 40 DAS) recorded lowest dry weight in both years and pooled values compared to others treatments.

4.2.3.7.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Amaranthus viridis*

Table 4.38(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Amaranthus viridis* at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.05 (0.63)	1.01 (0.56)	1.03 (0.60)	0.95 (0.45)	0.93 (0.40)	0.94 (0.43)	1.16 (0.93)	1.07 (0.70)	1.11 (0.81)	1.01 (0.57)	0.93 (0.40)	0.97 (0.49)
P₂ 30th June	1.13 (0.80)	1.06 (0.67)	1.10 (0.73)	1.04 (0.64)	0.99 (0.50)	1.01 (0.57)	1.30 (1.24)	1.25 (1.09)	1.27 (1.17)	1.03 (0.61)	0.95 (0.44)	0.99 (0.53)
P₃ 15th July	1.23 (1.03)	1.20 (0.96)	1.21 (1.00)	1.19 (0.94)	1.13 (0.85)	1.16 (0.89)	1.46 (1.70)	1.34 (1.35)	1.40 (1.52)	1.06 (0.65)	0.96 (0.46)	1.01 (0.55)
SEm±	0.03	0.03	0.02	0.03	0.02	0.02	0.03	0.03	0.02	0.03	0.02	0.02
CD at 5%	0.11	0.11	0.06	0.10	0.10	0.06	0.12	0.13	0.07	NS	NS	NS
Integrated weed Management (W)												
W₁	1.05 (0.62)	1.03 (0.59)	1.04 (0.60)	0.98 (0.47)	0.95 (0.42)	0.96 (0.44)	1.34 (1.31)	1.26 (1.12)	1.30 (1.21)	1.07 (0.65)	0.98 (0.46)	1.02 (0.55)
W₂	1.06 (0.64)	1.02 (0.56)	1.04 (0.60)	1.03 (0.59)	0.97 (0.44)	1.00 (0.51)	1.40 (1.47)	1.30 (1.21)	1.35 (1.34)	1.10 (0.70)	1.00 (0.50)	1.05 (0.60)
W₃	1.00 (0.51)	0.95 (0.44)	0.98 (0.47)	0.88 (0.29)	0.85 (0.23)	0.87 (0.26)	1.08 (0.70)	1.01 (0.53)	1.04 (0.61)	0.92 (0.34)	0.83 (0.19)	0.87 (0.27)
W₄	1.04 (0.58)	1.00 (0.50)	1.02 (0.54)	0.99 (0.49)	0.94 (0.40)	0.97 (0.44)	1.28 (1.16)	1.25 (1.08)	1.27 (1.12)	1.06 (0.62)	0.93 (0.37)	0.99 (0.49)
W₅	1.25 (1.09)	1.23 (1.03)	1.24 (1.06)	0.93 (0.37)	0.91 (0.33)	0.92 (0.35)	1.21 (0.98)	1.10 (0.72)	1.15 (0.85)	0.99 (0.48)	0.86 (0.24)	0.92 (0.36)
W₆	1.18 (0.90)	1.09 (0.70)	1.14 (0.80)	1.11 (0.75)	1.05 (0.62)	1.08 (0.68)	1.06 (0.65)	1.00 (0.51)	1.03 (0.58)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	1.37 (1.40)	1.33 (1.29)	1.35 (1.35)	1.50 (1.79)	1.44 (1.65)	1.47 (1.72)	1.78 (2.77)	1.60 (2.16)	1.69 (2.47)	1.38 (1.44)	1.32 (1.28)	1.35 (1.36)
SEm±	0.04	0.05	0.03	0.04	0.04	0.03	0.05	0.05	0.03	0.03	0.03	0.02
CD at 5%	0.11	0.14	0.09	0.12	0.11	0.08	0.14	0.14	0.10	0.08	0.10	0.06

: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.38(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Amaranthus viridis* L. at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	0.96 (0.42)	0.94 (0.40)	0.95 (0.41)	0.89 (0.29)	0.87 (0.27)	0.88 (0.28)	1.19 (0.92)	1.10 (0.71)	1.15 (0.82)	1.03 (0.57)	0.97 (0.43)	1.00 (0.50)
P₁W₂	0.97 (0.44)	0.94 (0.38)	0.95 (0.41)	0.91 (0.34)	0.89 (0.29)	0.90 (0.31)	1.26 (1.08)	1.15 (0.82)	1.20 (0.95)	1.08 (0.67)	0.99 (0.47)	1.03 (0.57)
P₁W₃	0.90 (0.31)	0.83 (0.20)	0.87 (0.25)	0.78 (0.10)	0.77 (0.09)	0.77 (0.10)	0.89 (0.30)	0.87 (0.25)	0.88 (0.28)	0.87 (0.26)	0.81 (0.15)	0.84 (0.20)
P₁W₄	0.94 (0.39)	0.92 (0.35)	0.93 (0.37)	0.87 (0.26)	0.86 (0.25)	0.87 (0.26)	1.13 (0.77)	1.09 (0.69)	1.11 (0.73)	1.02 (0.54)	0.92 (0.34)	0.97 (0.44)
P₁W₅	1.16 (0.86)	1.16 (0.86)	1.16 (0.86)	0.82 (0.17)	0.83 (0.19)	0.82 (0.18)	1.04 (0.59)	0.94 (0.38)	0.99 (0.49)	0.95 (0.41)	0.83 (0.20)	0.89 (0.30)
P₁W₆	1.10 (0.70)	1.03 (0.56)	1.06 (0.63)	1.00 (0.50)	0.98 (0.45)	0.99 (0.48)	0.87 (0.26)	0.86 (0.25)	0.87 (0.25)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.31 (1.31)	1.28 (1.15)	1.30 (1.23)	1.40 (1.51)	1.32 (1.28)	1.36 (1.40)	1.72 (2.59)	1.47 (1.78)	1.59 (2.19)	1.40 (1.45)	1.30 (1.23)	1.35 (1.34)
P₂W₁	1.05 (0.60)	0.98 (0.48)	1.01 (0.54)	0.91 (0.34)	0.93 (0.37)	0.92 (0.35)	1.34 (1.28)	1.29 (1.16)	1.31 (1.22)	1.07 (0.64)	0.98 (0.46)	1.02 (0.55)
P₂W₂	1.06 (0.62)	0.96 (0.42)	1.01 (0.52)	1.03 (0.56)	0.94 (0.39)	0.99 (0.48)	1.39 (1.44)	1.32 (1.25)	1.36 (1.35)	1.08 (0.67)	1.00 (0.50)	1.04 (0.59)
P₂W₃	1.00 (0.49)	0.96 (0.44)	0.98 (0.47)	0.86 (0.26)	0.83 (0.19)	0.85 (0.22)	1.08 (0.66)	1.04 (0.58)	1.06 (0.62)	0.90 (0.31)	0.82 (0.18)	0.86 (0.25)
P₂W₄	1.04 (0.57)	0.97 (0.44)	1.00 (0.51)	0.98 (0.47)	0.92 (0.35)	0.95 (0.41)	1.28 (1.14)	1.27 (1.13)	1.28 (1.13)	1.05 (0.61)	0.92 (0.34)	0.99 (0.48)
P₂W₅	1.24 (1.04)	1.22 (1.00)	1.23 (1.02)	0.92 (0.34)	0.89 (0.29)	0.90 (0.31)	1.21 (0.95)	1.12 (0.76)	1.16 (0.86)	0.98 (0.46)	0.85 (0.23)	0.92 (0.34)

P₂W₆	1.18 (0.89)	1.07 (0.64)	1.12 (0.77)	1.10 (0.71)	1.03 (0.56)	1.06 (0.63)	1.06 (0.63)	1.03 (0.56)	1.04 (0.59)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	1.36 (1.35)	1.30 (1.24)	1.33 (1.30)	1.49 (1.81)	1.36 (1.34)	1.42 (1.57)	1.74 (2.60)	1.65 (2.23)	1.70 (2.41)	1.41 (1.56)	1.34 (1.37)	1.37 (1.47)
P₃W₁	1.15 (0.83)	1.17 (0.89)	1.16 (0.86)	1.13 (0.77)	1.06 (0.62)	1.09 (0.69)	1.49 (1.72)	1.40 (1.48)	1.45 (1.60)	1.11 (0.73)	1.00 (0.49)	1.05 (0.61)
P₃W₂	1.16 (0.85)	1.17 (0.87)	1.16 (0.86)	1.17 (0.87)	1.07 (0.64)	1.12 (0.75)	1.54 (1.89)	1.43 (1.56)	1.49 (1.72)	1.13 (0.77)	1.02 (0.54)	1.07 (0.65)
P₃W₃	1.10 (0.72)	1.08 (0.68)	1.09 (0.70)	1.01 (0.52)	0.96 (0.42)	0.98 (0.47)	1.27 (1.13)	1.11 (0.75)	1.19 (0.94)	0.98 (0.46)	0.86 (0.24)	0.92 (0.35)
P₃W₄	1.13 (0.77)	1.09 (0.72)	1.11 (0.74)	1.11 (0.74)	1.04 (0.59)	1.08 (0.66)	1.44 (1.57)	1.39 (1.43)	1.41 (1.50)	1.10 (0.71)	0.95 (0.41)	1.03 (0.56)
P₃W₅	1.35 (1.38)	1.31 (1.22)	1.33 (1.30)	1.05 (0.60)	1.01 (0.52)	1.03 (0.56)	1.37 (1.38)	1.23 (1.02)	1.30 (1.20)	1.03 (0.56)	0.88 (0.28)	0.96 (0.42)
P₃W₆	1.27 (1.11)	1.19 (0.91)	1.23 (1.01)	1.24 (1.04)	1.16 (0.84)	1.20 (0.94)	1.25 (1.07)	1.11 (0.74)	1.18 (0.90)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	1.43 (1.55)	1.40 (1.46)	1.42 (1.51)	1.59 (2.05)	1.64 (2.32)	1.62 (2.18)	1.89 (3.13)	1.69 (2.47)	1.79 (2.80)	1.34 (1.30)	1.31 (1.24)	1.32 (1.27)
SEm± (PxW)	0.07	0.08	0.05	0.07	0.07	0.05	0.09	0.08	0.06	0.05	0.06	0.04
SEm± (WxP)	0.05	0.06	0.04	0.05	0.05	0.04	0.06	0.07	0.05	0.05	0.05	0.04
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

The study found no significant effect on the dry weight of *Amaranthus viridis* as presented in Table 4.38 (b) due to the interaction effect of sowing dates and integrated weed management during both years.

4.2.3.8 Weed dry weight (g m^{-2}) of *Borreria latifolia*

The data on the dry weight of *Borreria latifolia* influenced by sowing dates and integrated weed management recorded at 20, 40, and 60 DAS and harvest are presented in Table 4.39 (a) and Table 4.39 (b).

4.2.3.8.1 Effect of sowing dates on the dry weight of *Borreria latifolia*

An examination of two years' data and pooled values on weed biomass of *Borreria latifolia* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly, the highest dry weight at all stages of observations was recorded on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, the significantly lowest dry weight ($0.90, 0.85 \text{ g m}^{-2}$) was recorded on the sowing date of 15th June and was at par with 30th June in both years and pooled values. At 40 DAS, the sowing date of 15th June recorded the least dry weight ($0.87, 0.85 \text{ g m}^{-2}$) and was at par with the sowing date of 30th June in both years. At 60 DAS, data revealed that sowing on 15th June recorded the least dry weight ($2.31, 2.14 \text{ g m}^{-2}$) in both year and pooled values.

4.2.3.8.2 Effect of integrated weed management on the dry weight of *Borreria latifolia*

Variations in dry weight of *Borreria latifolia* due to integrated weed management were also found to be significant. Weedy check (W_7) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @ 1kg ha^{-1} fb imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS (W_3) recorded lowest weed dry weight ($0.79, 0.78 \text{ g m}^{-2}$). It was at par with W_4 (Pendimethalin 30EC @ 1kg ha^{-1} fb interculture at 30 DAS) in both years and pooled values.

At 40 DAS, application of pendimethalin 30 EC @ 1kg ha^{-1} fb imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS (W_3) recorded significantly lowest dry weight ($0.83, 0.79$

g m⁻²) and was at par with treatments W₄ (Pendimethalin 30EC @ 1kg ha⁻¹ fb interculture at 30 DAS), W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS) in both years and pooled values and W₁ (Soil solarization with black polythene 25 DAS fb hand weeding at 30 DAS) in both years.

At 60 DAS, hand weeding at 20 and 40 DAS (W₆) recorded significantly lowest dry weight (1.73, 1.41 g m⁻²) and was at par with W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) only in the first year.

At harvest, lowest dry weight of *Borreria latifolia* was recorded with hand weeding at 20 and 40 DAS (W₆) and this was par with treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both years and pooled values.

4.2.3.8.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Borreria latifolia*

The data on the dry weight of *Borreria latifolia* presented in Table 4.39 (b) showed that the interaction effect of sowing dates and integrated weed management were found to be non-significant during both years.

4.2.3.9 Weed dry weight (g m⁻²) of *Cleome rutidosperma*

The data on dry weight of *Cleome rutidosperma* influenced by sowing dates and integrated weed management recorded at 20, 40, 60 DAS and harvest are presented in Table 4.40 (a) and Table 4.40 (b).

4.2.3.9.1 Effect of sowing dates on dry weight of *Cleome rutidosperma*

A scrutiny of two years' data and pooled values on weed biomass of *Cleome rutidosperma* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly, the highest dry weight at all stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, the significantly lowest dry weight (0.87, 0.87 g m⁻²) was recorded on 15th June compared to the 30th June and 15th July sowing dates in both years and pooled values. At 40 DAS, the sowing date of 15th June recorded the least dry weight (0.83, 0.82 g m⁻²) and was at par with the sowing date of 30th June in both years. At 60

Table 4.39(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Borreria latifolia* at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	0.90 (0.34)	0.85 (0.23)	0.88 (0.28)	0.87 (0.27)	0.85 (0.24)	0.86 (0.25)	2.31 (5.55)	2.14 (4.57)	2.23 (5.06)	1.85 (3.56)	1.78 (3.15)	1.81 (3.36)
P₂ 30th June	0.93 (0.39)	0.92 (0.36)	0.93 (0.38)	0.94 (0.40)	0.91 (0.35)	0.93 (0.37)	2.67 (7.23)	2.38 (5.56)	2.52 (6.40)	1.90 (3.76)	1.83 (3.37)	1.86 (3.57)
P₃ 15th July	1.05 (0.63)	1.00 (0.52)	1.02 (0.57)	1.04 (0.61)	1.01 (0.56)	1.02 (0.58)	2.90 (8.48)	2.65 (7.10)	2.77 (7.79)	1.92 (3.83)	1.84 (3.47)	1.88 (3.65)
SEm±	0.02	0.02	0.02	0.02	0.02	0.01	0.06	0.06	0.04	0.06	0.05	0.04
CD at 5%	0.09	0.08	0.05	0.07	0.09	0.05	0.24	0.22	0.14	NS	NS	NS
Integrated weed Management (W)												
W₁	0.98 (0.48)	0.90 (0.31)	0.94 (0.39)	0.92 (0.35)	0.89 (0.31)	0.91 (0.33)	2.98 (8.45)	2.65 (6.61)	2.82 (7.53)	1.92 (3.20)	1.87 (3.00)	1.90 (3.10)
W₂	0.98 (0.47)	0.91 (0.33)	0.94 (0.40)	0.94 (0.39)	0.93 (0.37)	0.93 (0.38)	3.12 (9.29)	2.99 (8.52)	3.05 (8.91)	2.10 (3.91)	2.01 (3.54)	2.05 (3.73)
W₃	0.79 (0.13)	0.78 (0.11)	0.78 (0.12)	0.83 (0.19)	0.79 (0.13)	0.81 (0.16)	1.89 (3.19)	1.91 (3.19)	1.90 (3.19)	1.27 (1.11)	1.19 (.95)	1.23 (1.03)
W₄	0.80 (0.15)	0.81 (0.15)	0.81 (0.15)	0.90 (0.31)	0.87 (0.26)	0.89 (0.29)	2.33 (4.98)	2.30 (4.87)	2.31 (4.92)	1.71 (2.43)	1.64 (2.20)	1.68 (2.32)
W₅	1.05 (0.62)	1.00 (0.53)	1.03 (0.58)	0.85 (0.22)	0.81 (0.16)	0.83 (0.19)	2.22 (4.52)	1.98 (3.46)	2.10 (3.99)	1.52 (1.81)	1.47 (1.67)	1.49 (1.74)
W₆	1.05 (0.61)	0.96 (0.44)	1.01 (0.53)	0.99 (0.49)	0.98 (0.48)	0.99 (0.49)	1.73 (2.60)	1.41 (1.55)	1.57 (2.08)	1.11 (0.75)	1.09 (0.70)	1.10 (0.72)
W₇	1.08 (0.71)	1.09 (0.73)	1.09 (0.72)	1.21 (1.01)	1.19 (0.97)	1.2 (0.99)	4.09 (16.58)	3.49 (11.99)	3.79 (14.29)	3.62 (12.82)	3.41 (11.25)	3.51 (12.04)
SEm±	0.16	0.14	0.10	0.03	0.04	0.03	0.10	0.10	0.07	0.08	0.05	0.05
CD at 5%	0.46	0.39	0.30	0.10	0.11	0.07	0.28	0.29	0.20	0.24	0.16	0.14

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.39(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Borreria latifolia* at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	0.90 (0.30)	0.84 (0.20)	0.87 (0.25)	0.84 (0.20)	0.82 (0.17)	0.83 (0.18)	2.73 (7.02)	2.36 (5.08)	2.54 (6.05)	1.89 (3.10)	1.82 (2.81)	1.86 (2.95)
P₁W₂	0.93 (0.37)	0.84 (0.21)	0.88 (0.29)	0.85 (0.22)	0.83 (0.19)	0.84 (0.20)	2.93 (8.09)	2.66 (6.59)	2.79 (7.34)	2.06 (3.78)	2.00 (3.48)	2.03 (3.63)
P₁W₃	0.73 (0.03)	0.73 (0.04)	0.73 (0.04)	0.79 (0.13)	0.77 (0.10)	0.78 (0.12)	1.49 (1.74)	1.68 (2.32)	1.58 (2.03)	1.24 (1.04)	1.26 (1.10)	1.25 (1.07)
P₁W₄	0.75 (0.07)	0.78 (0.11)	0.77 (0.09)	0.82 (0.17)	0.81 (0.16)	0.81 (0.17)	2.01 (3.55)	2.07 (3.90)	2.04 (3.72)	1.69 (2.35)	1.62 (2.14)	1.66 (2.25)
P₁W₅	0.99 (0.49)	0.90 (0.31)	0.95 (0.40)	0.78 (0.11)	0.78 (0.11)	0.78 (0.11)	1.85 (2.94)	1.78 (2.67)	1.81 (2.80)	1.50 (1.74)	1.39 (1.44)	1.44 (1.59)
P₁W₆	1.00 (0.49)	0.87 (0.26)	0.93 (0.37)	0.90 (0.31)	0.87 (0.25)	0.88 (0.28)	1.35 (1.34)	1.26 (1.08)	1.31 (1.21)	1.03 (0.56)	1.03 (0.56)	1.03 (0.56)
P₁W₇	1.04 (0.62)	0.98 (0.48)	1.01 (0.55)	1.11 (0.74)	1.10 (0.70)	1.10 (0.72)	3.79 (14.14)	3.21 (10.36)	3.50 (12.25)	3.57 (12.39)	3.31 (10.50)	3.44 (11.45)
P₂W₁	0.93 (0.36)	0.89 (0.30)	0.91 (0.33)	0.90 (0.31)	0.88 (0.27)	0.89 (0.29)	2.99 (8.47)	2.69 (6.79)	2.84 (7.63)	1.94 (3.28)	1.91 (3.15)	1.93 (3.21)
P₂W₂	0.96 (0.42)	0.90 (0.31)	0.93 (0.36)	0.92 (0.34)	0.91 (0.34)	0.92 (0.34)	3.19 (9.67)	3.00 (8.50)	3.09 (9.09)	2.11 (4.01)	2.03 (3.63)	2.07 (3.82)
P₂W₃	0.77 (0.09)	0.78 (0.11)	0.78 (0.10)	0.81 (0.16)	0.80 (0.14)	0.81 (0.15)	1.95 (3.31)	1.94 (3.26)	1.94 (3.28)	1.25 (1.06)	1.18 (0.89)	1.21 (0.97)
P₂W₄	0.77 (0.10)	0.80 (0.14)	0.79 (0.12)	0.88 (0.28)	0.85 (0.22)	0.87 (0.25)	2.36 (5.08)	2.28 (4.72)	2.32 (4.90)	1.72 (2.46)	1.66 (2.25)	1.69 (2.36)
P₂W₅	1.03 (0.56)	1.00 (0.50)	1.01 (0.53)	0.83 (0.20)	0.82 (0.17)	0.83 (0.18)	2.25 (4.58)	1.97 (3.41)	2.11 (4.00)	1.51 (1.80)	1.52 (1.80)	1.52 (1.80)

P₂W₆	1.02 (0.55)	0.95 (0.40)	0.99 (0.47)	0.98 (0.45)	0.96 (0.43)	0.97 (0.44)	1.75 (2.58)	1.41 (1.49)	1.58 (2.03)	1.10 (0.70)	1.10 (0.72)	1.10 (0.71)
P₂W₇	1.06 (0.68)	1.11 (0.77)	1.08 (0.72)	1.24 (1.03)	1.18 (0.88)	1.21 (0.96)	4.16 (16.95)	3.35 (10.75)	3.76 (13.85)	3.65 (13.00)	3.39 (11.17)	3.52 (12.08)
P₃W₁	1.12 (0.77)	0.96 (0.43)	1.04 (0.60)	1.02 (0.55)	0.99 (0.48)	1.01 (0.52)	3.22 (9.85)	2.91 (7.97)	3.06 (8.91)	1.93 (3.23)	1.88 (3.05)	1.91 (3.14)
P₃W₂	1.06 (0.62)	0.98 (0.46)	1.02 (0.54)	1.05 (0.59)	1.04 (0.59)	1.04 (0.59)	3.25 (10.10)	3.31 (10.48)	3.28 (10.29)	2.11 (3.95)	2.00 (3.50)	2.05 (3.73)
P₃W₃	0.87 (0.27)	0.82 (0.18)	0.84 (0.22)	0.89 (0.28)	0.81 (0.15)	0.85 (0.22)	2.24 (4.52)	2.11 (4.00)	2.18 (4.26)	1.31 (1.23)	1.13 (0.86)	1.22 (1.04)
P₃W₄	0.88 (0.29)	0.84 (0.21)	0.86 (0.25)	0.99 (0.49)	0.95 (0.41)	0.97 (0.45)	2.61 (6.31)	2.54 (5.99)	2.57 (6.15)	1.72 (2.47)	1.65 (2.22)	1.69 (2.34)
P₃W₅	1.14 (0.81)	1.11 (0.78)	1.13 (0.79)	0.92 (0.35)	0.84 (0.21)	0.88 (0.28)	2.56 (6.04)	2.18 (4.31)	2.37 (5.18)	1.54 (1.88)	1.51 (1.77)	1.52 (1.83)
P₃W₆	1.14 (0.79)	1.08 (0.66)	1.11 (0.73)	1.10 (0.72)	1.11 (0.75)	1.11 (0.73)	2.09 (3.89)	1.57 (2.09)	1.83 (2.99)	1.22 (0.99)	1.15 (0.81)	1.18 (0.90)
P₃W₇	1.15 (0.83)	1.18 (0.94)	1.17 (0.88)	1.28 (1.26)	1.29 (1.32)	1.29 (1.29)	4.32 (18.65)	3.92 (14.87)	4.12 (16.76)	3.63 (13.08)	3.54 (12.08)	3.58 (12.58)
SEm± (P×W)	0.07	0.06	0.04	0.06	0.06	0.04	0.17	0.18	0.12	0.15	0.09	0.09
SEm± (W×P)	0.05	0.04	0.03	0.04	0.05	0.03	0.13	0.12	0.09	0.12	0.10	0.08
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

DAS, data revealed that sowing on 15th June recorded the least dry weight (0.97, 0.95 g m⁻²) in both years and pooled values.

4.2.3.9.2 Effect of integrated weed management on the dry weight of *Cleome rutidosperma*

Differences in dry weight of *Cleome rutidosperma* due to integrated weed management were also found to be significant. Weedy check (W₇) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded lowest weed dry weight (0.84, 0.80 g m⁻²). It was at par with W₄ (Pendimethalin 30EC @ 1kg ha⁻¹ fb interculture at 30 DAS) in both years and pooled values.

At 40 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest dry weight (0.81, 0.78 g m⁻²), and was at par with other treatments in both years and pooled values except W₆ (Hand weeding at 20 and 40 DAS) and W₇ (Weedy check) in both years.

At 60 DAS, hand weeding at 20 and 40 DAS (W₆) recorded significantly lowest dry weight (0.86, 0.83 g m⁻²). This treatment was at par with W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both years and pooled values and also at par with treatment W₅ in the second year only. At harvest, treatments W₆ recorded significantly lower dry weight (0.71, 0.71 g m⁻²). and was at par with treatment W₃ in the first year.

4.2.3.9.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Cleome rutidosperma*

The data on the dry weight of *Cleome rutidosperma* presented in Table 4.40 (b) shows that the interaction effect of sowing dates and integrated weed management were found to be non-significant during both years.

4.2.3.10 Weed dry weight (g m⁻²) of *Mimosa pudica*

The data on the dry weight of *Mimosa pudica* influenced by sowing dates and integrated weed management recorded at 20, 40, and 60 DAS and harvest are presented in Table 4.41 (a) and Table 4.41 (b).

Table 4.40(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Cleome rutidosperma* at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	0.87 (0.26)	0.87 (0.27)	0.87 (0.26)	0.83 (0.21)	0.82 (0.19)	0.82 (0.20)	0.97 (0.48)	0.94 (0.43)	0.95 (0.45)	0.89 (0.32)	0.85 (0.25)	0.87 (0.28)
P₂ 30th June	0.99 (0.48)	0.97 (0.48)	0.98 (0.48)	0.92 (0.36)	0.89 (0.31)	0.90 (0.34)	1.01 (0.56)	1.00 (0.54)	1.01 (0.55)	0.90 (0.34)	0.87 (0.29)	0.89 (0.32)
P₃ 15th July	1.13 (0.81)	1.00 (0.52)	1.06 (0.66)	1.05 (0.65)	0.94 (0.42)	0.99 (0.53)	1.19 (0.96)	1.10 (0.75)	1.15 (0.86)	0.92 (0.38)	0.88 (0.30)	0.90 (0.34)
SEm±	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01
CD at 5%	0.09	0.06	0.04	0.06	0.07	0.04	0.08	0.08	0.05	NS	NS	NS
Integrated weed Management (W)												
W₁	0.95 (0.41)	0.87 (0.25)	0.91 (0.33)	0.89 (0.30)	0.83 (0.19)	0.86 (0.25)	1.07 (0.65)	1.02 (0.55)	1.05 (0.60)	0.93 (0.37)	0.88 (0.27)	0.91 (0.32)
W₂	0.98 (0.48)	0.88 (0.28)	0.93 (0.38)	0.90 (0.32)	0.84 (0.21)	0.87 (0.27)	1.15 (0.84)	1.06 (0.63)	1.11 (0.73)	0.99 (0.48)	0.92 (0.34)	0.95 (0.41)
W₃	0.84 (0.21)	0.80 (0.14)	0.82 (0.17)	0.81 (0.15)	0.78 (0.10)	0.79 (0.13)	0.91 (0.33)	0.88 (0.27)	0.89 (0.30)	0.78 (0.12)	0.76 (0.08)	0.77 (0.10)
W₄	0.92 (0.35)	0.79 (0.13)	0.86 (0.24)	0.86 (0.25)	0.82 (0.17)	0.84 (0.21)	1.02 (0.54)	1.00 (0.51)	1.01 (0.53)	0.89 (0.30)	0.87 (0.25)	0.88 (0.28)
W₅	1.08 (0.72)	1.16 (0.87)	1.12 (0.79)	0.83 (0.19)	0.8 (0.14)	0.81 (0.16)	0.99 (0.49)	0.89 (0.29)	0.94 (0.39)	0.80 (0.15)	0.79 (0.13)	0.80 (0.14)
W₆	1.08 (0.68)	0.92 (0.34)	1.00 (0.51)	0.94 (0.40)	0.87 (0.27)	0.91 (0.33)	0.86 (0.25)	0.83 (0.20)	0.85 (0.23)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	1.11 (0.76)	1.21 (0.97)	1.16 (0.86)	1.29 (1.23)	1.24 (1.07)	1.27 (1.15)	1.42 (1.57)	1.41 (1.56)	1.42 (1.56)	1.22 (1.01)	1.16 (0.88)	1.19 (0.94)
SEm±	0.04	0.03	0.02	0.04	0.02	0.02	0.06	0.08	0.05	0.03	0.02	0.02
CD at 5%	0.11	0.07	0.06	0.12	0.06	0.07	0.19	0.23	0.15	0.08	0.07	0.05

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.40(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Cleome rutidosperma*.at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	0.83 (0.19)	0.81 (0.15)	0.82 (0.17)	0.77 (0.09)	0.76 (0.08)	0.77 (0.09)	0.98 (0.45)	0.93 (0.36)	0.95 (0.41)	0.91 (0.32)	0.84 (0.21)	0.87 (0.26)
P₁W₂	0.85 (0.22)	0.82 (0.18)	0.83 (0.20)	0.78 (0.10)	0.77 (0.09)	0.77 (0.09)	1.06 (0.62)	0.97 (0.44)	1.01 (0.53)	0.97 (0.44)	0.88 (0.28)	0.93 (0.36)
P₁W₃	0.78 (0.12)	0.75 (0.06)	0.77 (0.09)	0.74 (0.04)	0.73 (0.04)	0.73 (0.04)	0.82 (0.18)	0.81 (0.16)	0.82 (0.17)	0.78 (0.12)	0.75 (0.07)	0.77 (0.09)
P₁W₄	0.82 (0.17)	0.76 (0.07)	0.79 (0.12)	0.76 (0.08)	0.76 (0.07)	0.76 (0.08)	0.93 (0.37)	0.91 (0.33)	0.92 (0.35)	0.87 (0.26)	0.84 (0.20)	0.85 (0.23)
P₁W₅	0.93 (0.36)	1.04 (0.57)	0.98 (0.47)	0.75 (0.06)	0.75 (0.07)	0.75 (0.06)	0.91 (0.32)	0.82 (0.18)	0.87 (0.25)	0.80 (0.14)	0.77 (0.10)	0.79 (0.12)
P₁W₆	0.92 (0.34)	0.85 (0.22)	0.88 (0.28)	0.82 (0.17)	0.77 (0.09)	0.79 (0.13)	0.79 (0.13)	0.79 (0.12)	0.79 (0.13)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	0.94 (0.39)	1.07 (0.66)	1.01 (0.52)	1.20 (0.94)	1.18 (0.89)	1.19 (0.92)	1.31 (1.26)	1.33 (1.41)	1.32 (1.34)	1.20 (0.95)	1.17 (0.90)	1.18 (0.92)
P₂W₁	0.95 (0.39)	0.88 (0.28)	0.91 (0.34)	0.85 (0.23)	0.83 (0.19)	0.84 (0.21)	1.03 (0.56)	1.00 (0.51)	1.02 (0.53)	0.94 (0.38)	0.90 (0.30)	0.92 (0.34)
P₂W₂	0.98 (0.46)	0.89 (0.30)	0.94 (0.38)	0.86 (0.24)	0.84 (0.21)	0.85 (0.23)	1.10 (0.71)	1.04 (0.59)	1.07 (0.65)	0.99 (0.49)	0.92 (0.35)	0.96 (0.42)
P₂W₃	0.82 (0.18)	0.83 (0.18)	0.82 (0.18)	0.81 (0.16)	0.77 (0.09)	0.79 (0.13)	0.87 (0.27)	0.86 (0.24)	0.87 (0.25)	0.79 (0.12)	0.76 (0.07)	0.77 (0.10)
P₂W₄	0.92 (0.34)	0.79 (0.13)	0.86 (0.24)	0.85 (0.23)	0.82 (0.18)	0.84 (0.20)	0.97 (0.44)	0.99 (0.47)	0.98 (0.46)	0.89 (0.29)	0.88 (0.27)	0.88 (0.28)
P₂W₅	1.07 (0.65)	1.21 (1.01)	1.14 (0.83)	0.84 (0.20)	0.81 (0.16)	0.83 (0.18)	0.94 (0.39)	0.87 (0.26)	0.91 (0.33)	0.79 (0.13)	0.79 (0.12)	0.79 (0.13)

P₂W₆	1.07 (0.64)	0.93 (0.36)	1.00 (0.50)	0.90 (0.32)	0.88 (0.27)	0.89 (0.29)	0.83 (0.19)	0.82 (0.17)	0.82 (0.18)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	1.10 (0.71)	1.27 (1.12)	1.19 (0.91)	1.29 (1.17)	1.25 (1.05)	1.27 (1.11)	1.35 (1.39)	1.42 (1.51)	1.39 (1.45)	1.21 (0.99)	1.16 (0.88)	1.19 (0.94)
P₃W₁	1.07 (0.64)	0.91 (0.32)	0.99 (0.48)	1.04 (0.59)	0.89 (0.30)	0.97 (0.44)	1.20 (0.95)	1.13 (0.78)	1.17 (0.87)	0.95 (0.40)	0.90 (0.31)	0.93 (0.36)
P₃W₂	1.12 (0.75)	0.93 (0.36)	1.02 (0.55)	1.06 (0.62)	0.91 (0.33)	0.98 (0.48)	1.29 (1.17)	1.17 (0.86)	1.23 (1.02)	1.01 (0.51)	0.94 (0.39)	0.97 (0.45)
P₃W₃	0.91 (0.34)	0.82 (0.18)	0.87 (0.26)	0.87 (0.26)	0.83 (0.18)	0.85 (0.22)	1.03 (0.55)	0.95 (0.41)	0.99 (0.48)	0.78 (0.11)	0.77 (0.09)	0.77 (0.10)
P₃W₄	1.02 (0.54)	0.83 (0.20)	0.93 (0.37)	0.97 (0.45)	0.86 (0.25)	0.92 (0.35)	1.14 (0.81)	1.11 (0.74)	1.13 (0.77)	0.92 (0.35)	0.88 (0.28)	0.90 (0.32)
P₃W₅	1.23 (1.15)	1.23 (1.02)	1.23 (1.08)	0.89 (0.29)	0.83 (0.20)	0.86 (0.24)	1.12 (0.76)	0.97 (0.44)	1.04 (0.60)	0.81 (0.16)	0.81 (0.16)	0.81 (0.16)
P₃W₆	1.25 (1.07)	0.97 (0.44)	1.11 (0.75)	1.10 (0.72)	0.97 (0.44)	1.04 (0.58)	0.97 (0.45)	0.89 (0.30)	0.93 (0.37)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	1.28 (1.17)	1.28 (1.13)	1.28 (1.15)	1.38 (1.58)	1.30 (1.25)	1.34 (1.42)	1.58 (2.05)	1.50 (1.74)	1.54 (1.90)	1.24 (1.09)	1.17 (0.87)	1.20 (0.98)
SEm± (PxW)	0.07	0.04	0.04	0.07	0.04	0.04	0.07	0.06	0.05	0.05	0.04	0.03
SEm± (WxP)	0.05	0.03	0.03	0.04	0.03	0.03	0.05	0.04	0.03	0.04	0.04	0.03
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

4.2.3.10.1 Effect of sowing dates on dry weight of *Mimosa pudica*

An examination of two years' data and pooled values on weed biomass of *Mimosa pudica* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly, the highest dry weight at all stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, the significantly lowest dry weight (0.83, 0.82 g m⁻²) was recorded on 15th June and was at par with 30th June during the first and second years, while the pooled values were non-significant. At 40 DAS, the sowing date of 15th June recorded the least dry weight (0.80, 0.79 g m⁻²) and was at par with the sowing date of 30th June in the first years only. At 60 DAS, data revealed that sowing on 15th June recorded the least dry weight (0.89, 0.85 g m⁻²) in both years and pooled values and at par with sowing on 30th June during both years.

4.2.3.10.2 Effect of integrated weed management on the dry weight of *Mimosa pudica*

Variations in dry weight of *Mimosa pudica* due to integrated weed management were also found to be significant. Weedy check (W₇) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded lowest weed dry weight (0.81, 0.80 g m⁻²). It was at par with W₄ (Pendimethalin 30EC @ 1kg ha⁻¹ fb interculture at 30 DAS) in both years and pooled values.

At 40 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest pooled value of dry weight (0.78 g m⁻²) and was at par with treatment W₄ and W₅ in both years and pooled values.

At 60 DAS, hand weeding at 20 and 40 DAS (W₆) recorded significantly lowest dry weight (0.85, 0.86 g m⁻²) and was at par with W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) and W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS) in both year and pooled values.

At harvest, treatments W₆ (hand weeding at 20 and 40 DAS) recorded

Table 4.41(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Mimosa pudica* L. at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	0.83 (0.19)	0.82 (0.18)	0.82 (0.18)	0.80 (0.14)	0.79 (0.12)	0.79 (0.13)	0.89 (0.33)	0.85 (0.24)	0.87 (0.28)	0.87 (0.30)	0.82 (0.19)	0.85 (0.25)
P₂ 30th June	0.90 (0.31)	0.88 (0.28)	0.89 (0.29)	0.88 (0.30)	0.84 (0.22)	0.86 (0.26)	0.97 (0.47)	0.94 (0.41)	0.95 (0.44)	0.92 (0.37)	0.86 (0.25)	0.89 (0.31)
P₃ 15th July	1.00 (0.53)	0.96 (0.44)	0.98 (0.49)	0.97 (0.48)	0.93 (0.38)	0.95 (0.43)	1.11 (0.80)	1.10 (0.72)	1.10 (0.76)	0.97 (0.46)	0.87 (0.25)	0.92 (0.36)
SEm±	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01
CD at 5%	0.08	0.08	0.04	0.08	0.06	0.04	0.07	0.09	0.05	NS	NS	NS
Integrated weed Management (W)												
W₁	0.90 (0.31)	0.88 (0.28)	0.89 (0.30)	0.87 (0.27)	0.85 (0.22)	0.86 (0.25)	0.96 (0.44)	0.93 (0.38)	0.95 (0.41)	0.92 (0.34)	0.86 (0.24)	0.89 (0.29)
W₂	0.91 (0.33)	0.89 (0.30)	0.90 (0.32)	0.91 (0.33)	0.87 (0.25)	0.89 (0.29)	1.00 (0.52)	1.00 (0.52)	1.00 (0.52)	0.92 (0.36)	0.90 (0.31)	0.91 (0.33)
W₃	0.81 (0.16)	0.80 (0.14)	0.80 (0.15)	0.78 (0.11)	0.78 (0.11)	0.78 (0.11)	0.86 (0.25)	0.88 (0.28)	0.87 (0.27)	0.81 (0.16)	0.8 (0.14)	0.81 (0.15)
W₄	0.82 (0.17)	0.81 (0.16)	0.82 (0.17)	0.81 (0.16)	0.81 (0.17)	0.81 (0.16)	0.91 (0.35)	0.94 (0.40)	0.93 (0.38)	0.87 (0.27)	0.84 (0.21)	0.86 (0.24)
W₅	0.98 (0.48)	0.95 (0.41)	0.96 (0.44)	0.79 (0.12)	0.8 (0.14)	0.79 (0.13)	0.90 (0.32)	0.92 (0.36)	0.91 (0.34)	0.86 (0.24)	0.81 (0.15)	0.83 (0.20)
W₆	0.96 (0.42)	0.91 (0.34)	0.94 (0.38)	0.93 (0.38)	0.88 (0.29)	0.91 (0.33)	0.85 (0.22)	0.86 (0.24)	0.85 (0.23)	0.79 (0.13)	0.78 (0.10)	0.79 (0.12)
W₇	1.00 (0.54)	0.96 (0.44)	0.98 (0.49)	1.10 (0.78)	0.99 (0.51)	1.04 (0.64)	1.44 (1.64)	1.20 (1.00)	1.32 (1.32)	1.27 (1.15)	0.97 (0.47)	1.12 (0.81)
SEm±	0.03	0.02	0.02	0.04	0.03	0.03	0.06	0.08	0.05	0.02	0.02	0.02
CD at 5%	0.09	0.06	0.05	0.12	0.08	0.07	0.19	0.23	0.15	0.06	0.07	0.05

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.41(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Mimosa pudica* L.at 20,40,60 DAS and at harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	0.82 (0.17)	0.81 (0.15)	0.81 (0.16)	0.79 (0.13)	0.77 (0.10)	0.78 (0.11)	0.87 (0.26)	0.80 (0.14)	0.84 (0.20)	0.85 (0.23)	0.80 (0.14)	0.83 (0.19)
P₁W₂	0.83 (0.18)	0.82 (0.17)	0.82 (0.18)	0.80 (0.14)	0.79 (0.12)	0.79 (0.13)	0.88 (0.27)	0.88 (0.27)	0.88 (0.27)	0.87 (0.25)	0.88 (0.28)	0.88 (0.27)
P₁W₃	0.76 (0.07)	0.75 (0.06)	0.75 (0.07)	0.74 (0.04)	0.74 (0.05)	0.74 (0.04)	0.79 (0.12)	0.79 (0.13)	0.79 (0.12)	0.76 (0.08)	0.77 (0.10)	0.77 (0.09)
P₁W₄	0.76 (0.07)	0.75 (0.07)	0.75 (0.07)	0.75 (0.06)	0.75 (0.06)	0.75 (0.06)	0.83 (0.19)	0.84 (0.20)	0.83 (0.19)	0.80 (0.15)	0.82 (0.17)	0.81 (0.16)
P₁W₅	0.87 (0.25)	0.87 (0.26)	0.87 (0.26)	0.73 (0.03)	0.75 (0.06)	0.74 (0.04)	0.81 (0.16)	0.82 (0.17)	0.81 (0.16)	0.79 (0.12)	0.79 (0.12)	0.79 (0.12)
P₁W₆	0.87 (0.25)	0.85 (0.23)	0.86 (0.24)	0.82 (0.17)	0.79 (0.13)	0.80 (0.15)	0.78 (0.10)	0.78 (0.10)	0.78 (0.10)	0.75 (0.06)	0.76 (0.07)	0.75 (0.07)
P₁W₇	0.89 (0.30)	0.89 (0.29)	0.89 (0.30)	0.97 (0.45)	0.91 (0.35)	0.94 (0.40)	1.29 (1.20)	1.05 (0.65)	1.17 (0.92)	1.30 (1.24)	0.94 (0.44)	1.12 (0.84)
P₂W₁	0.89 (0.29)	0.87 (0.26)	0.88 (0.27)	0.86 (0.24)	0.83 (0.18)	0.84 (0.21)	0.96 (0.42)	0.91 (0.33)	0.93 (0.37)	0.93 (0.36)	0.88 (0.28)	0.90 (0.32)
P₂W₂	0.89 (0.30)	0.88 (0.28)	0.89 (0.29)	0.90 (0.30)	0.84 (0.21)	0.87 (0.26)	0.96 (0.43)	0.97 (0.44)	0.97 (0.44)	0.93 (0.37)	0.90 (0.31)	0.91 (0.34)
P₂W₃	0.81 (0.16)	0.80 (0.13)	0.81 (0.15)	0.77 (0.10)	0.77 (0.09)	0.77 (0.10)	0.84 (0.21)	0.85 (0.23)	0.85 (0.22)	0.80 (0.14)	0.81 (0.16)	0.81 (0.15)
P₂W₄	0.83 (0.18)	0.82 (0.17)	0.82 (0.17)	0.81 (0.16)	0.80 (0.14)	0.80 (0.15)	0.89 (0.30)	0.91 (0.33)	0.90 (0.31)	0.86 (0.25)	0.85 (0.22)	0.86 (0.23)
P₂W₅	0.96 (0.41)	0.95 (0.40)	0.95 (0.41)	0.79 (0.13)	0.79 (0.12)	0.79 (0.12)	0.87 (0.26)	0.89 (0.29)	0.88 (0.27)	0.84 (0.20)	0.82 (0.16)	0.83 (0.18)

P₂W₆	0.95 (0.40)	0.89 (0.29)	0.92 (0.34)	0.91 (0.33)	0.87 (0.26)	0.89 (0.30)	0.83 (0.19)	0.83 (0.19)	0.83 (0.19)	0.79 (0.12)	0.79 (0.12)	0.79 (0.12)
P₂W₇	0.97 (0.44)	0.95 (0.41)	0.96 (0.42)	1.12 (0.84)	1.01 (0.53)	1.07 (0.68)	1.41 (1.52)	1.23 (1.06)	1.32 (1.29)	1.28 (1.13)	1.00 (0.50)	1.14 (0.82)
P₃W₁	0.99 (0.48)	0.96 (0.43)	0.97 (0.46)	0.97 (0.45)	0.94 (0.38)	0.96 (0.41)	1.07 (0.64)	1.08 (0.68)	1.07 (0.66)	0.97 (0.45)	0.89 (0.30)	0.93 (0.37)
P₃W₂	1.00 (0.51)	0.97 (0.45)	0.99 (0.48)	1.02 (0.55)	0.96 (0.43)	0.99 (0.49)	1.17 (0.87)	1.16 (0.84)	1.16 (0.85)	0.98 (0.45)	0.92 (0.34)	0.95 (0.40)
P₃W₃	0.86 (0.24)	0.84 (0.21)	0.85 (0.22)	0.83 (0.20)	0.82 (0.18)	0.83 (0.19)	0.96 (0.42)	1.00 (0.50)	0.98 (0.46)	0.87 (0.26)	0.81 (0.16)	0.84 (0.21)
P₃W₄	0.87 (0.26)	0.87 (0.26)	0.87 (0.26)	0.88 (0.27)	0.89 (0.30)	0.89 (0.28)	1.01 (0.57)	1.09 (0.68)	1.05 (0.63)	0.96 (0.41)	0.85 (0.22)	0.90 (0.32)
P₃W₅	1.11 (0.76)	1.03 (0.58)	1.07 (0.67)	0.84 (0.21)	0.86 (0.24)	0.85 (0.23)	1.02 (0.54)	1.05 (0.61)	1.04 (0.58)	0.94 (0.39)	0.82 (0.17)	0.88 (0.28)
P₃W₆	1.06 (0.62)	1.00 (0.51)	1.03 (0.56)	1.06 (0.64)	0.99 (0.48)	1.03 (0.56)	0.94 (0.38)	0.96 (0.42)	0.95 (0.40)	0.85 (0.21)	0.79 (0.12)	0.82 (0.17)
P₃W₇	1.15 (0.87)	1.05 (0.63)	1.10 (0.75)	1.19 (1.05)	1.04 (0.64)	1.12 (0.85)	1.60 (2.19)	1.33 (1.28)	1.47 (1.74)	1.25 (1.07)	0.98 (0.47)	1.12 (0.77)
SEm± (PxW)	0.05	0.04	0.03	0.07	0.05	0.04	0.08	0.05	0.05	0.04	0.04	0.03
SEm± (WxP)	0.04	0.04	0.03	0.05	0.03	0.03	0.04	0.04	0.03	0.04	0.03	0.03
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

significantly the lowest pooled value of the dry weight 0.79 g m^{-2} and 0.78 g m^{-2} , respectively in both years and pooled values. This treatment was statistically at par with W_3 and W_5 in both years and pooled values. Whereas, treatment W_4 was also found to par with treatment W_6 , in the first year only.

4.2.3.10.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Mimosa pudica*

The data on the dry weight of *Mimosa pudica* presented in Table 4.41 (b) shows that the interaction effect of sowing dates and integrated weed management were found to be non-significant during both years.

4.2.3.11 Weed dry weight (g m^{-2}) of *Mollugo pentaphylla*

The data on dry weight of *Mollugo pentaphylla* influenced by sowing dates and integrated weed management recorded at 20, 40, and 60 DAS and at harvest are presented in Table 4.42 (a) and Table 4.42 (b).

4.2.3.11.1 Effect of sowing dates on dry weight of *Mollugo pentaphylla*

An inquisition of two years' data and pooled values on weed biomass of *Mollugo pentaphylla* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly, the highest dry weight at all stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, significantly the lowest dry weight ($1.05, 1.00 \text{ g m}^{-2}$) was recorded on 15th June in both years and pooled values. It was at par with the sowing date of 30th June in both years and the highest dry weight was recorded on 15th July. At 40 DAS, the sowing date of 15th June recorded the least dry weight ($0.90, 0.86 \text{ g m}^{-2}$) and was at par with the sowing date of 30th June in both years and pooled values. At 60 DAS, data revealed that sowing on 15th June recorded the least dry weight ($1.03, 0.97 \text{ g m}^{-2}$) and was at par with 30th June in both years and pooled values.

4.2.3.11.2 Effect of integrated weed management on the dry weight of *Mollugo pentaphylla*

Variations in the dry weight of *Mollugo pentaphylla* due to integrated weed

management were also found to be significant. Weedy check (W₇) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded lowest pooled value of weed dry weight (0.83 g m⁻²). It was at par with W₄ (Pendimethalin 30EC @ 1kg ha⁻¹ fb interculture at 30 DAS) in both years and pooled values.

At 40 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest dry weight (0.76, 0.75 g m⁻²) and was at par with other treatments W₄ and W₅ in both year and pooled values.

At 60 DAS, hand weeding at 20 and 40 DAS (W₆) recorded significantly lowest pooled value of dry weight (0.91 g m⁻²) and was at par with W₃, W₄, and W₅ in both years and pooled values and also at par with treatment W₁ in the second year. At harvest, W₆ (Hand weeding at 20 and 40 DAS) recorded the lowest dry weight and was at par with treatments W₃ and W₅ in both years and pooled values, while W₄ was also at par with W₆ in both years.

4.2.3.11.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Mollugo pentaphylla*

The study found no significant effect on the dry weight of *Mollugo pentaphylla* due to the interaction effect of sowing dates and integrated weed management during both years.

4.2.3.12 Weed dry weight (g m⁻²) of *Scorparia dulcis*

The data on the dry weight of *Scorparia dulcis* influenced by sowing dates and integrated weed management recorded at 20, 40, 60 DAS and harvest are presented in Table 4.43 (a) and Table 4.43 (b).

4.2.3.12.1 Effect of sowing dates on dry weight of *Scorparia dulcis*

An examination of two years' data and pooled values on weed biomass of *Scorparia dulcis* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly, the highest dry weight at all stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

Table 4.42(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Mollugo pentaphylla* at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.05 (0.65)	1.00 (0.54)	1.03 (0.59)	0.90 (0.37)	0.86 (0.28)	0.88 (0.33)	1.03 (0.63)	0.97 (0.50)	1.00 (0.56)	0.83 (0.22)	0.82 (0.19)	0.83 (0.20)
P₂ 30th June	1.13 (.83)	1.09 (0.71)	1.11 (0.77)	0.93 (0.43)	0.9 (0.35)	0.92 (0.39)	1.09 (0.76)	1.00 (0.52)	1.04 (0.64)	0.86 (0.27)	0.84 (0.23)	0.85 (0.25)
P₃ 15th July	1.25 (1.15)	1.23 (1.08)	1.24 (1.11)	1.06 (.73)	1.01 (.61)	1.03 (.67)	1.25 (1.20)	1.19 (.98)	1.22 (1.09)	0.88 (.33)	0.86 (.28)	0.87 (.30)
SEm±	0.03	0.03	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01
CD at 5%	0.10	0.11	0.06	0.08	0.07	0.04	0.08	0.06	0.04	NS	NS	NS
Integrated weed Management (W)												
W₁	1.12 (0.76)	1.12 (0.77)	1.12 (0.77)	0.86 (0.24)	0.85 (0.22)	0.85 (0.23)	1.09 (0.71)	1.07 (0.66)	1.08 (0.69)	0.89 (0.30)	0.87 (0.26)	0.88 (0.28)
W₂	1.22 (1.01)	1.18 (0.90)	1.2 (0.96)	0.89 (0.30)	0.86 (0.24)	0.87 (0.27)	1.12 (0.76)	1.08 (0.69)	1.1 (0.73)	0.9 (0.31)	0.88 (0.28)	0.89 (0.29)
W₃	0.83 (0.19)	0.83 (0.20)	0.83 (0.20)	0.76 (0.07)	0.75 (0.06)	0.75 (0.07)	0.95 (0.42)	0.9 (0.32)	0.93 (0.37)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₄	0.86 (0.25)	0.86 (0.25)	0.86 (0.25)	0.77 (0.09)	0.76 (0.08)	0.76 (0.09)	0.99 (0.48)	0.94 (0.40)	0.96 (0.44)	0.78 (0.10)	0.77 (0.10)	0.78 (0.10)
W₅	1.33 (1.31)	1.25 (1.11)	1.29 (1.21)	0.76 (0.08)	0.75 (0.07)	0.76 (0.08)	0.97 (0.45)	0.93 (0.37)	0.95 (0.41)	0.76 (0.07)	0.75 (0.07)	0.76 (0.07)
W₆	1.26 (1.10)	1.2 (0.97)	1.23 (1.04)	1.22 (1.03)	1.16 (0.87)	1.19 (0.95)	0.94 (0.38)	0.89 (0.30)	0.91 (0.34)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	1.39 (1.50)	1.29 (1.22)	1.34 (1.36)	1.49 (1.77)	1.34 (1.34)	1.42 (1.56)	1.79 (2.84)	1.53 (1.92)	1.66 (2.38)	1.26 (1.12)	1.18 (.93)	1.22 (1.02)
SEm±	0.05	0.05	0.03	0.03	0.04	0.03	0.05	0.05	0.04	0.02	0.03	0.02
CD at 5%	0.13	0.14	0.09	0.1	0.11	0.07	0.15	0.14	0.10	0.07	0.08	0.05

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.42(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Mollugo pentaphylla* at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.06 (0.63)	1.02 (0.55)	1.04 (0.59)	0.79 (0.13)	0.78 (0.10)	0.78 (0.11)	0.98 (0.47)	0.94 (0.39)	0.96 (0.43)	0.87 (0.26)	0.86 (0.23)	0.86 (0.25)
P₁W₂	1.12 (0.76)	1.07 (0.63)	1.09 (0.70)	0.80 (0.13)	0.78 (0.11)	0.79 (0.12)	1.00 (0.51)	0.95 (0.41)	0.98 (0.46)	0.88 (0.27)	0.86 (0.24)	0.87 (0.26)
P₁W₃	0.77 (0.09)	0.77 (0.10)	0.77 (0.09)	0.74 (0.04)	0.73 (0.03)	0.73 (0.03)	0.87 (0.26)	0.81 (0.16)	0.84 (0.21)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₄	0.79 (0.12)	0.78 (0.10)	0.78 (0.11)	0.74 (0.05)	0.73 (0.04)	0.74 (0.04)	0.92 (0.34)	0.86 (0.23)	0.89 (0.29)	0.77 (0.10)	0.77 (0.10)	0.77 (0.10)
P₁W₅	1.18 (0.90)	1.10 (0.72)	1.14 (0.81)	0.74 (0.04)	0.73 (0.03)	0.73 (0.04)	0.91 (0.33)	0.85 (0.23)	0.88 (0.28)	0.75 (0.06)	0.75 (0.07)	0.75 (0.06)
P₁W₆	1.15 (0.83)	1.10 (0.70)	1.12 (0.77)	1.11 (0.74)	1.05 (0.60)	1.08 (0.67)	0.89 (0.30)	0.83 (0.19)	0.86 (0.25)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.30 (1.20)	1.19 (0.95)	1.25 (1.08)	1.39 (1.46)	1.25 (1.05)	1.32 (1.26)	1.64 (2.21)	1.52 (1.85)	1.58 (2.03)	1.15 (0.82)	1.10 (0.71)	1.12 (0.77)
P₂W₁	1.11 (0.74)	1.09 (0.69)	1.10 (0.72)	0.84 (0.20)	0.81 (0.16)	0.82 (0.18)	1.06 (0.62)	1.01 (0.53)	1.04 (0.57)	0.90 (0.31)	0.87 (0.25)	0.88 (0.28)
P₂W₂	1.21 (0.97)	1.19 (0.92)	1.20 (0.95)	0.84 (0.21)	0.83 (0.18)	0.83 (0.20)	1.08 (0.66)	1.03 (0.56)	1.05 (0.61)	0.91 (0.32)	0.87 (0.26)	0.89 (0.29)
P₂W₃	0.82 (0.18)	0.83 (0.18)	0.82 (0.18)	0.75 (0.06)	0.74 (0.04)	0.74 (0.05)	0.92 (0.34)	0.85 (0.23)	0.89 (0.29)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₄	0.85 (0.23)	0.89 (0.28)	0.87 (0.26)	0.75 (0.07)	0.74 (0.05)	0.75 (0.06)	0.96 (0.42)	0.90 (0.32)	0.93 (0.37)	0.78 (0.11)	0.77 (0.10)	0.78 (0.10)
P₂W₅	1.29 (1.17)	1.21 (0.98)	1.25 (1.07)	0.75 (0.06)	0.74 (0.05)	0.75 (0.06)	0.95 (0.40)	0.90 (0.30)	0.92 (0.35)	0.76 (0.08)	0.75 (0.06)	0.75 (0.07)

P₂W₆	1.25 (1.07)	1.19 (0.91)	1.22 (0.99)	1.16 (0.86)	1.11 (0.73)	1.14 (0.79)	0.93 (0.37)	0.87 (0.26)	0.90 (0.32)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	1.39 (1.44)	1.23 (1.02)	1.31 (1.23)	1.44 (1.58)	1.31 (1.23)	1.38 (1.40)	1.73 (2.50)	1.40 (1.46)	1.56 (1.98)	1.26 (1.09)	1.20 (0.94)	1.23 (1.02)
P₃W₁	1.19 (0.93)	1.25 (1.08)	1.22 (1.01)	0.95 (0.41)	0.95 (0.40)	0.95 (0.40)	1.24 (1.04)	1.25 (1.07)	1.25 (1.06)	0.91 (0.32)	0.89 (0.29)	0.90 (0.31)
P₃W₂	1.34 (1.30)	1.28 (1.15)	1.31 (1.22)	1.02 (0.55)	0.97 (0.43)	0.99 (0.49)	1.27 (1.12)	1.27 (1.11)	1.27 (1.12)	0.91 (0.34)	0.91 (0.33)	0.91 (0.33)
P₃W₃	0.90 (0.31)	0.91 (0.32)	0.90 (0.32)	0.78 (0.11)	0.79 (0.12)	0.79 (0.12)	1.02 (0.53)	1.00 (0.50)	1.01 (0.51)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₄	0.95 (0.39)	0.93 (0.36)	0.94 (0.38)	0.81 (0.16)	0.80 (0.15)	0.81 (0.15)	1.09 (0.68)	1.07 (0.64)	1.08 (0.66)	0.78 (0.11)	0.78 (0.10)	0.78 (0.11)
P₃W₅	1.52 (1.85)	1.43 (1.62)	1.48 (1.73)	0.80 (0.14)	0.79 (0.13)	0.80 (0.14)	1.06 (0.63)	1.05 (0.60)	1.05 (0.61)	0.77 (0.09)	0.76 (0.09)	0.76 (0.09)
P₃W₆	1.38 (1.41)	1.33 (1.30)	1.35 (1.36)	1.39 (1.49)	1.31 (1.27)	1.35 (1.38)	1.04 (0.58)	1.01 (0.52)	1.02 (0.55)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	1.48 (1.86)	1.46 (1.69)	1.47 (1.78)	1.65 (2.27)	1.46 (1.75)	1.56 (2.01)	2.01 (3.80)	1.67 (2.45)	1.84 (3.13)	1.37 (1.44)	1.25 (1.14)	1.31 (1.29)
SEm± (PxW)	0.08	0.08	0.06	0.06	0.07	0.05	0.09	0.08	0.06	0.04	0.05	0.03
SEm± (WxP)	0.06	0.06	0.04	0.04	0.04	0.03	0.05	0.05	0.03	0.04	0.04	0.03
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

At 20 DAS, significantly the lowest dry weight (0.91, 0.84 g m⁻²) was recorded on 15th June in both years and pooled values. It was at par with the sowing date of 30th June in both years and the highest dry weight was recorded on 15th July. At 40 DAS, the sowing date of 15th June recorded the least dry weight (0.85, 0.83 g m⁻²) and was at par with 30th June in both years and pooled values. At 60 DAS, data revealed that sowing on 15th June recorded the least dry weight (1.07, 1.01 g m⁻²) and was at par with 30th June in both year and pooled values.

4.2.3.12.2 Effect of integrated weed management on the dry weight of *Scorparia dulcis*

Variations in dry weight of *Scorparia dulcis* due to integrated weed management were also found to be significant. Weedy check (W₇) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded lowest weed dry weight (0.85, 0.80 g m⁻²). It was at par with W₄ (Pendimethalin 30EC @ 1kg ha⁻¹ fb interculture at 30 DAS) in both years and pooled values.

At 40 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest dry weight (0.79, 0.76 g m⁻²), and was at par with other treatments W₄ in both years and W₅ in both year and pooled values.

At 60 DAS, hand weeding at 20 and 40 DAS (W₆) recorded significantly the lowest dry weight (1.01, 0.95 g m⁻²) and was at par with W₃, W₄, and W₅ in both years and pooled values. At harvest, W₆ (Hand weeding at 20 and 40DAS) recorded the lowest dry weight and was at par with treatments W₃ and W₅ in both years and pooled values.

4.2.3.12.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Scorparia dulcis*

The data on dry weight of *Scorparia dulcis* presented in Table 4.43 (b) shows that the interaction effect of sowing dates and integrated weed management were found to be non-significant during both years.

Table 4.43(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Scorparia dulcis* at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	0.91 (0.34)	0.84 (0.21)	0.88 (0.27)	0.85 (0.23)	0.83 (0.21)	0.84 (0.22)	1.07 (0.68)	1.01 (0.56)	1.04 (0.62)	1.04 (0.61)	1.02 (0.58)	1.03 (0.59)
P₂ 30th June	0.97 (0.45)	0.92 (0.35)	0.94 (0.40)	0.89 (0.31)	0.85 (0.24)	0.87 (0.27)	1.13 (0.81)	1.08 (0.69)	1.10 (0.75)	1.06 (0.68)	1.04 (0.63)	1.05 (0.66)
P₃ 15th July	1.02 (0.56)	1.01 (0.55)	1.02 (0.55)	1.01 (0.56)	0.94 (0.42)	0.98 (0.49)	1.31 (1.28)	1.25 (1.14)	1.28 (1.21)	1.07 (0.70)	1.05 (0.65)	1.06 (0.67)
SEm±	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.04	0.05	0.03
CD at 5%	0.07	0.08	0.04	0.06	0.06	0.04	0.10	0.09	0.05	NS	NS	NS
Integrated weed Management (W)												
W₁	0.97 (0.44)	0.89 (0.29)	0.93 (0.36)	0.88 (0.27)	0.84 (0.21)	0.86 (0.24)	1.20 (0.94)	1.13 (0.79)	1.16 (0.86)	1.10 (0.71)	1.06 (0.63)	1.08 (0.67)
W₂	0.98 (0.45)	0.91 (0.33)	0.94 (0.39)	0.89 (0.29)	0.85 (0.23)	0.87 (0.26)	1.22 (1.00)	1.15 (0.83)	1.19 (0.92)	1.13 (0.77)	1.08 (0.66)	1.10 (0.72)
W₃	0.85 (0.22)	0.80 (0.14)	0.82 (0.18)	0.79 (0.13)	0.76 (0.09)	0.78 (0.11)	1.03 (0.57)	0.98 (0.47)	1.01 (0.52)	0.90 (0.32)	0.90 (0.31)	0.90 (0.32)
W₄	0.88 (0.28)	0.82 (0.17)	0.85 (0.23)	0.86 (0.24)	0.83 (0.20)	0.85 (0.22)	1.11 (0.73)	1.04 (0.59)	1.07 (0.66)	1.02 (0.54)	0.99 (0.48)	1.00 (0.51)
W₅	1.03 (0.56)	0.99 (0.51)	1.01 (0.54)	0.84 (0.21)	0.80 (0.14)	0.82 (0.18)	1.05 (0.61)	1.00 (0.51)	1.02 (0.56)	0.91 (.33)	0.90 (0.32)	0.91 (0.33)
W₆	1.02 (0.55)	0.97 (0.45)	0.99 (0.50)	0.93 (0.38)	0.88 (0.28)	0.91 (0.33)	1.01 (0.53)	0.95 (0.41)	0.98 (0.47)	0.89 (0.29)	0.87 (0.26)	0.88 (0.27)
W₇	1.06 (0.66)	1.08 (0.68)	1.07 (0.67)	1.21 (1.01)	1.17 (0.88)	1.19 (0.95)	1.57 (2.07)	1.53 (1.95)	1.55 (2.01)	1.46 (1.67)	1.46 (1.67)	1.46 (1.67)
SEm±	0.03	0.03	0.02	0.04	0.03	0.02	0.04	0.05	0.03	0.03	0.03	0.02
CD at 5%	0.10	0.09	0.06	0.10	0.08	0.06	0.12	0.13	0.09	0.09	0.09	0.06

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.43(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Scorparia dulcis*.at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	0.91 (0.33)	0.80 (0.14)	0.86 (0.24)	0.81 (0.16)	0.80 (0.14)	0.81 (0.15)	1.11 (0.73)	1.04 (0.59)	1.08 (0.66)	1.10 (0.73)	1.05 (0.61)	1.08 (0.67)
P₁W₂	0.92 (0.35)	0.82 (0.17)	0.87 (0.26)	0.82 (0.17)	0.81 (0.15)	0.81 (0.16)	1.14 (0.79)	1.06 (0.62)	1.10 (0.71)	1.13 (0.78)	1.07 (0.65)	1.10 (0.72)
P₁W₃	0.83 (0.19)	0.76 (0.07)	0.79 (0.13)	0.76 (0.08)	0.72 (0.02)	0.74 (0.05)	0.96 (0.42)	0.89 (0.29)	0.92 (0.35)	0.90 (0.30)	0.89 (0.29)	0.89 (0.30)
P₁W₄	0.85 (0.23)	0.76 (0.08)	0.81 (0.16)	0.79 (0.13)	0.79 (0.13)	0.79 (0.13)	1.03 (0.56)	0.95 (0.41)	0.99 (0.48)	1.02 (0.54)	0.95 (0.39)	0.98 (0.47)
P₁W₅	0.96 (0.42)	0.90 (0.32)	0.93 (0.37)	0.79 (0.12)	0.77 (0.09)	0.78 (0.10)	0.97 (0.44)	0.91 (0.32)	0.94 (0.38)	0.90 (0.31)	0.90 (0.30)	0.90 (0.30)
P₁W₆	0.96 (0.42)	0.87 (0.25)	0.91 (0.33)	0.83 (0.12)	0.84 (0.09)	0.83 (0.10)	0.93 (0.37)	0.85 (0.23)	0.89 (0.30)	0.88 (0.27)	0.86 (0.24)	0.87 (0.25)
P₁W₇	0.97 (0.44)	0.96 (0.42)	0.96 (0.43)	1.12 (0.75)	1.10 (0.72)	1.11 (0.74)	1.39 (1.45)	1.39 (1.44)	1.39 (1.45)	1.35 (1.33)	1.43 (1.54)	1.39 (1.44)
P₂W₁	0.97 (0.44)	0.87 (0.26)	0.92 (0.35)	0.84 (0.20)	0.82 (0.17)	0.83 (0.19)	1.16 (0.85)	1.10 (0.71)	1.13 (0.78)	1.09 (0.69)	1.07 (0.64)	1.08 (0.67)
P₂W₂	0.97 (0.45)	0.90 (0.31)	0.94 (0.38)	0.85 (0.22)	0.83 (0.18)	0.84 (0.20)	1.19 (0.91)	1.12 (0.75)	1.15 (0.83)	1.13 (0.77)	1.08 (0.67)	1.10 (0.72)
P₂W₃	0.85 (0.22)	0.78 (0.12)	0.82 (0.17)	0.78 (0.11)	0.73 (0.03)	0.76 (0.07)	1.00 (0.50)	0.95 (0.40)	0.98 (0.45)	0.90 (0.32)	0.91 (0.32)	0.90 (0.32)
P₂W₄	0.88 (0.28)	0.80 (0.14)	0.84 (0.21)	0.83 (0.19)	0.81 (0.16)	0.82 (0.17)	1.07 (0.65)	1.01 (0.53)	1.04 (0.59)	1.03 (0.55)	1.00 (0.50)	1.01 (0.53)
P₂W₅	1.02 (0.53)	1.01 (0.53)	1.01 (0.53)	0.81 (0.15)	0.77 (0.10)	0.79 (0.13)	1.02 (0.54)	0.97 (0.44)	0.99 (0.49)	0.92 (0.34)	0.91 (0.33)	0.91 (0.34)

P₂W₆	1.01 (0.52)	0.96 (0.42)	0.98 (0.47)	0.89 (0.28)	0.86 (0.23)	0.87 (0.26)	0.98 (0.47)	0.92 (0.35)	0.95 (0.41)	0.88 (0.28)	0.87 (0.25)	0.87 (0.27)
P₂W₇	1.09 (0.74)	1.09 (0.69)	1.09 (0.72)	1.22 (0.98)	1.15 (0.82)	1.18 (0.90)	1.49 (1.76)	1.46 (1.64)	1.48 (1.70)	1.51 (1.80)	1.47 (1.71)	1.49 (1.76)
P₃W₁	1.01 (0.53)	0.99 (0.48)	1.00 (0.50)	0.97 (0.45)	0.90 (0.32)	0.94 (0.38)	1.32 (1.23)	1.25 (1.07)	1.28 (1.15)	1.09 (0.70)	1.07 (0.63)	1.08 (0.67)
P₃W₂	1.03 (0.57)	1.01 (0.52)	1.02 (0.54)	1.00 (0.49)	0.91 (0.34)	0.95 (0.41)	1.35 (1.32)	1.27 (1.11)	1.31 (1.21)	1.12 (0.76)	1.08 (0.66)	1.10 (0.71)
P₃W₃	0.87 (0.25)	0.86 (0.24)	0.86 (0.24)	0.84 (0.20)	0.84 (0.23)	0.84 (0.21)	1.14 (0.80)	1.11 (0.72)	1.12 (0.76)	0.91 (0.34)	0.90 (0.32)	0.91 (0.33)
P₃W₄	0.91 (0.33)	0.89 (0.30)	0.90 (0.32)	0.95 (0.41)	0.89 (0.30)	0.92 (0.36)	1.22 (0.99)	1.16 (0.85)	1.19 (0.92)	1.01 (0.52)	1.02 (0.53)	1.01 (0.53)
P₃W₅	1.10 (0.72)	1.07 (0.69)	1.08 (0.71)	0.93 (0.37)	0.86 (0.24)	0.89 (0.30)	1.16 (0.85)	1.12 (0.76)	1.14 (0.81)	0.92 (0.35)	0.91 (0.32)	0.91 (0.34)
P₃W₆	1.09 (0.72)	1.08 (0.67)	1.09 (0.69)	1.08 (0.67)	0.95 (0.41)	1.02 (0.54)	1.12 (0.77)	1.08 (0.66)	1.10 (0.71)	0.90 (0.31)	0.88 (0.28)	0.89 (0.30)
P₃W₇	1.13 (0.81)	1.18 (0.93)	1.15 (0.87)	1.29 (1.30)	1.25 (1.10)	1.27 (1.20)	1.83 (2.99)	1.75 (2.78)	1.79 (2.89)	1.53 (1.89)	1.49 (1.75)	1.51 (1.82)
SEm± (PxW)	0.06	0.05	0.04	0.06	0.05	0.04	0.07	0.08	0.05	0.05	0.05	0.04
SEm± (WxP)	0.04	0.04	0.03	0.04	0.03	0.03	0.05	0.05	0.04	0.05	0.05	0.03
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

4.2.3.13 Weed dry weight (g m^{-2}) of *Alternanthera sessilis*

The data on dry weight of *Alternanthera sessilis* influenced by sowing dates and integrated weed management recorded at 20, 40, 60 DAS and harvest are presented in Table 4.44 (a) and Table 4.44 (b).

4.2.3.13.1 Effect of sowing dates on dry weight of *Alternanthera sessilis*

An examination of two years' data and pooled values on weed biomass of *Alternanthera sessilis* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly highest dry weight at all stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, significantly the lowest dry weight ($1.10, 1.01 \text{ g m}^{-2}$) was recorded on 15th June in both years and pooled values. It was at par with the sowing date of 30th June in the first year and the highest dry weight was recorded on 15th July. At 40 DAS, the sowing date of 15th June recorded the least dry weight ($1.00, 0.96 \text{ g m}^{-2}$), followed by 30th June in both years and pooled values. At 60 DAS, data revealed that sowing on 15th June recorded the least dry weight ($1.06, 1.02 \text{ g m}^{-2}$) and was at par with 30th June in the first year.

4.2.3.13.2 Effect of integrated weed management on dry weight of *Alternanthera sessilis*

Significant results were observed on dry weight of *Alternanthera sessilis* due to integrated weed management. Weedy check (W_7) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @ 1 kg ha^{-1} fb imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS (W_3) recorded lowest weed dry weight ($1.04, 0.94 \text{ g m}^{-2}$). It was at par with W_4 (Pendimethalin 30EC @ 1 kg ha^{-1} fb interculture at 30 DAS) in both years and pooled values.

At 40 days after sowing (DAS), applying pendimethalin 30 EC @ 1 kg ha^{-1} fb imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS (W_3) achieved a significantly lower dry weight ($0.93, 0.89 \text{ g m}^{-2}$). This result was statistically at par by other treatments W_5 across both years and pooled values.

Table 4.44(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Alternanthera sessilis* at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.10 (0.71)	1.01 (0.52)	1.05 (0.62)	1.00 (0.54)	0.96 (0.45)	0.98 (0.49)	1.06 (0.67)	1.02 (0.59)	1.04 (0.63)	0.91 (0.36)	0.91 (0.36)	0.91 (0.36)
P₂ 30th June	1.15 (0.83)	1.15 (0.86)	1.15 (0.84)	1.12 (0.79)	1.09 (0.70)	1.10 (0.74)	1.13 (0.82)	1.10 (0.73)	1.12 (0.77)	0.95 (0.43)	0.93 (0.39)	0.94 (0.41)
P₃ 15th July	1.25 (1.08)	1.21 (0.98)	1.23 (1.03)	1.20 (1.00)	1.14 (0.84)	1.17 (0.92)	1.24 (1.08)	1.23 (1.04)	1.23 (1.06)	0.96 (0.49)	0.95 (0.45)	0.96 (0.47)
SEm±	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.01
CD at 5%	0.09	0.11	0.06	0.07	0.1	0.05	0.07	0.08	0.05	NS	NS	NS
Integrated weed Management (W)												
W₁	1.17 (0.87)	1.13 (0.79)	1.15 (0.83)	1.09 (0.69)	1.05 (0.60)	1.07 (0.65)	1.13 (0.78)	1.11 (0.75)	1.12 (0.77)	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)
W₂	1.18 (0.89)	1.14 (0.80)	1.16 (0.85)	1.11 (0.74)	1.07 (0.64)	1.09 (0.69)	1.16 (0.85)	1.14 (0.82)	1.15 (0.83)	1.03 (0.56)	1.02 (0.53)	1.02 (0.55)
W₃	1.04 (0.58)	0.94 (0.38)	0.99 (0.48)	0.93 (0.36)	0.89 (0.29)	0.91 (0.33)	1.00 (0.52)	0.98 (0.48)	0.99 (0.50)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₄	1.08 (0.68)	0.94 (0.39)	1.01 (0.53)	1.06 (0.63)	1.02 (0.54)	1.04 (0.58)	1.11 (0.74)	1.09 (0.71)	1.10 (0.72)	0.96 (0.43)	0.96 (0.42)	0.96 (0.43)
W₅	1.21 (0.97)	1.20 (0.96)	1.21 (0.97)	0.94 (0.40)	0.93 (0.38)	0.94 (0.39)	1.09 (0.69)	1.07 (0.66)	1.08 (0.68)	0.88 (0.28)	0.86 (0.24)	0.87 (0.26)
W₆	1.21 (0.96)	1.19 (0.93)	1.20 (0.95)	1.13 (0.78)	1.09 (0.70)	1.11 (0.74)	0.95 (0.40)	0.93 (0.37)	0.94 (0.38)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	1.26 (1.15)	1.30 (1.26)	1.28 (1.20)	1.50 (1.82)	1.39 (1.49)	1.45 (1.66)	1.57 (2.03)	1.47 (1.73)	1.52 (1.88)	1.30 (1.21)	1.26 (1.12)	1.28 (1.17)
SEm±	0.04	0.04	0.03	0.04	0.03	0.02	0.04	0.04	0.03	0.03	0.03	0.02
CD at 5%	0.11	0.11	0.08	0.11	0.09	0.07	0.13	0.12	0.09	0.07	0.08	0.05

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.44(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Alternanthera sessilis*.at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.11 (0.73)	1.01 (0.53)	1.06 (0.63)	1.00 (0.49)	0.96 (0.43)	0.98 (0.46)	1.03 (0.57)	1.00 (0.49)	1.01 (0.53)	0.98 (0.46)	0.98 (0.47)	0.98 (0.46)
P₁W₂	1.12 (0.76)	1.03 (0.56)	1.08 (0.66)	1.02 (0.54)	0.99 (0.48)	1.00 (0.51)	1.05 (0.60)	1.01 (0.52)	1.03 (0.56)	1.00 (0.51)	1.00 (0.50)	1.00 (0.50)
P₁W₃	0.98 (0.46)	0.89 (0.30)	0.93 (0.38)	0.82 (0.17)	0.80 (0.13)	0.81 (0.15)	0.93 (0.38)	0.90 (0.31)	0.92 (0.35)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₄	1.03 (0.56)	0.91 (0.34)	0.97 (0.45)	0.98 (0.45)	0.94 (0.39)	0.96 (0.42)	1.02 (0.54)	0.98 (0.47)	1.00 (0.51)	0.94 (0.39)	0.94 (0.38)	0.94 (0.39)
P₁W₅	1.15 (0.82)	1.06 (0.63)	1.10 (0.73)	0.82 (0.18)	0.80 (0.14)	0.81 (0.16)	1.01 (0.51)	0.97 (0.44)	0.99 (0.48)	0.87 (0.26)	0.85 (0.22)	0.86 (0.24)
P₁W₆	1.15 (0.82)	1.06 (0.62)	1.10 (0.72)	1.04 (0.58)	1.00 (0.50)	1.02 (0.54)	0.89 (0.29)	0.85 (0.23)	0.87 (0.26)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.15 (0.82)	1.09 (0.69)	1.12 (0.76)	1.35 (1.34)	1.24 (1.06)	1.30 (1.20)	1.47 (1.82)	1.42 (1.67)	1.45 (1.74)	1.19 (0.92)	1.21 (0.97)	1.20 (0.94)
P₂W₁	1.16 (0.84)	1.17 (0.88)	1.17 (0.86)	1.10 (0.71)	1.07 (0.64)	1.08 (0.68)	1.13 (0.77)	1.09 (0.70)	1.11 (0.73)	1.00 (0.51)	1.00 (0.50)	1.00 (0.50)
P₂W₂	1.17 (0.87)	1.16 (0.84)	1.16 (0.85)	1.12 (0.75)	1.09 (0.70)	1.11 (0.73)	1.16 (0.84)	1.12 (0.76)	1.14 (0.80)	1.03 (0.57)	1.02 (0.54)	1.03 (0.56)
P₂W₃	1.02 (0.55)	0.95 (0.41)	0.99 (0.48)	0.96 (0.42)	0.90 (0.31)	0.93 (0.36)	1.00 (0.49)	0.97 (0.43)	0.98 (0.46)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₄	1.07 (0.65)	0.89 (0.30)	0.98 (0.47)	1.05 (0.60)	1.05 (0.60)	1.05 (0.60)	1.11 (0.72)	1.08 (0.66)	1.09 (0.69)	0.96 (0.43)	0.96 (0.42)	0.96 (0.43)
P₂W₅	1.21 (0.96)	1.22 (1.01)	1.22 (0.99)	0.98 (0.45)	0.97 (0.45)	0.98 (0.45)	1.08 (0.67)	1.05 (0.61)	1.07 (0.64)	0.87 (0.27)	0.85 (0.23)	0.86 (0.25)

P₂W₆	1.20 (0.93)	1.21 (0.97)	1.20 (0.95)	1.15 (0.82)	1.11 (0.73)	1.13 (0.77)	0.94 (0.39)	0.91 (0.34)	0.93 (0.36)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	1.21 (0.97)	1.41 (1.62)	1.31 (1.29)	1.49 (1.74)	1.41 (1.49)	1.45 (1.61)	1.53 (1.83)	1.46 (1.63)	1.49 (1.73)	1.32 (1.25)	1.25 (1.06)	1.28 (1.15)
P₃W₁	1.24 (1.04)	1.20 (0.95)	1.22 (0.99)	1.17 (0.87)	1.11 (0.73)	1.14 (0.80)	1.23 (1.01)	1.25 (1.07)	1.24 (1.04)	1.03 (0.55)	1.01 (0.53)	1.02 (0.54)
P₃W₂	1.25 (1.06)	1.23 (1.01)	1.24 (1.03)	1.19 (0.92)	1.12 (0.75)	1.15 (0.83)	1.26 (1.10)	1.30 (1.18)	1.28 (1.14)	1.05 (0.61)	1.03 (0.55)	1.04 (0.58)
P₃W₃	1.10 (0.72)	0.97 (0.44)	1.04 (0.58)	1.01 (0.51)	0.97 (0.43)	0.99 (0.47)	1.08 (0.68)	1.09 (0.70)	1.08 (0.69)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₄	1.15 (0.83)	1.02 (0.53)	1.08 (0.68)	1.15 (0.83)	1.06 (0.62)	1.11 (0.73)	1.20 (0.95)	1.22 (1.00)	1.21 (0.97)	0.98 (0.46)	0.98 (0.47)	0.98 (0.47)
P₃W₅	1.28 (1.14)	1.32 (1.25)	1.30 (1.19)	1.03 (0.57)	1.02 (0.53)	1.03 (0.55)	1.18 (0.89)	1.20 (0.94)	1.19 (0.92)	0.90 (0.31)	0.88 (0.28)	0.89 (0.29)
P₃W₆	1.28 (1.14)	1.30 (1.19)	1.29 (1.17)	1.20 (0.93)	1.17 (0.88)	1.19 (0.91)	1.01 (0.52)	1.02 (0.53)	1.01 (0.52)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	1.42 (1.66)	1.40 (1.47)	1.41 (1.56)	1.66 (2.38)	1.53 (1.93)	1.60 (2.16)	1.70 (2.44)	1.54 (1.87)	1.62 (2.16)	1.38 (1.46)	1.32 (1.33)	1.35 (1.40)
SEm± (PxW)	0.07	0.07	0.05	0.07	0.05	0.04	0.08	0.07	0.05	0.04	0.05	0.03
SEm± (WxP)	0.05	0.05	0.04	0.04	0.05	0.03	0.05	0.05	0.03	0.03	0.04	0.03
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

At 60 DAS and harvest, hand weeding at 20 and 40 DAS (W_6) recorded significantly lowest pooled values of 0.94 g m^{-2} and 0.71 g m^{-2} , respectively and was at par with W_3 in both years and pooled values.

4.2.3.13.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Alternanthera sessilis*

The study found no significant effect on dry weight of *Alternanthera sessilis* due to the interaction effect of sowing dates and integrated weed management in all the stages of observation during both years.

4.2.3.14 Weed dry weight (g m^{-2}) of *Commelina benghalensis*

The data on the dry weight of *Commelina benghalensis* influenced by sowing dates and integrated weed management recorded at 20, 40, and 60 DAS and harvest are presented in Table 4.45 (a) and Table 4.45 (b).

4.2.3.14.1 Effect of sowing dates on dry weight of *Commelina benghalensis*

An examination of two years' data and pooled values on weed biomass of *Commelina benghalensis* revealed significant variation among sowing dates at various stages of observations except at harvest. Significantly highest dry weight at all stages of observations was observed on the late sowing date of 15th July in both years and pooled values.

At 20 DAS, significantly the lowest dry weight ($0.95, 0.93 \text{ g m}^{-2}$) was recorded on 15th June in both years and pooled values compared to other sowing dates, i.e., 30th June and 15th July. At 40 DAS, the sowing date of 15th June recorded the least dry weight ($0.89, 0.68 \text{ g m}^{-2}$) and was at par with 30th June in the first year. At 60 DAS, data revealed that sowing on 15th June recorded the least dry weight ($1.02, 0.98 \text{ g m}^{-2}$) and was at par with 30th June in both years and pooled values.

4.2.3.14.2 Effect of integrated weed management on the dry weight of *Commelina benghalensis*

Variations in the dry weight of *Commelina benghalensis* due to integrated weed management were also found to be significant. Weedy check (W_7) recorded significantly the highest dry weight during all the stages of observation. At 20 DAS,

Table 4.45(a): Effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Commelina benghalensis* at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	0.95 (0.41)	0.93 (0.40)	0.94 (0.41)	0.89 (0.32)	0.68 (0.28)	0.78 (0.30)	1.02 (0.57)	0.98 (0.48)	1.00 (0.52)	0.94 (0.41)	0.85 (0.24)	0.89 (0.33)
P₂ 30th June	1.07 (0.68)	1.00 (0.53)	1.03 (0.60)	0.95 (0.43)	0.94 (0.41)	0.94 (0.42)	1.05 (0.64)	1.02 (0.57)	1.04 (0.60)	0.91 (0.35)	0.86 (0.25)	0.88 (0.30)
P₃ 15th July	1.14 (0.83)	1.07 (0.68)	1.10 (0.75)	1.02 (0.58)	0.99 (0.56)	1.00 (0.57)	1.17 (0.93)	1.16 (0.90)	1.16 (0.91)	0.90 (0.34)	0.87 (0.28)	0.89 (0.31)
SEm±	0.02	0.02	0.01	0.02	0.75	0.38	0.02	0.02	0.01	0.02	0.02	0.01
CD at 5%	0.09	0.06	0.05	0.07	2.95	1.22	0.09	0.07	0.05	NS	NS	NS
Integrated weed Management (W)												
W₁	1.01 (0.52)	0.96 (0.42)	0.98 (0.47)	0.91 (0.34)	0.86 (0.31)	0.88 (0.32)	1.05 (0.61)	1.02 (0.54)	1.03 (0.58)	0.98 (0.47)	0.90 (0.30)	0.94 (0.39)
W₂	1.05 (0.61)	0.97 (0.45)	1.01 (0.53)	0.92 (0.35)	0.90 (0.33)	0.91 (0.34)	1.06 (0.63)	1.03 (0.58)	1.05 (0.61)	0.99 (0.48)	0.92 (0.35)	0.95 (0.42)
W₃	0.86 (0.23)	0.79 (0.13)	0.83 (0.18)	0.86 (0.25)	0.78 (0.26)	0.82 (0.25)	0.99 (0.47)	0.97 (0.45)	0.98 (0.46)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₄	0.87 (0.27)	0.81 (0.17)	0.84 (0.22)	0.81 (0.17)	0.91 (0.11)	0.86 (0.14)	1.01 (0.52)	0.99 (0.50)	1.00 (0.51)	0.96 (0.43)	0.88 (0.28)	0.92 (0.35)
W₅	1.21 (1.01)	1.15 (0.84)	1.18 (0.92)	0.83 (0.20)	0.87 (0.19)	0.85 (0.19)	1.00 (0.50)	0.99 (0.49)	0.99 (0.50)	0.90 (0.31)	0.87 (0.25)	0.88 (0.28)
W₆	1.15 (0.83)	1.06 (0.64)	1.10 (0.74)	0.95 (0.43)	0.83 (0.38)	0.89 (0.40)	0.96 (0.42)	0.95 (0.41)	0.96 (0.41)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W₇	1.21 (1.01)	1.25 (1.09)	1.23 (1.05)	1.37 (1.37)	0.93 (1.33)	1.15 (1.35)	1.50 (1.82)	1.41 (1.56)	1.46 (1.69)	1.17 (0.88)	1.04 (0.60)	1.11 (0.74)
SEm±	0.04	0.04	0.03	0.04	0.01	0.02	0.04	0.05	0.03	0.02	0.02	0.02
CD at 5%	0.13	0.11	0.08	0.10	0.02	0.05	0.12	0.13	0.09	0.05	0.07	0.04

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

Table 4.45(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of *Commelina benghalensis*.at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	0.94 (0.39)	0.93 (0.37)	0.94 (0.38)	0.85 (0.23)	0.00 (0.16)	0.42 (0.20)	0.98 (0.47)	0.95 (0.40)	0.97 (0.43)	0.98 (0.46)	0.88 (0.27)	0.93 (0.37)
P₁W₂	0.96 (0.43)	0.93 (0.37)	0.94 (0.40)	0.85 (0.22)	0.81 (0.17)	0.83 (0.20)	0.99 (0.49)	0.97 (0.45)	0.98 (0.47)	0.98 (0.47)	0.89 (0.29)	0.94 (0.38)
P₁W₃	0.81 (0.16)	0.76 (0.07)	0.78 (0.12)	0.75 (0.06)	0.82 (0.04)	0.78 (0.05)	0.94 (0.38)	0.92 (0.34)	0.93 (0.36)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₄	0.83 (0.19)	0.78 (0.10)	0.80 (0.15)	0.79 (0.12)	0.73 (0.13)	0.76 (0.12)	0.96 (0.42)	0.93 (0.36)	0.94 (0.39)	0.97 (0.45)	0.86 (0.24)	0.92 (0.35)
P₁W₅	1.03 (0.56)	1.03 (0.57)	1.03 (0.56)	0.78 (0.12)	0.79 (0.08)	0.79 (0.10)	0.95 (0.40)	0.92 (0.34)	0.93 (0.37)	0.95 (0.41)	0.85 (0.22)	0.90 (0.31)
P₁W₆	1.02 (0.55)	0.88 (0.28)	0.95 (0.42)	0.86 (0.26)	0.76 (0.20)	0.81 (0.23)	0.93 (0.37)	0.91 (0.33)	0.92 (0.35)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.05 (0.61)	1.22 (1.05)	1.14 (0.83)	1.32 (1.24)	0.84 (1.15)	1.08 (1.20)	1.40 (1.46)	1.27 (1.11)	1.33 (1.29)	1.26 (1.11)	1.07 (0.66)	1.17 (0.89)
P₂W₁	1.02 (0.55)	0.95 (0.40)	0.98 (0.47)	0.89 (0.30)	1.28 (0.33)	1.09 (0.31)	1.01 (0.51)	0.99 (0.47)	1.00 (0.49)	0.98 (0.47)	0.90 (0.31)	0.94 (0.39)
P₂W₂	1.09 (0.70)	0.96 (0.44)	1.03 (0.57)	0.90 (0.32)	0.91 (0.34)	0.91 (0.33)	1.01 (0.53)	1.00 (0.50)	1.01 (0.51)	0.99 (0.49)	0.91 (0.33)	0.95 (0.41)
P₂W₃	0.86 (0.25)	0.80 (0.14)	0.83 (0.19)	0.82 (0.17)	0.92 (0.13)	0.87 (0.15)	0.96 (0.41)	0.94 (0.38)	0.95 (0.40)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₄	0.87 (0.26)	0.82 (0.18)	0.85 (0.22)	0.87 (0.26)	0.79 (0.28)	0.83 (0.27)	0.98 (0.46)	0.95 (0.41)	0.97 (0.43)	0.98 (0.45)	0.87 (0.26)	0.92 (0.36)
P₂W₅	1.27 (1.20)	1.14 (0.83)	1.20 (1.01)	0.84 (0.22)	0.88 (0.20)	0.86 (0.21)	0.97 (0.45)	0.95 (0.41)	0.96 (0.43)	0.88 (0.28)	0.87 (0.25)	0.87 (0.27)

P₂W₆	1.13 (0.78)	1.10 (0.73)	1.12 (0.75)	0.93 (0.38)	0.83 (0.40)	0.88 (0.39)	0.95 (0.41)	0.93 (0.37)	0.94 (0.39)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₂W₇	1.22 (1.02)	1.21 (0.97)	1.21 (1.00)	1.36 (1.36)	0.95 (1.20)	1.15 (1.28)	1.48 (1.68)	1.39 (1.45)	1.43 (1.56)	1.11 (0.75)	1.03 (0.59)	1.07 (0.67)
P₃W₁	1.07 (0.64)	0.99 (0.49)	1.03 (0.56)	0.98 (0.47)	1.30 (0.45)	1.14 (0.46)	1.16 (0.85)	1.12 (0.76)	1.14 (0.80)	0.99 (0.47)	0.91 (0.33)	0.95 (0.40)
P₃W₂	1.10 (0.71)	1.02 (0.55)	1.06 (0.63)	1.01 (0.52)	0.97 (0.48)	0.99 (0.50)	1.18 (0.89)	1.13 (0.80)	1.15 (0.84)	0.99 (0.48)	0.97 (0.45)	0.98 (0.46)
P₃W₃	0.89 (0.30)	0.83 (0.19)	0.86 (0.24)	0.87 (0.26)	0.99 (0.16)	0.93 (0.21)	1.06 (0.63)	1.06 (0.62)	1.06 (0.62)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₄	0.92 (0.35)	0.85 (0.22)	0.88 (0.28)	0.92 (0.36)	0.81 (0.37)	0.86 (0.37)	1.09 (0.70)	1.10 (0.73)	1.10 (0.71)	0.93 (0.37)	0.91 (0.33)	0.92 (0.35)
P₃W₅	1.33 (1.28)	1.27 (1.12)	1.30 (1.20)	0.87 (0.26)	0.93 (0.29)	0.90 (0.28)	1.07 (0.65)	1.10 (0.73)	1.08 (0.69)	0.87 (0.26)	0.89 (0.29)	0.88 (0.27)
P₃W₆	1.29 (1.17)	1.19 (0.91)	1.24 (1.04)	1.05 (0.65)	0.89 (0.54)	0.97 (0.60)	0.99 (0.49)	1.01 (0.52)	1.00 (0.50)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₃W₇	1.37 (1.38)	1.32 (1.26)	1.34 (1.32)	1.42 (1.53)	1.02 (1.63)	1.22 (1.58)	1.63 (2.31)	1.57 (2.12)	1.60 (2.22)	1.13 (0.79)	1.02 (0.55)	1.08 (0.67)
SEm± (PxW)	0.08	0.07	0.05	0.06	0.02	0.03	0.07	0.08	0.05	0.03	0.04	0.03
SEm± (WxP)	0.05	0.04	0.03	0.04	1.26	0.63	0.05	0.05	0.03	0.03	0.03	0.02
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded lowest weed dry weight (0.86, 0.79 g m⁻²). It was at par with W₄ (Pendimethalin 30EC @ 1kg ha⁻¹ fb interculture at 30 DAS) in both years and pooled values.

At 40 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest dry weight (0.86, 0.78 g m⁻²), it was at par with other treatments both year and pooled values except for W₇ (Weedy check).

At 60 DAS, hand weeding at 20 and 40 DAS (W₆) recorded significantly the lowest dry weight (0.96, 0.95 g m⁻²), followed by other treatments in both years and pooled values. At harvest, treatments W₆ and W₃ recorded significantly lowest weed dry weight in both years and pooled values (0.71 and 0.71 g m⁻²) compared to other treatments,

4.2.3.14.3 Interaction effect of sowing dates and integrated weed management on the dry weight of *Commelina benghalensis*

The data on the dry weight of *Commelina benghalensis* presented in Table 4.45 (b) shows that the interaction effect of sowing dates and integrated weed management were found to be non-significant during both years.

4.2.3.15 Grasses dry weight (g m⁻²)

The data on the dry weight of grasses as influenced by sowing dates and integrated weed management are given in Table 4.46 (a) and Table 4.46 (b). These measurement were taken at intervals of 20, 40, and 60 days after sowing (DAS), as well as at the point of harvest.

4.2.3.15.1 Effect of sowing dates on dry weight of grasses

Throughout all observation stages, except for the harvest stage, the differences in the dry weight of grasses due to sowing dates were statistically significant. The grasses consistently showed the lowest dry weight when sown on June 15 at every stage of observation. In contrast, sowing on July 15 led to the highest dry weight at 20, 40, and 60 days after sowing (DAS). Nevertheless, at the harvest stage, the variations were not statistically significant in both the individual years and the combined data.

Table 4.46(a): Effect of sowing dates and integrated weed management treatments on total dry weight (g m⁻²) of Grasses at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	2.96 (8.87)	2.57 (6.53)	2.77 (7.70)	2.81 (9.20)	2.49 (7.14)	2.65 (8.17)	4.39 (20.42)	4.14 (18.14)	4.27 (19.28)	3.88 (15.82)	3.64 (13.53)	3.76 (14.68)
P₂ 30th June	3.44 (11.89)	2.94 (8.66)	3.19 (10.28)	3.34 (12.48)	2.84 (9.01)	3.09 (10.74)	4.85 (24.82)	4.63 (22.25)	4.74 (23.53)	4.08 (17.16)	3.73 (14.16)	3.91 (15.66)
P₃ 15th July	4.34 (18.81)	3.76 (14.00)	4.05 (16.40)	4.06 (17.34)	3.63 (13.62)	3.84 (15.48)	5.80 (34.74)	5.33 (29.06)	5.56 (31.90)	4.13 (17.49)	3.77 (14.55)	3.95 (16.02)
SEm±	0.03	0.05	0.03	0.08	0.05	0.05	0.04	0.10	0.06	0.07	0.09	0.06
CD at 5%	0.11	0.21	0.10	0.32	0.18	0.15	0.15	0.41	0.18	NS	NS	NS
Integrated weed Management (W)												
W₁	3.31 (10.97)	2.91 (8.45)	3.11 (9.71)	3.13 (9.69)	2.74 (7.27)	2.93 (8.48)	5.01 (25.01)	4.74 (22.41)	4.88 (23.71)	4.21 (17.28)	4.00 (15.55)	4.11 (16.42)
W₂	3.56 (12.57)	2.98 (8.71)	3.27 (10.64)	3.29 (10.56)	2.82 (7.69)	3.05 (9.13)	5.21 (27.10)	4.94 (24.20)	5.08 (25.65)	4.46 (19.44)	4.29 (17.97)	4.38 (18.70)
W₃	2.57 (6.50)	2.25 (4.93)	2.41 (5.71)	2.27 (5.06)	2.06 (4.09)	2.16 (4.57)	3.97 (15.50)	3.80 (14.21)	3.88 (14.86)	3.18 (9.63)	2.90 (7.93)	3.04 (8.78)
W₄	2.75 (7.41)	2.38 (5.52)	2.57 (6.46)	2.66 (6.93)	2.31 (5.20)	2.48 (6.06)	4.75 (22.63)	4.47 (19.73)	4.61 (21.18)	3.87 (14.56)	3.70 (13.18)	3.79 (13.87)
W₅	4.26 (18.04)	3.63 (12.89)	3.95 (15.46)	2.46 (5.89)	2.19 (4.67)	2.32 (5.28)	4.6 (21.24)	4.3 (18.27)	4.45 (19.75)	3.43 (11.30)	3.12 (9.26)	3.27 (10.28)
W₆	4.05 (16.25)	3.45 (11.58)	3.75 (13.92)	3.73 (13.60)	3.28 (10.44)	3.50 (12.02)	3.69 (13.35)	3.51 (12.08)	3.60 (12.71)	2.92 (8.08)	2.66 (6.60)	2.79 (7.34)
W₇	4.55 (20.59)	4.03 (16.03)	4.29 (18.31)	6.29 (39.32)	5.51 (30.12)	5.9 (34.72)	7.87 (61.79)	7.16 (51.16)	7.51 (56.47)	6.14 (37.48)	5.33 (28.06)	5.74 (32.77)
SEm±	0.11	0.09	0.07	0.09	0.11	0.07	0.12	0.13	0.09	0.13	0.12	0.09
CD at 5%	0.33	0.27	0.21	0.27	0.30	0.20	0.35	0.37	0.25	0.38	0.34	0.25

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.46(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of Grasses.at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	2.64 (6.49)	2.31 (4.83)	2.47 (5.66)	2.47 (5.61)	2.21 (4.51)	2.34 (5.06)	4.34 (18.32)	4.17 (17.39)	4.25 (17.85)	4.13 (16.57)	3.96 (15.16)	4.04 (15.87)
P₁W₂	2.97 (8.31)	2.41 (5.31)	2.69 (6.81)	2.74 (6.98)	2.32 (4.90)	2.53 (5.94)	4.52 (19.91)	4.38 (18.69)	4.45 (19.30)	4.30 (18.01)	4.25 (17.57)	4.27 (17.79)
P₁W₃	1.87 (3.02)	1.71 (2.43)	1.79 (2.72)	1.61 (2.18)	1.54 (1.91)	1.57 (2.04)	3.22 (11.83)	2.93 (10.16)	3.07 (10.99)	2.96 (8.26)	2.79 (7.27)	2.87 (7.77)
P₁W₄	2.13 (4.05)	1.82 (2.80)	1.97 (3.42)	1.99 (3.46)	1.73 (2.55)	1.86 (3.00)	3.99 (15.41)	3.85 (14.32)	3.92 (14.86)	3.68 (13.09)	3.61 (12.53)	3.65 (12.81)
P₁W₅	3.63 (12.71)	3.11 (9.18)	3.37 (10.94)	1.79 (2.71)	1.65 (2.24)	1.72 (2.48)	3.84 (14.28)	3.69 (13.14)	3.77 (13.71)	3.20 (9.76)	3.05 (8.86)	3.13 (9.31)
P₁W₆	3.39 (10.99)	3.04 (8.74)	3.21 (9.87)	3.24 (9.99)	2.82 (7.49)	3.03 (8.74)	3.51 (9.84)	3.26 (8.13)	3.39 (8.99)	2.75 (7.12)	2.62 (6.38)	2.69 (6.75)
P₁W₇	4.11 (16.54)	3.60 (12.43)	3.85 (14.48)	5.82 (33.47)	5.15 (26.39)	5.49 (29.93)	7.32 (53.33)	6.73 (45.14)	7.02 (49.23)	6.17 (37.93)	5.23 (26.92)	5.70 (32.43)
P₂W₁	3.14 (9.38)	2.70 (6.78)	2.92 (8.08)	3.07 (8.98)	2.60 (6.29)	2.84 (7.63)	4.86 (23.12)	4.76 (22.24)	4.81 (22.68)	4.25 (17.57)	4.03 (15.73)	4.14 (16.65)
P₂W₂	3.37 (10.86)	2.80 (7.33)	3.08 (9.09)	3.20 (9.75)	2.67 (6.70)	2.94 (8.22)	5.00 (24.52)	4.89 (23.39)	4.94 (23.95)	4.46 (19.54)	4.27 (17.76)	4.37 (18.65)
P₂W₃	2.40 (5.28)	1.99 (3.47)	2.20 (4.37)	2.19 (4.44)	1.82 (2.88)	2.01 (3.66)	3.57 (13.64)	3.41 (12.97)	3.49 (13.30)	3.26 (10.14)	2.93 (8.09)	3.09 (9.11)
P₂W₄	2.59 (6.23)	2.18 (4.24)	2.38 (5.23)	2.51 (5.83)	2.10 (3.94)	2.31 (4.88)	4.56 (20.38)	4.39 (18.74)	4.47 (19.56)	3.97 (15.28)	3.78 (13.80)	3.87 (14.54)
P₂W₅	4.22 (17.30)	3.57 (12.23)	3.89 (14.77)	2.37 (5.13)	1.98 (3.55)	2.18 (4.34)	4.36 (18.57)	4.22 (17.30)	4.29 (17.94)	3.45 (11.46)	3.10 (9.18)	3.28 (10.32)

P₂W₆	3.93 (14.98)	3.35 (10.75)	3.64 (12.87)	3.66 (12.88)	3.19 (9.68)	3.42 (11.28)	3.75 (12.25)	3.67 (11.10)	3.71 (11.68)	3.04 (8.73)	2.69 (6.73)	2.86 (7.73)
P₂W₇	4.41 (19.21)	4.01 (15.84)	4.21 (17.52)	6.38 (40.34)	5.52 (30.02)	5.95 (35.18)	7.85 (61.23)	7.09 (50.02)	7.47 (55.63)	6.13 (37.39)	5.32 (27.83)	5.73 (32.61)
P₃W₁	4.15 (17.02)	3.73 (13.74)	3.94 (15.38)	3.86 (14.48)	3.39 (11.01)	3.63 (12.75)	5.84 (33.59)	5.30 (27.59)	5.57 (30.59)	4.26 (17.70)	4.03 (15.76)	4.15 (16.73)
P₃W₂	4.35 (18.55)	3.73 (13.50)	4.04 (16.03)	3.93 (14.96)	3.46 (11.47)	3.69 (13.21)	6.10 (36.87)	5.57 (30.51)	5.83 (33.69)	4.61 (20.76)	4.36 (18.58)	4.49 (19.67)
P₃W₃	3.42 (11.20)	3.04 (8.88)	3.23 (10.04)	3.01 (8.56)	2.82 (7.46)	2.91 (8.01)	4.29 (21.05)	4.18 (19.50)	4.24 (20.28)	3.31 (10.48)	2.99 (8.44)	3.15 (9.46)
P₃W₄	3.53 (11.96)	3.15 (9.51)	3.34 (10.74)	3.46 (11.51)	3.10 (9.10)	3.28 (10.31)	5.70 (32.09)	5.16 (26.14)	5.43 (29.12)	3.98 (15.30)	3.70 (13.22)	3.84 (14.26)
P₃W₅	4.94 (24.12)	4.21 (17.25)	4.58 (20.69)	3.20 (9.81)	2.95 (8.21)	3.08 (9.01)	5.59 (30.86)	4.99 (24.37)	5.29 (27.61)	3.63 (12.68)	3.20 (9.74)	3.41 (11.21)
P₃W₆	4.82 (22.77)	3.97 (15.26)	4.39 (19.01)	4.28 (17.91)	3.82 (14.16)	4.05 (16.04)	4.64 (17.95)	4.47 (16.99)	4.55 (17.47)	2.98 (8.39)	2.68 (6.70)	2.83 (7.54)
P₃W₇	5.14 (26.01)	4.50 (19.84)	4.82 (22.92)	6.66 (44.17)	5.85 (33.94)	6.26 (39.05)	8.43 (70.80)	7.66 (58.31)	8.04 (64.55)	6.13 (37.11)	5.43 (29.43)	5.78 (33.27)
SEm± (PxW)	0.20	0.16	0.13	0.16	0.18	0.12	0.19	0.18	0.13	0.16	0.12	0.10
SEm± (WxP)	0.10	0.12	0.08	0.15	0.11	0.10	0.10	0.19	0.11	0.14	0.17	0.11
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

4.2.3.15.2 Effect of integrated weed management on the dry weight of grasses

Integrated weed management influenced the dry weight of grasses significantly. Weedy check recorded significantly the highest dry weight during all the stages of observation. At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded the lowest weed dry weight. This was at par with W₄ (Pendimethalin 30 EC @1kg ha⁻¹ fb interculture at 30 DAS) in both years and pooled values. Pendimethalin is known to be absorbed by germinating weeds, disrupting cell division, particularly the mitotic process, primarily in the meristematic tissue of weeds, which are responsible for lateral and secondary root formation. Zain *et al.* (2020) also reported similar results.

Application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest dry weight (2.27, 2.06 g m⁻²) at 40 DAS. This was par with treatments W₅ in both years and pooled values and W₄ during the second year. Similar results were also obtained by Kutariye *et al.* (2021) with the application of post-emergence on weed density and dry weight.

However, at 60 DAS and harvest, W₆ (hand weeding at 20 and 40 DAS) recorded significantly the lowest pooled value of the dry weight 3.60 g m⁻² and 2.79 g m⁻², respectively in both years and pooled values. This treatment was statistically at par with W₃ at 60 DAS in both years and at harvest in the first year only. These findings are consistent with those reported by Meena *et al.* (2022).

4.2.3.15.3 Interaction effect of sowing dates and integrated weed management on the dry weight of grasses

Table 4.46 (b) showed that the interaction effect of the sowing dates and integrated weed management was found to be non-significant during both years.

4.2.3.16 Sedges dry weight (g m⁻²)

Table 4.47 (a) and Table 4.47 (b) present the dry weight measurements of sedges, which are impacted by the time of sowing and the implementation of integrated weed management strategies. These measurements were recorded at intervals of 20, 40, and 60 days after sowing (DAS), as well as at the point of harvest.

4.2.3.16.1 Effect of dates of sowing on the dry weight of sedges

There was a significant variation in the dry mass of sedges across different sowing dates at 20, 40, and 60 days after sowing (DAS); however, at harvest the differences were not statistically significant in both individual years and pooled values. Soybean sown on early on June 15th consistently exhibited the lower dry weight of sedge-weed (1.43, 1.36 g m⁻²) in both years and pooled values. This outcome was at par to the result from June 30th in the second year. Conversely, the highest values were observed under the 15th July at 20 DAS.

During 40 and 60 DAS, the highest total dry weight of sedges (1.24, 1.12 g m⁻²) and (1.63, 1.27 g m⁻²) was recorded on 15th June and was at par with the sowing date of 30th June in the first year for both days of observation i.e., 40, 60 DAS. The highest total dry weight of sedges in all the stages was recorded under treatment weedy check (W₇). The higher dry mass of sedges with later sowing could be attributed to the higher concentration of weeds and their dominance in utilizing limited resources.

4.2.3.16.2 Effect of integrated weed management on the dry weight of sedges

Throughout all stages of observation, the data concerning the dry weight of sedges demonstrated significant outcomes attributable to integrated weed management strategies. At 20 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded the lowest weed dry weight (1.25, 1.19 g m⁻²). It was at par with treatment W₄ (Pendimethalin 30EC @ 1 kg⁻¹ fb by interculture at 30 DAS) in both years and pooled values.

At 40 DAS, application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded significantly lowest dry weight (1.10, 1.05 g m⁻²) and was at par with W₅ in both years and pooled values and W₄ in second year. Shwetha *et al.* (2024) also observed a significant decrease in the dry weight of monocot weeds with the use of a post-emergence herbicide.

However, at 60 DAS and harvest, treatment W₆ (Hand weeding at 20 and 40 DAS) recorded the lowest dry weight significantly in both the years and pooled values (0.84 g m⁻² and 0.75 g m⁻², respectively). In contrast, the weedy check consistently exhibited a significantly greater dry weight compared to other treatments at all observation stages. The reduction in dry weight of sedges in these weed management

Table 4.47(a): Effect of sowing dates and integrated weed management treatments on total dry weight (g m⁻²) of Sedges at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	1.43 (1.57)	1.36 (1.38)	1.39 (1.48)	1.24 (1.11)	1.12 (0.85)	1.18 (0.98)	1.63 (2.47)	1.27 (1.45)	1.45 (1.96)	1.33 (1.42)	1.27 (1.26)	1.30 (1.34)
P₂ 30th June	1.56 (1.98)	1.45 (1.64)	1.50 (1.81)	1.29 (1.24)	1.31 (1.31)	1.30 (1.27)	1.47 (2.04)	1.45 (1.96)	1.46 (2.00)	1.35 (1.49)	1.30 (1.32)	1.33 (1.40)
P₃ 15th July	1.73 (2.61)	1.63 (2.26)	1.68 (2.43)	1.62 (2.25)	1.49 (1.84)	1.56 (2.05)	1.61 (2.43)	1.72 (2.85)	1.67 (2.64)	1.41 (1.63)	1.34 (1.41)	1.37 (1.52)
SEm±	0.02	0.02	0.02	0.04	0.02	0.02	0.04	0.01	0.02	0.02	0.03	0.02
CD at 5%	0.09	0.09	0.05	0.16	0.10	0.08	0.15	0.06	0.07	NS	NS	NS
Integrated weed Management (W)												
W₁	1.54 (1.90)	1.45 (1.63)	1.50 (1.76)	1.31 (1.25)	1.23 (1.04)	1.27 (1.15)	1.62 (2.14)	1.58 (2.06)	1.60 (2.10)	1.47 (1.66)	1.43 (1.54)	1.45 (1.60)
W₂	1.56 (1.95)	1.49 (1.72)	1.52 (1.83)	1.33 (1.31)	1.24 (1.07)	1.29 (1.19)	1.65 (2.23)	1.59 (2.09)	1.62 (2.16)	1.52 (1.82)	1.45 (1.59)	1.48 (1.71)
W₃	1.25 (1.08)	1.19 (.91)	1.22 (1.00)	1.10 (0.73)	1.05 (0.61)	1.07 (0.67)	1.24 (1.06)	1.14 (0.87)	1.19 (0.96)	1.14 (0.81)	1.09 (0.70)	1.12 (0.76)
W₄	1.30 (1.20)	1.23 (1.01)	1.26 (1.11)	1.26 (1.12)	1.14 (.82)	1.20 (.97)	1.41 (1.50)	1.36 (1.42)	1.39 (1.46)	1.32 (1.25)	1.28 (1.15)	1.30 (1.20)
W₅	1.77 (2.69)	1.66 (2.33)	1.71 (2.51)	1.15 (0.84)	1.08 (0.68)	1.11 (0.76)	1.29 (1.19)	1.19 (1.00)	1.24 (1.10)	1.20 (0.95)	1.16 (0.84)	1.18 (0.90)
W₆	1.71 (2.46)	1.60 (2.08)	1.66 (2.27)	1.55 (1.93)	1.45 (1.63)	1.50 (1.78)	0.92 (0.38)	0.75 (0.08)	0.84 (0.23)	0.76 (0.09)	0.74 (0.05)	0.75 (0.07)
W₇	1.87 (3.10)	1.75 (2.62)	1.81 (2.86)	1.99 (3.55)	1.97 (3.48)	1.98 (3.52)	2.86 (7.68)	2.74 (7.08)	2.80 (7.38)	2.12 (4.02)	1.97 (3.43)	2.05 (3.72)
SEm±	0.07	0.05	0.04	0.05	0.05	0.03	0.04	0.06	0.04	0.02	0.04	0.02
CD at 5%	0.19	0.15	0.12	0.13	0.14	0.10	0.11	0.17	0.10	0.05	0.11	0.06

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.47(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of Sedges at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	1.39 (1.43)	1.34 (1.31)	1.37 (1.37)	1.16 (0.84)	1.05 (0.60)	1.10 (0.72)	1.67 (2.30)	1.33 (1.27)	1.50 (1.79)	1.44 (1.57)	1.41 (1.49)	1.42 (1.53)
P₁W₂	1.40 (1.47)	1.38 (1.40)	1.39 (1.43)	1.17 (0.88)	1.02 (0.54)	1.10 (0.71)	1.68 (2.32)	1.35 (1.33)	1.51 (1.83)	1.49 (1.73)	1.43 (1.55)	1.46 (1.64)
P₁W₃	1.15 (0.83)	1.12 (0.75)	1.14 (0.79)	0.98 (0.47)	0.89 (0.29)	0.94 (0.38)	1.33 (1.29)	0.88 (0.28)	1.11 (0.79)	1.09 (0.70)	1.05 (0.61)	1.07 (0.65)
P₁W₄	1.19 (0.92)	1.16 (0.84)	1.17 (0.88)	1.11 (0.74)	0.96 (0.42)	1.04 (0.58)	1.48 (1.69)	1.11 (0.76)	1.30 (1.23)	1.28 (1.14)	1.25 (1.07)	1.27 (1.10)
P₁W₅	1.60 (2.05)	1.50 (1.77)	1.55 (1.91)	1.03 (0.55)	0.90 (0.31)	0.96 (0.43)	1.36 (1.39)	0.93 (0.40)	1.15 (0.89)	1.17 (0.87)	1.13 (0.78)	1.15 (0.82)
P₁W₆	1.56 (1.92)	1.48 (1.69)	1.52 (1.81)	1.39 (1.45)	1.25 (1.06)	1.32 (1.25)	1.00 (0.50)	0.71 (0.00)	0.85 (0.25)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
P₁W₇	1.70 (2.39)	1.55 (1.92)	1.63 (2.15)	1.82 (2.86)	1.79 (2.74)	1.81 (2.80)	2.88 (7.79)	2.56 (6.07)	2.72 (6.93)	2.10 (3.94)	1.92 (3.30)	2.01 (3.62)
P₂W₁	1.53 (1.85)	1.43 (1.55)	1.48 (1.70)	1.21 (0.96)	1.23 (1.02)	1.22 (0.99)	1.55 (1.94)	1.54 (1.90)	1.54 (1.92)	1.46 (1.62)	1.43 (1.53)	1.44 (1.58)
P₂W₂	1.55 (1.89)	1.46 (1.64)	1.50 (1.76)	1.22 (0.99)	1.27 (1.11)	1.24 (1.05)	1.56 (1.94)	1.55 (1.91)	1.55 (1.93)	1.51 (1.79)	1.44 (1.57)	1.48 (1.68)
P₂W₃	1.25 (1.06)	1.18 (0.90)	1.21 (0.98)	1.02 (0.55)	1.04 (0.59)	1.03 (0.57)	1.15 (0.83)	1.11 (0.73)	1.13 (0.78)	1.13 (0.78)	1.09 (0.70)	1.11 (0.74)
P₂W₄	1.29 (1.15)	1.21 (0.98)	1.25 (1.07)	1.16 (0.85)	1.14 (0.80)	1.15 (0.82)	1.33 (1.27)	1.37 (1.39)	1.35 (1.33)	1.31 (1.22)	1.28 (1.14)	1.30 (1.18)
P₂W₅	1.75 (2.56)	1.61 (2.10)	1.68 (2.33)	1.06 (0.63)	1.08 (0.67)	1.07 (0.65)	1.21 (0.96)	1.15 (0.86)	1.18 (0.91)	1.19 (0.92)	1.17 (0.86)	1.18 (0.89)

P₂W₆	1.71 (2.45)	1.56 (1.95)	1.64 (2.20)	1.44 (1.57)	1.46 (1.65)	1.45 (1.61)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.76 (0.07)	0.71 (0.00)	0.73 (0.04)
P₂W₇	1.85 (2.91)	1.68 (2.37)	1.77 (2.64)	1.90 (3.11)	1.93 (3.34)	1.92 (3.23)	2.79 (7.30)	2.72 (6.93)	2.76 (7.11)	2.12 (4.01)	1.97 (3.42)	2.05 (3.72)
P₃W₁	1.71 (2.41)	1.59 (2.04)	1.65 (2.23)	1.57 (1.96)	1.41 (1.50)	1.49 (1.73)	1.63 (2.18)	1.86 (3.02)	1.75 (2.60)	1.51 (1.78)	1.45 (1.60)	1.48 (1.69)
P₃W₂	1.72 (2.49)	1.62 (2.12)	1.67 (2.30)	1.59 (2.05)	1.44 (1.57)	1.52 (1.81)	1.71 (2.42)	1.88 (3.04)	1.79 (2.73)	1.56 (1.94)	1.47 (1.65)	1.51 (1.79)
P₃W₃	1.35 (1.34)	1.26 (1.09)	1.31 (1.22)	1.29 (1.17)	1.20 (0.96)	1.25 (1.07)	1.25 (1.06)	1.44 (1.59)	1.34 (1.32)	1.21 (0.96)	1.14 (0.81)	1.18 (0.89)
P₃W₄	1.42 (1.53)	1.31 (1.21)	1.36 (1.37)	1.51 (1.77)	1.32 (1.25)	1.42 (1.51)	1.43 (1.56)	1.61 (2.10)	1.52 (1.83)	1.37 (1.38)	1.32 (1.23)	1.34 (1.31)
P₃W₅	1.95 (3.46)	1.87 (3.13)	1.91 (3.29)	1.36 (1.35)	1.25 (1.06)	1.30 (1.21)	1.31 (1.22)	1.49 (1.75)	1.40 (1.48)	1.24 (1.05)	1.18 (0.89)	1.21 (0.97)
P₃W₆	1.87 (3.02)	1.76 (2.62)	1.82 (2.82)	1.81 (2.76)	1.63 (2.18)	1.72 (2.47)	1.07 (0.64)	0.83 (0.22)	0.95 (0.43)	0.83 (0.19)	0.80 (0.15)	0.81 (0.17)
P₃W₇	2.06 (3.99)	2.00 (3.58)	2.03 (3.79)	2.23 (4.67)	2.18 (4.37)	2.20 (4.52)	2.91 (7.96)	2.95 (8.24)	2.93 (8.10)	2.14 (4.10)	2.01 (3.57)	2.08 (3.83)
SEm± (PxW)	0.11	0.09	0.07	0.08	0.09	0.06	0.07	0.10	0.06	0.03	0.07	0.04
SEm± (WxP)	0.06	0.06	0.04	0.08	0.06	0.05	0.07	0.05	0.04	0.03	0.06	0.04
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x} + 0.5$ transformation.

practices may be attributed to the broad spectrum and season-long weed control provided by the application of herbicides and hand weeding. Meena *et al.* (2022) also reported similar results in lower biomass of sedges with two instances hand weeding compared to other treatments.

4.2.3.16.3 Interaction effect of sowing dates and integrated weed management on the dry weight of sedges

The study found no significant effect on the dry weight of sedges presented in Table 4.47 (b) due to the interaction effect of sowing dates and integrated weed management in both the years and pooled values.

4.2.3.17 Broad-leaved weeds dry weight (g m^{-2})

The data on the dry weight of broad-leaved weeds as influenced by the dates of sowing and integrated weed management recorded at 20, 40, and 60 DAS and harvest are presented in Table 4.48 (a) and Table 4.48 (b).

4.2.3.17.1 Effect of sowing dates on dry weight of broad-leaved weeds

Data regarding the dry weight of broad-leaved weeds revealed that there was a significant effect due to the dates of sowing at different stages of observation except at harvest. Sowing of soybean on 15th June recorded significantly lowest pooled values of total dry weight at 20 DAS (1.98 g m^{-2}), 40 DAS (1.71 g m^{-2}) and 60 DAS (3.02 g m^{-2}) compared to other dates of sowing. The highest pooled values of the broad-leaved dry weight of weeds were observed on the sowing date of 15th July at all the stages of observation.

4.2.3.17.2 Effect of integrated weed management on dry weight of broad-leaved weeds

Variations in dry weight of broad-leaved weeds were found to be significant due to integrated weed management. Application of pendimethalin 30 EC @ 1 kg ha^{-1} fb imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS (W₃) significantly reduced dry weight of weeds in both years and pooled values at 20 and 40 DAS and par with W₄ during the second year at 20 DAS and W₅ during the first year at 40 DAS. A similar result was obtained by Kutariye *et al.* (2021).

Table 4.48(a): Effect of sowing dates and integrated weed management treatments on dry weight (g m⁻²) of broad-leaved weeds at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	2.07 (3.98)	1.88 (3.27)	1.98 (3.62)	1.71 (2.87)	1.70 (2.78)	1.71 (2.83)	3.14 (10.57)	2.89 (8.70)	3.02 (9.63)	2.48 (6.72)	2.31 (5.74)	2.39 (6.23)
P₂ 30th June	2.37 (5.33)	2.20 (4.63)	2.29 (4.98)	2.03 (4.04)	1.88 (3.42)	1.96 (3.73)	3.58 (13.34)	3.26 (10.88)	3.42 (12.11)	2.57 (7.32)	2.41 (6.29)	2.49 (6.81)
P₃ 15th July	2.77 (7.43)	2.58 (6.47)	2.68 (6.95)	2.48 (6.16)	2.20 (4.79)	2.34 (5.47)	4.12 (17.61)	3.82 (15.03)	3.97 (16.32)	2.67 (7.77)	2.46 (6.61)	2.57 (7.19)
SEm±	0.01	0.04	0.02	0.04	0.03	0.02	0.04	0.04	0.03	0.05	0.04	0.03
CD at 5%	0.05	0.16	0.07	0.14	0.10	0.07	0.17	0.15	0.09	NS	NS	NS
Integrated weed Management (W)												
W₁	2.30 (4.89)	2.13 (4.11)	2.22 (4.50)	1.90 (3.21)	1.77 (2.67)	1.83 (2.94)	3.88 (14.67)	3.53 (12.14)	3.70 (13.40)	2.75 (7.05)	2.57 (6.09)	2.66 (6.57)
W₂	2.42 (5.45)	2.20 (4.40)	2.31 (4.93)	1.99 (3.61)	1.84 (2.94)	1.92 (3.27)	4.09 (16.36)	3.87 (14.70)	3.98 (15.53)	2.96 (8.29)	2.75 (7.07)	2.86 (7.68)
W₃	1.70 (2.46)	1.53 (1.92)	1.62 (2.19)	1.45 (1.67)	1.30 (1.24)	1.37 (1.45)	2.70 (7.00)	2.62 (6.48)	2.66 (6.74)	1.81 (2.80)	1.66 (2.26)	1.73 (2.53)
W₄	1.85 (2.99)	1.62 (2.18)	1.73 (2.58)	1.76 (2.68)	1.65 (2.25)	1.70 (2.46)	3.26 (10.26)	3.18 (9.78)	3.22 (10.02)	2.44 (5.47)	2.25 (4.56)	2.34 (5.01)
W₅	2.84 (7.70)	2.70 (6.93)	2.77 (7.31)	1.56 (2.02)	1.46 (1.68)	1.51 (1.85)	3.08 (9.18)	2.79 (7.40)	2.93 (8.29)	1.94 (3.26)	1.81 (2.77)	1.87 (3.01)
W₆	2.69 (6.84)	2.40 (5.35)	2.54 (6.09)	2.31 (4.98)	2.14 (4.16)	2.23 (4.57)	2.50 (5.95)	2.19 (4.44)	2.35 (5.19)	1.30 (1.21)	1.25 (1.06)	1.28 (1.14)
W₇	3.02 (8.73)	3.00 (8.63)	3.01 (8.68)	3.56 (12.33)	3.33 (10.71)	3.45 (11.52)	5.79 (33.48)	5.10 (25.82)	5.45 (29.65)	4.81 (22.82)	4.48 (19.71)	4.64 (21.26)
SEm±	0.04	0.05	0.03	0.05	0.04	0.03	0.09	0.07	0.06	0.07	0.06	0.04
CD at 5%	0.12	0.14	0.09	0.13	0.12	0.09	0.26	0.20	0.16	0.19	0.16	0.12

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.48(b): Interaction effect of sowing dates and integrated weed management treatments on weed dry weight (g m⁻²) of Broad-leaved at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	2.00 (3.48)	1.81 (2.78)	1.90 (3.13)	1.55 (1.89)	1.55 (1.90)	1.55 (1.90)	3.46 (11.51)	3.04 (8.74)	3.25 (10.12)	2.66 (6.60)	2.47 (5.62)	2.57 (6.11)
P₁W₂	2.10 (3.93)	1.87 (3.00)	1.99 (3.46)	1.60 (2.07)	1.63 (2.15)	1.61 (2.11)	3.71 (13.28)	3.37 (10.84)	3.54 (12.06)	2.89 (7.86)	2.69 (6.74)	2.79 (7.30)
P₁W₃	1.44 (1.57)	1.23 (1.02)	1.34 (1.29)	1.13 (0.78)	1.06 (0.63)	1.09 (0.70)	2.16 (4.18)	2.19 (4.31)	2.18 (4.24)	1.71 (2.44)	1.64 (2.21)	1.68 (2.32)
P₁W₄	1.57 (1.97)	1.35 (1.33)	1.46 (1.65)	1.41 (1.49)	1.45 (1.61)	1.43 (1.55)	2.80 (7.36)	2.75 (7.14)	2.78 (7.25)	2.34 (5.00)	2.17 (4.22)	2.26 (4.61)
P₁W₅	2.43 (5.42)	2.28 (4.72)	2.36 (5.07)	1.21 (0.97)	1.21 (0.97)	1.21 (0.97)	2.58 (6.14)	2.37 (5.10)	2.47 (5.62)	1.86 (2.94)	1.70 (2.40)	1.78 (2.67)
P₁W₆	2.33 (4.92)	2.00 (3.53)	2.17 (4.23)	1.91 (3.15)	1.90 (3.10)	1.90 (3.13)	1.99 (3.46)	1.82 (2.80)	1.90 (3.13)	1.21 (0.96)	1.17 (0.87)	1.19 (0.92)
P₁W₇	2.65 (6.55)	2.64 (6.49)	2.65 (6.52)	3.20 (9.78)	3.10 (9.12)	3.15 (9.45)	5.32 (28.05)	4.72 (21.95)	5.02 (25.00)	4.65 (21.25)	4.31 (18.14)	4.48 (19.69)
P₂W₁	2.26 (4.61)	2.08 (3.85)	2.17 (4.23)	1.80 (2.75)	1.73 (2.50)	1.77 (2.63)	3.83 (14.18)	3.51 (11.86)	3.67 (13.02)	2.76 (7.12)	2.61 (6.31)	2.68 (6.72)
P₂W₂	2.41 (5.30)	2.16 (4.16)	2.28 (4.73)	1.92 (3.19)	1.81 (2.78)	1.87 (2.99)	4.07 (16.07)	3.83 (14.18)	3.95 (15.13)	2.97 (8.34)	2.77 (7.17)	2.87 (7.75)
P₂W₃	1.68 (2.31)	1.54 (1.87)	1.61 (2.09)	1.44 (1.57)	1.26 (1.10)	1.35 (1.33)	2.69 (6.72)	2.59 (6.21)	2.64 (6.47)	1.77 (2.65)	1.64 (2.19)	1.71 (2.42)
P₂W₄	1.83 (2.85)	1.56 (1.93)	1.69 (2.39)	1.71 (2.43)	1.62 (2.14)	1.67 (2.29)	3.21 (9.83)	3.11 (9.21)	3.16 (9.52)	2.45 (5.50)	2.26 (4.62)	2.36 (5.06)
P₂W₅	2.80 (7.39)	2.68 (6.74)	2.74 (7.07)	1.56 (1.92)	1.45 (1.60)	1.50 (1.76)	3.04 (8.77)	2.73 (6.95)	2.89 (7.86)	1.92 (3.20)	1.85 (2.91)	1.88 (3.05)

P₂W₆	2.65 (6.53)	2.37 (5.14)	2.51 (5.84)	2.22 (4.44)	2.09 (3.86)	2.15 (4.15)	2.47 (5.61)	2.14 (4.09)	2.31 (4.85)	1.28 (1.14)	1.27 (1.10)	1.27 (1.12)
P₂W₇	2.96 (8.31)	3.03 (8.72)	3.00 (8.51)	3.52 (11.96)	3.23 (9.94)	3.38 (10.95)	5.71 (32.23)	4.91 (23.68)	5.31 (27.95)	4.86 (23.28)	4.49 (19.76)	4.67 (21.52)
P₃W₁	2.66 (6.57)	2.49 (5.70)	2.57 (6.14)	2.34 (4.99)	2.03 (3.61)	2.18 (4.30)	4.34 (18.32)	4.04 (15.82)	4.19 (17.07)	2.81 (7.42)	2.62 (6.35)	2.72 (6.88)
P₃W₂	2.76 (7.12)	2.56 (6.06)	2.66 (6.59)	2.46 (5.55)	2.09 (3.88)	2.28 (4.71)	4.49 (19.73)	4.42 (19.06)	4.46 (19.39)	3.03 (8.68)	2.79 (7.30)	2.91 (7.99)
P₃W₃	2.00 (3.50)	1.83 (2.87)	1.92 (3.19)	1.78 (2.67)	1.57 (1.99)	1.68 (2.33)	3.25 (10.10)	3.07 (8.92)	3.16 (9.51)	1.95 (3.31)	1.69 (2.37)	1.82 (2.84)
P₃W₄	2.16 (4.15)	1.94 (3.26)	2.05 (3.71)	2.15 (4.13)	1.87 (2.98)	2.01 (3.56)	3.75 (13.59)	3.67 (13.00)	3.71 (13.29)	2.53 (5.90)	2.31 (4.84)	2.42 (5.37)
P₃W₅	3.28 (10.28)	3.13 (9.32)	3.21 (9.80)	1.91 (3.16)	1.72 (2.48)	1.82 (2.82)	3.62 (12.62)	3.26 (10.15)	3.44 (11.39)	2.04 (3.65)	1.87 (2.99)	1.95 (3.32)
P₃W₆	3.09 (9.06)	2.81 (7.39)	2.95 (8.22)	2.80 (7.35)	2.45 (5.50)	2.62 (6.43)	3.05 (8.79)	2.62 (6.42)	2.83 (7.60)	1.42 (1.52)	1.31 (1.21)	1.37 (1.37)
P₃W₇	3.43 (11.34)	3.34 (10.69)	3.39 (11.02)	3.96 (15.25)	3.67 (13.06)	3.81 (14.15)	6.34 (40.16)	5.68 (31.84)	6.01 (36.00)	4.92 (23.93)	4.64 (21.22)	4.78 (22.57)
SEm± (PxW)	0.07	0.08	0.05	0.08	0.08	0.06	0.16	0.12	0.10	0.12	0.10	0.08
SEm± (WxP)	0.04	0.08	0.04	0.07	0.06	0.04	0.10	0.08	0.07	0.10	0.09	0.07
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

However, at 60 DAS and harvest, the significantly lowest dry weight of broad-leaved weed was recorded with hand weeding at 20 and 40 DAS (W_6) in both years (2.50, 2.19 g m⁻² and 1.30, 1.25 g m⁻², respectively) and pooled values (2.35 g m⁻² and 1.28 g m⁻², respectively). Conversely, the weedy check (W_7) exhibited significantly the highest dry mass of broad-leaved in both years and pooled values at all observation stages. These findings align with those reported by Virk *et al.* (2018) and Meena *et al.* (2022).

4.2.3.17.3 Interaction effect of sowing dates and integrated weed management on the dry weight of broad-leaved weeds

As indicated by the data in Table 4.48 (b), the interaction between sowing dates and integrated weed management was not statistically significant in either year.

4.2.3.18 Total dry weight of weeds (g m⁻²)

The data on total weed dry weight as influenced by sowing dates and integrated weed management recorded at 20, 40, and 60 DAS and at harvest are presented in Table 4.49 (a) and Table 4.49 (b), Figure 4.5 and Figure 4.6.

4.2.3.18.1 Effect of sowing dates on the total dry weight of weeds

Different dates of sowing showed a significant effect on total weed dry weight at different stages of observation in both years. Late sowing of soybean on 15th July recorded significantly higher total dry weight while significantly minimum total dry weight was observed when the crop was sown on 15th June.

Early sowing of soybean on the 15th of June decreased the dry weight of weeds by 10.99% and 28% over the 30th of June and 15th of July, respectively. Weed dry matter increased with time advancement. This could be attributed to the minimum density of grasses, sedges and broad-leaved weeds, which led to lower utilization of limited resources, resulting in lower dry weight of weeds. Sai *et al.* (2019) and Hamoda *et al.* (2021) observed similar findings in lower weed dry weight in early sowing dates. Akter *et al.* (2016) also reported that late planting increased the accumulation of weed dry matter, while early planting reduced it.

Table 4.49(a): Effect of sowing dates and integrated weed management treatments on total weed dry weight (g m⁻²) at 20,40,60 DAS and harvest

Treatment	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	3.75 (14.42)	3.32 (11.18)	3.53 (12.80)	3.36 (13.19)	3.05 (10.78)	3.20 (11.98)	5.55 (33.45)	5.12 (28.28)	5.34 (30.87)	4.69 (23.97)	4.39 (20.53)	4.54 (22.25)
P₂ 30th June	4.34 (19.20)	3.82 (14.93)	4.08 (17.07)	3.99 (17.75)	3.51 (13.73)	3.75 (15.74)	6.13 (40.20)	5.77 (35.09)	5.95 (37.65)	4.92 (25.97)	4.53 (21.77)	4.72 (23.87)
P₃ 15th July	5.34 (28.84)	4.75 (22.72)	5.05 (25.78)	4.93 (25.75)	4.38 (20.25)	4.65 (23.00)	7.23 (54.79)	6.72 (46.94)	6.97 (50.87)	5.02 (26.89)	4.60 (22.58)	4.81 (24.74)
SEm±	0.02	0.04	0.02	0.08	0.03	0.04	0.03	0.06	0.04	0.07	0.09	0.06
CD at 5%	0.09	0.16	0.08	0.30	0.11	0.13	0.13	0.25	0.12	NS	NS	NS
Integrated weed Management (W)												
W₁	4.21 (17.75)	3.77 (14.19)	3.99 (15.97)	3.76 (14.15)	3.34 (10.99)	3.55 (12.57)	6.47 (41.82)	6.04 (36.61)	6.26 (39.22)	5.14 (25.99)	4.87 (23.19)	5.00 (24.59)
W₂	4.47 (19.97)	3.86 (14.83)	4.17 (17.40)	3.94 (15.48)	3.45 (11.70)	3.69 (13.59)	6.76 (45.69)	6.40 (40.99)	6.58 (43.34)	5.48 (29.55)	5.21 (26.63)	5.34 (28.09)
W₃	3.17 (10.03)	2.80 (7.76)	2.99 (8.90)	2.73 (7.46)	2.45 (5.94)	2.59 (6.70)	4.86 (23.56)	4.65 (21.56)	4.75 (22.56)	3.70 (13.24)	3.37 (10.89)	3.54 (12.07)
W₄	3.42 (11.60)	2.97 (8.70)	3.19 (10.15)	3.27 (10.74)	2.90 (8.27)	3.08 (9.50)	5.85 (34.39)	5.56 (30.94)	5.71 (32.66)	4.66 (21.27)	4.4 (18.89)	4.53 (20.08)
W₅	5.33 (28.43)	4.72 (22.14)	5.02 (25.29)	2.96 (8.75)	2.67 (7.03)	2.81 (7.89)	5.60 (31.61)	5.17 (26.67)	5.38 (29.14)	3.99 (15.51)	3.65 (12.87)	3.82 (14.19)
W₆	5.05 (25.55)	4.38 (19.02)	4.72 (22.28)	4.54 (20.50)	4.06 (16.23)	4.30 (18.36)	4.45 (19.68)	4.08 (16.59)	4.27 (18.14)	3.14 (9.38)	2.86 (7.72)	3.00 (8.55)
W₇	5.70 (32.42)	5.24 (27.29)	5.47 (29.85)	7.44 (55.21)	6.67 (44.30)	7.05 (49.75)	10.14 (102.95)	9.17 (84.06)	9.65 (93.50)	8.04 (64.31)	7.18 (51.20)	7.61 (57.76)
SEm±	0.10	0.07	0.06	0.09	0.09	0.06	0.12	0.09	0.08	0.07	0.07	0.05
CD at 5%	0.29	0.20	0.17	0.26	0.25	0.18	0.35	0.26	0.21	0.20	0.21	0.14

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

Table 4.49(b): Interaction effect of sowing dates and integrated weed management treatments on total weed dry weight (g m⁻²) at 20,40,60 DAS and harvest

Treatments	20 DAS			40 DAS			60 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	3.45 (11.40)	3.07 (8.92)	3.26 (10.16)	2.97 (8.35)	2.73 (7.01)	2.85 (7.68)	5.71 (32.13)	5.24 (27.40)	5.48 (29.77)	5.02 (24.74)	4.77 (22.27)	4.90 (23.51)
P₁W₂	3.77 (13.70)	3.19 (9.71)	3.48 (11.71)	3.23 (9.94)	2.84 (7.60)	3.04 (8.77)	6.00 (35.51)	5.60 (30.87)	5.80 (33.19)	5.30 (27.61)	5.13 (25.87)	5.22 (26.74)
P₁W₃	2.43 (5.41)	2.17 (4.21)	2.30 (4.81)	1.96 (3.42)	1.82 (2.83)	1.89 (3.13)	4.22 (17.29)	3.90 (14.76)	4.06 (16.02)	3.45 (11.40)	3.25 (10.08)	3.35 (10.74)
P₁W₄	2.72 (6.94)	2.34 (4.97)	2.53 (5.95)	2.49 (5.68)	2.25 (4.58)	2.37 (5.13)	4.99 (24.45)	4.77 (22.22)	4.88 (23.34)	4.44 (19.23)	4.28 (17.82)	4.36 (18.53)
P₁W₅	4.55 (20.18)	4.02 (15.66)	4.28 (17.92)	2.17 (4.23)	2.00 (3.53)	2.09 (3.88)	4.72 (21.82)	4.37 (18.64)	4.55 (20.23)	3.75 (13.57)	3.54 (12.03)	3.64 (12.80)
P₁W₆	4.28 (17.84)	3.80 (13.96)	4.04 (15.90)	3.88 (14.59)	3.49 (11.66)	3.68 (13.12)	3.78 (13.81)	3.38 (10.94)	3.58 (12.37)	2.92 (8.08)	2.78 (7.26)	2.85 (7.67)
P₁W₇	5.08 (25.48)	4.62 (20.83)	4.85 (23.16)	6.82 (46.11)	6.21 (38.25)	6.52 (42.18)	9.44 (89.17)	8.58 (73.16)	9.01 (81.16)	7.97 (63.13)	6.99 (48.36)	7.48 (55.74)
P₂W₁	4.04 (15.85)	3.56 (12.18)	3.80 (14.02)	3.63 (12.69)	3.21 (9.82)	3.42 (11.25)	6.30 (39.25)	6.04 (36.00)	6.17 (37.62)	5.18 (26.32)	4.91 (23.57)	5.04 (24.94)
P₂W₂	4.31 (18.05)	3.69 (13.12)	4.00 (15.58)	3.80 (13.94)	3.32 (10.58)	3.56 (12.26)	6.56 (42.54)	6.32 (39.47)	6.44 (41.01)	5.49 (29.67)	5.20 (26.50)	5.34 (28.08)
P₂W₃	3.02 (8.65)	2.60 (6.24)	2.81 (7.44)	2.64 (6.56)	2.24 (4.57)	2.44 (5.56)	4.65 (21.19)	4.52 (19.90)	4.58 (20.55)	3.75 (13.57)	3.39 (10.97)	3.57 (12.27)
P₂W₄	3.27 (10.23)	2.77 (7.15)	3.02 (8.69)	3.10 (9.11)	2.72 (6.88)	2.91 (7.99)	5.65 (31.49)	5.46 (29.34)	5.56 (30.41)	4.74 (22.00)	4.48 (19.56)	4.61 (20.78)
P₂W₅	5.27 (27.25)	4.64 (21.08)	4.95 (24.16)	2.86 (7.68)	2.50 (5.82)	2.68 (6.75)	5.37 (28.30)	5.06 (25.11)	5.21 (26.71)	4.01 (15.57)	3.66 (12.95)	3.83 (14.26)

P₂W₆	4.94 (23.96)	4.28 (17.84)	4.61 (20.90)	4.40 (18.88)	3.96 (15.19)	4.18 (17.03)	4.28 (17.86)	3.96 (15.19)	4.12 (16.53)	3.23 (9.95)	2.89 (7.83)	3.06 (8.89)
P₂W₇	5.54 (30.43)	5.23 (26.93)	5.38 (28.68)	7.47 (55.42)	6.61 (43.29)	7.04 (49.36)	10.06 (100.76)	9.00 (80.63)	9.53 (90.70)	8.06 (64.68)	7.17 (51.01)	7.61 (57.85)
P₃W₁	5.13 (26.01)	4.67 (21.48)	4.90 (23.75)	4.68 (21.43)	4.08 (16.13)	4.38 (18.78)	7.39 (54.09)	6.85 (46.42)	7.12 (50.26)	5.23 (26.89)	4.92 (23.71)	5.08 (25.30)
P₃W₂	5.35 (28.15)	4.71 (21.67)	5.03 (24.91)	4.80 (22.55)	4.17 (16.92)	4.49 (19.74)	7.71 (59.01)	7.29 (52.62)	7.50 (55.81)	5.65 (31.38)	5.29 (27.53)	5.47 (29.46)
P₃W₃	4.07 (16.04)	3.64 (12.85)	3.85 (14.44)	3.59 (12.40)	3.30 (10.42)	3.45 (11.41)	5.72 (32.20)	5.52 (30.01)	5.62 (31.11)	3.91 (14.75)	3.48 (11.62)	3.69 (13.19)
P₃W₄	4.26 (17.64)	3.80 (13.99)	4.03 (15.82)	4.23 (17.42)	3.72 (13.34)	3.97 (15.38)	6.90 (47.24)	6.46 (41.24)	6.68 (44.24)	4.80 (22.58)	4.45 (19.29)	4.63 (20.94)
P₃W₅	6.18 (37.86)	5.49 (29.70)	5.84 (33.78)	3.84 (14.33)	3.50 (11.75)	3.67 (13.04)	6.71 (44.70)	6.06 (36.27)	6.39 (40.48)	4.23 (17.38)	3.76 (13.63)	3.99 (15.50)
P₃W₆	5.94 (34.84)	5.07 (25.26)	5.51 (30.05)	5.34 (28.03)	4.72 (21.84)	5.03 (24.93)	5.28 (27.38)	4.91 (23.63)	5.09 (25.51)	3.25 (10.10)	2.93 (8.06)	3.09 (9.08)
P₃W₇	6.46 (41.34)	5.88 (34.11)	6.17 (37.73)	8.01 (64.09)	7.19 (51.37)	7.60 (57.73)	10.90 (118.92)	9.94 (98.38)	10.42 (108.65)	8.10 (65.14)	7.37 (54.22)	7.73 (59.68)
SEm± (PxW)	0.17	0.12	0.11	0.15	0.15	0.11	0.21	0.16	0.13	0.12	0.13	0.09
SEm± (WxP)	0.09	0.09	0.06	0.14	0.08	0.08	0.11	0.13	0.08	0.13	0.16	0.10
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Data in parenthesis indicates original values which were subjected to $\sqrt{x + 0.5}$ transformation.

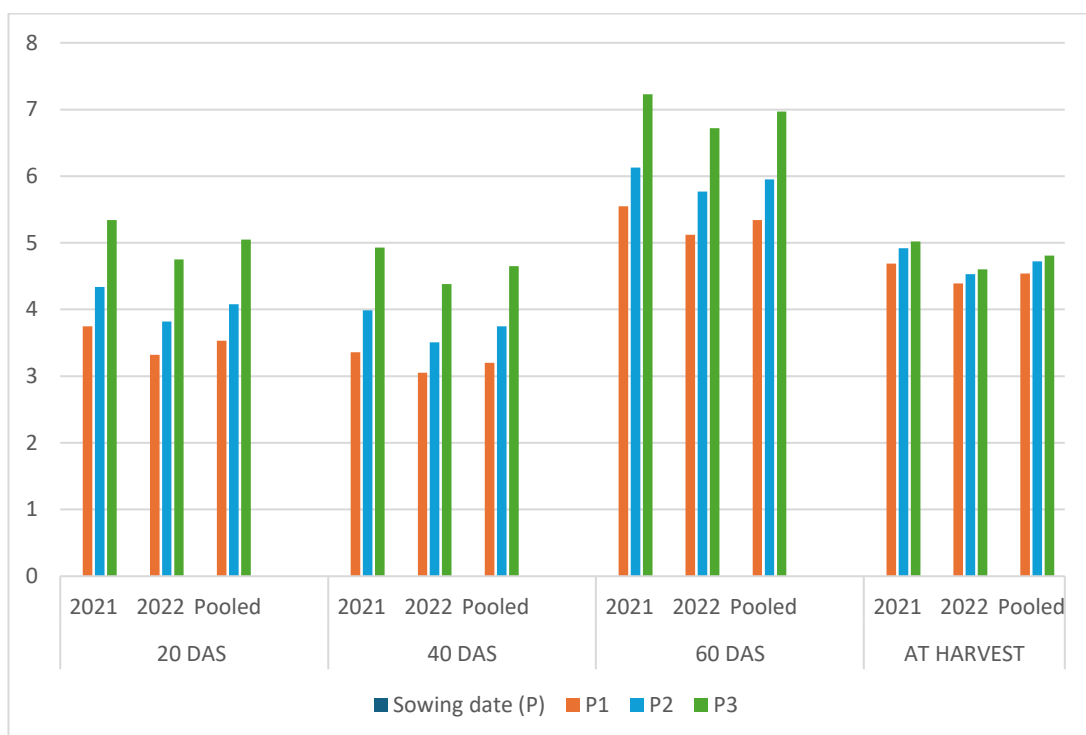


Fig 4.5 Effect of sowing dates on total dry weight of weed

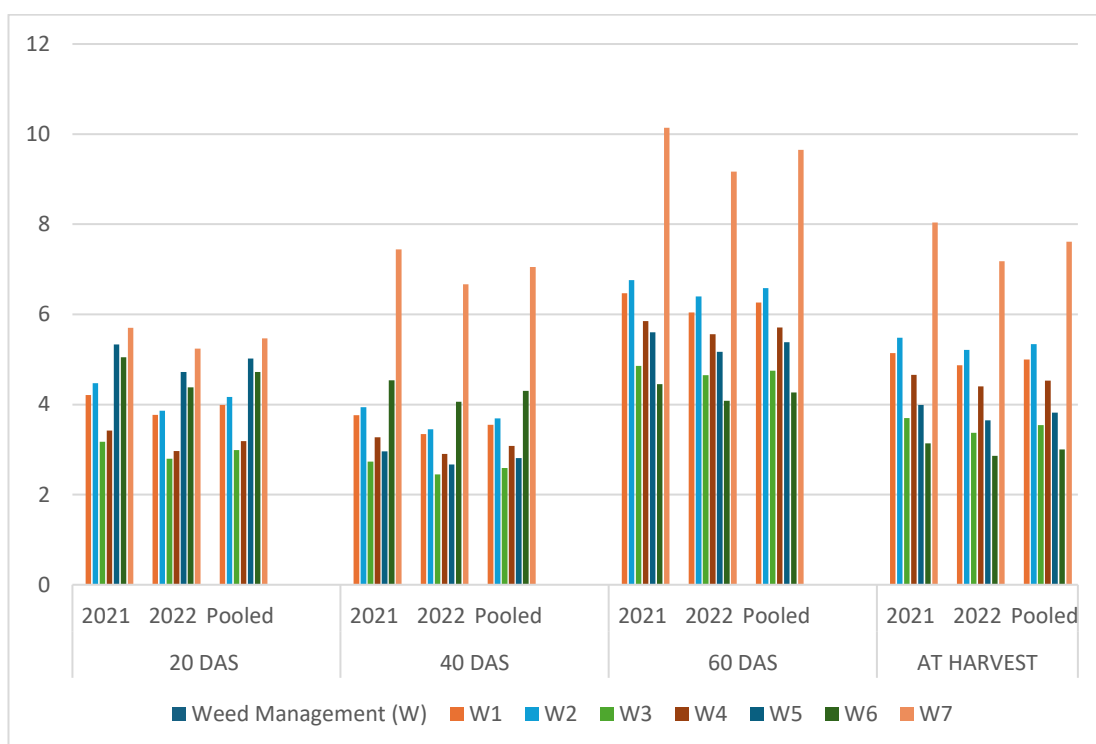


Fig 4.6 Effect of integrated weed management on total dry weight of weed

4.2.3.18.2 Effect of integrated weed management on the total dry weight of weeds

Throughout both years of the study, integrated weed management yielded significant effect on the total dry weight of weeds in both years of the experiment and the average data for two-years period at all stages of observations. Weedy check (W₇) recorded a significant maximum dry weight of weeds in all the stages of observation in both years. The higher total dry weight could be due to higher weed intensity and its dominance in utilizing resources like nutrients, moisture, light, etc.

The lowest total dry weight of weed at 20 and 40 DAS was recorded by W₃, application of pendimethalin 30 EC @ 1 kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹. The pre-emergence use of pendimethalin effectively prevents the emergence of monocot and grassy weeds by inhibiting root and shoot growth. The reduced dry weight of weeds with these treatments can be attributed to the pre-emergence herbicide ability to hinder early weed growth, while the post-emergence application successfully manages later emerging weeds by disrupting cell division, cell growth and impeding weed germination. The results are in agreement with the results of Tamang *et al.* (2015) and Vijay *et al.* (2018).

At 60 DAS and harvest treatment, W₆ (Hand weeding at 20 and 40 DAS) recorded the minimum total dry weight of weeds, followed by treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in both years and pooled values. In the case of two-hand weeding, weed growth of early flush of weeds was checked by hand weeding performed at 20 DAS, and the later stage of weed emergence was effectively controlled by second-hand weeding, which was done at 40 DAS. The result conforms with that of Kalyan *et al.* (2024).

4.2.3.18.3 Interaction effect of sowing dates and integrated weed management on total weeds dry weight

Data presented in Table 4.49 (b) revealed that the interaction effect between the dates of sowing and integrated weed management was found to be non-significant in both years.

4.2.4 Weed control efficiency (%) [WCE]

Weed control efficiency denote the relative efficiency of weed control practices

compared to weedy check. The crop yield is directly proportional to weed control efficiency. The data illustrating the impact of sowing dates and IWM on weed control efficiency are presented in Table 4.50 (a) and Table 4.50 (b).

4.2.4.1 Effect of sowing dates on weed control efficiency

The effect of sowing dates on WCE was notably significant. When the crop was planted on June 15th, the pooled values from two years showed the highest WCE, reaching 44.26% at 20 DAS and 71.42% at 40 DAS, respectively. Conversely, the lowest efficiency, recorded on July 15th, was 31.63% at 20 DAS and 59.52% at 40 DAS, respectively.

Analysis of data collected over two years revealed that sowing the crop on June 15 resulted in the highest WCE of 61.65% at 60 days after sowing (DAS) and 59.72% at harvest. Conversely, the lowest WCE values of 52.61% and 58.12% were recorded when sowing took place on July 15. Pandey *et al.* (2004) and Samant and Mohanty (2017) also found that early sowing date led to higher weed control efficiency.

4.2.4.2 Effect of integrated weed management on weed control efficiency

Significantly highest pooled value on weed control efficiency at 20 DAS (71.36%) and 40 DAS (86.99%) was recorded with the application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃). The results are in validation with those of Raj *et al.* (2020) and Pawar *et al.* (2022).

At 60 and harvest, hand weeding at 20 and 40 DAS (W₆) recorded the highest weed control efficiency (80.75% and 85.00%, respectively) in pooled values, followed by pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃). Weedy check (W₇) recorded the lowest WEC at all the stages. The higher weed control efficiency observed under the weed management treatment can be attributed to reduced weed density and minimum dry mass of weeds, resulting from successful suppression of weed growth. These findings are consistent with those reported by Datta *et al.* (2017). Vijay *et al.* (2018), Samudre *et al.* 2019. Raj *et al.* (2020) and Emmiganur and Hosmath (2020).

Table 4.50(a): Effect of sowing dates and integrated weed management treatments on weed control efficiency (%) and weed index (%) at different stages of soybean

Treatments	Weed control efficiency (%)												weed index (%)		
	20 DAS			40 DAS			60 DAS			At harvest			60 DAS		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)															
P₁ 15th June	42.23	46.29	44.26	71.39	71.44	71.42	61.98	61.32	61.65	61.92	57.51	59.72	22.29	21.11	21.70
P₂ 30th June	35.73	43.88	39.80	67.92	68.16	68.04	60.09	56.26	58.17	59.54	57.18	58.36	25.14	23.80	24.47
P₃ 15th July	29.94	33.32	31.63	58.93	60.12	59.52	53.17	52.05	52.61	58.58	57.65	58.12	31.82	28.79	30.30
Integrated weed Management (W)															
W₁	45.74	49.38	47.56	74.86	75.35	75.11	59.17	56.85	58.01	59.29	54.18	56.73	34.28	29.32	31.80
W₂	38.11	46.71	42.41	72.22	73.83	73.02	55.50	51.42	53.46	53.76	47.35	50.55	41.45	37.74	39.60
W₃	69.80	72.91	71.36	86.95	87.04	86.99	77.22	74.79	76.00	79.31	78.53	78.92	8.47	6.72	7.60
W₄	64.53	69.38	66.95	81.13	81.82	81.48	66.52	63.54	65.03	66.71	62.74	64.73	23.61	21.39	22.50
W₅	12.51	19.27	15.89	84.60	84.56	84.58	69.53	68.64	69.08	75.81	74.57	75.19	13.78	11.84	12.81
W₆	21.07	30.48	25.77	62.81	63.42	63.12	80.96	80.55	80.75	85.23	84.77	85.00	0.00	0.00	0.00
W₇	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.33	64.94	64.14

Table 4.50(b): Interaction effect of sowing dates and integrated weed management treatments on weed control efficiency (%) and weed index (%) at different stages of soybean

Treatments	Weed control efficiency (%)												weed index (%)		
	20 DAS			40 DAS			60 DAS			At harvest			60 DAS		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	53.55	57.12	55.34	81.83	80.68	81.25	63.21	62.85	63.03	60.64	53.84	57.24	23.53	21.67	22.60
P₁W₂	44.75	53.33	49.04	78.44	79.80	79.12	59.35	57.62	58.48	56.14	46.30	51.22	34.89	32.54	33.71
P₁W₃	77.97	79.82	78.90	92.69	92.33	92.51	80.29	79.86	80.07	81.83	79.18	80.50	6.54	5.82	6.18
P₁W₄	71.85	76.12	73.98	87.64	87.92	87.78	71.84	69.60	70.72	69.32	63.15	66.24	17.87	17.46	17.66
P₁W₅	18.81	24.73	21.77	90.84	90.33	90.58	74.99	74.42	74.70	78.51	75.13	76.82	12.47	10.86	11.66
P₁W₆	28.65	32.94	30.79	68.30	69.04	68.67	84.18	84.90	84.54	87.03	84.99	86.01	0.00	0.00	0.00
P₁W₇	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	60.76	59.40	60.08
P₂W₁	46.06	54.13	50.09	77.13	77.15	77.14	61.02	55.21	58.12	58.71	53.55	56.13	34.77	28.90	31.84
P₂W₂	38.59	50.44	44.52	74.81	75.35	75.08	57.78	50.58	54.18	53.59	47.78	50.69	40.33	33.86	37.10
P₂W₃	70.52	76.65	73.58	88.31	89.40	88.85	78.95	75.17	77.06	78.87	78.29	78.58	9.15	7.17	8.16
P₂W₄	64.66	73.07	68.87	83.47	84.04	83.75	68.75	63.28	66.01	65.63	61.61	63.62	22.31	18.26	20.29
P₂W₅	10.54	20.20	15.37	86.04	86.46	86.25	71.88	68.54	70.21	75.70	74.42	75.06	11.11	10.92	11.01
P₂W₆	19.71	32.64	26.17	65.71	64.73	65.22	82.27	81.01	81.64	84.29	84.57	84.43	0.00	0.00	0.00
P₂W₇	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.31	67.52	62.92
P₃W₁	37.60	36.89	37.24	65.62	68.22	66.92	53.29	52.49	52.89	58.52	55.15	56.83	44.53	37.40	40.96
P₃W₂	30.98	36.36	33.67	63.40	66.34	64.87	49.36	46.06	47.71	51.54	47.96	49.75	49.13	46.84	47.98
P₃W₃	60.92	62.27	61.59	79.86	79.38	79.62	72.42	69.33	70.88	77.24	78.12	77.68	9.74	7.17	8.45
P₃W₄	57.07	58.96	58.01	72.28	73.51	72.90	58.96	57.75	58.36	65.19	63.45	64.32	30.64	28.46	29.55
P₃W₅	8.17	12.87	10.52	76.91	76.90	76.91	61.72	62.95	62.34	73.22	74.16	73.69	17.77	13.75	15.76
P₃W₆	14.86	25.86	20.36	54.42	56.50	55.46	76.42	75.75	76.08	84.37	84.74	84.56	0.00	0.00	0.00
P₃W₇	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	65.24	67.91	66.57

4.2.4.3 Interaction effect of sowing dates and integrated weed management on weed control efficiency

The data on weed control efficiency, as revealed in Table 4.50 (b) showed that the interaction effect of sowing dates and integrated weed management was not statistically significant in either year.

4.2.5 Weed Index (%)

The weed index denotes a reduction in yield due to the presence of weeds in comparison to the yield of weed-free plots. The data on weed index as influenced by sowing dates and integrated weed management are presented in Table 4.50 (a) and Table 4.50 (b).

4.2.5.1 Effect of sowing dates on weed index

The differences in weed index due to sowing dates were found to be significant. According to data obtained from pooled value, the lowest weed index at 60 DAS (22.29, 21.11%) was recorded when the crop was sown on 15th June. A significant maximum weed index (31.82, 28.79%) was observed under the 15th July sowing date in both years.

4.2.5.2 Effect of integrated weed management on weed index

In both years of the research, integrated weed management greatly influenced the weed index. A remarkably higher pooled value of weed index (64.14 %) was observed in weedy checked (W₇) treatment, attributed to the presence of weeds through out the crop season. These findings are consistent with those reported by Patil *et al.* (2018).

Significantly lowest pooled value of weed index (7.60%) at 60 DAS was recorded with the application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) after W₆, hand weeding at 20 and 40 DAS. The results conform with the results obtained by Patil *et al.* (2018), Samudre *et al.* (2019) and Pawar *et al.* (2022).

4.2.5.3 Interaction effect of sowing dates and integrated weed management on weed index

The data on the weed index presented in Table 4.50 (b) indicate that the interaction

effect of sowing dates and integrated weed management were not statistically significant in either year.

4.3 Soil parameters

The data on soil chemical properties viz. pH (soil reaction), soil electrical conductivity, soil organic carbon (%), available nitrogen (kg ha^{-1}), available phosphorus (kg ha^{-1}) and available potassium (kg ha^{-1}) after crop harvest is presented in Table 4.51 (a and b) and Table 4.52 (a and b).

4.3.1 Soil pH

Effects of sowing dates and integrated weed management on soil pH after harvest were found to be non-significant in both years and are presented in Table 4.51 (a and b).

4.3.2 Soil organic carbon (%)

Data pertaining to soil organic carbon after harvest as influenced by sowing dates and integrated weed management presented in Table 4.51 (a and b) was found to be non-significant in both years.

4.3.3 Soil electrical conductivity (dSm^{-1})

The data on soil electrical conductivity (dSm^{-1}) after harvest as influenced by sowing dates and integrated weed management presented in Table 4.51 (a and b) was found to be non-significant in both years.

4.3.4 Soil available nitrogen (kg ha^{-1})

A proper examination of the data presented in Table 4.52 (a) and Table 4.52 (b) indicated that the sowing dates and integrated weed management did not exert a significant effect on available nitrogen in both years.

4.3.5 Soil available phosphorus (kg ha^{-1})

Table 4.52 (a) and Table 4.52 (b) revealed that neither sowing dates nor integrated weed management showed any significant effect on available phosphorus during both years.

Table 4.51(a): Effect of sowing dates and integrated weed management treatments on soil pH, OC, and EC at harvest

Treatments	Soil pH			Organic carbon (%)			Electrical conductivity (dSm ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)									
P₁ 15th June	4.50	4.55	4.53	1.49	1.54	1.52	0.20	0.21	0.21
P₂ 30th June	4.54	4.59	4.56	1.53	1.58	1.55	0.21	0.24	0.22
P₃ 15th July	4.58	4.63	4.60	1.56	1.61	1.59	0.23	0.26	0.24
SEm±	0.09	0.09	0.07	0.03	0.04	0.02	0.01	0.01	0.01
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)									
W₁	4.50	4.56	4.53	1.50	1.55	1.53	0.20	0.23	0.21
W₂	4.49	4.50	4.49	1.49	1.51	1.50	0.18	0.21	0.19
W₃	4.58	4.67	4.63	1.57	1.63	1.60	0.24	0.27	0.25
W₄	4.52	4.59	4.55	1.53	1.58	1.55	0.22	0.24	0.23
W₅	4.58	4.62	4.60	1.55	1.60	1.57	0.23	0.25	0.24
W₆	4.66	4.71	4.69	1.60	1.65	1.63	0.27	0.28	0.27
W₇	4.42	4.47	4.44	1.44	1.50	1.47	0.16	0.19	0.17
SEm±	0.15	0.15	0.11	0.06	0.06	0.04	0.03	0.02	0.02
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.51(b): Interaction effect of sowing dates and integrated weed management treatments on soil pH, OC, and EC at harvest

Treatments	Soil pH			Organic carbon (%)			Electrical conductivity (d Sm ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	4.46	4.51	4.48	1.47	1.53	1.50	0.19	0.20	0.20
P₁W₂	4.44	4.47	4.45	1.46	1.46	1.46	0.16	0.19	0.17
P₁W₃	4.62	4.67	4.65	1.56	1.62	1.59	0.26	0.26	0.26
P₁W₄	4.52	4.57	4.54	1.50	1.54	1.52	0.22	0.22	0.22
P₁W₅	4.52	4.56	4.54	1.51	1.58	1.54	0.23	0.22	0.23
P₁W₆	4.53	4.65	4.59	1.54	1.59	1.56	0.24	0.26	0.25
P₁W₇	4.40	4.45	4.42	1.42	1.44	1.43	0.12	0.15	0.14
P₂W₁	4.51	4.57	4.54	1.50	1.55	1.52	0.20	0.22	0.21
P₂W₂	4.51	4.46	4.48	1.49	1.52	1.51	0.19	0.20	0.19
P₂W₃	4.62	4.75	4.68	1.61	1.67	1.64	0.26	0.27	0.26
P₂W₄	4.52	4.56	4.54	1.53	1.58	1.55	0.22	0.25	0.23
P₂W₅	4.58	4.63	4.61	1.54	1.61	1.58	0.22	0.25	0.24
P₂W₆	4.58	4.68	4.63	1.57	1.63	1.60	0.23	0.26	0.25
P₂W₇	4.42	4.47	4.45	1.44	1.47	1.45	0.17	0.20	0.18
P₃W₁	4.54	4.59	4.57	1.53	1.58	1.56	0.21	0.25	0.23
P₃W₂	4.51	4.57	4.54	1.51	1.56	1.53	0.20	0.24	0.22
P₃W₃	4.75	4.73	4.74	1.64	1.67	1.66	0.28	0.30	0.29
P₃W₄	4.53	4.64	4.58	1.57	1.61	1.59	0.23	0.26	0.25
P₃W₅	4.63	4.67	4.65	1.59	1.62	1.60	0.24	0.28	0.26
P₃W₆	4.64	4.68	4.66	1.61	1.67	1.64	0.25	0.29	0.27
P₃W₇	4.43	4.50	4.46	1.48	1.58	1.53	0.18	0.22	0.20
SEm± (PxW)	0.26	0.27	0.19	0.10	0.10	0.07	0.05	0.04	0.03
SEm± (WxP)	0.20	0.20	0.14	0.07	0.08	0.05	0.03	0.03	0.02
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.52(a): Effect of sowing dates and integrated weed management treatments on soil NPK at harvest

Treatments	Available Nitrogen (kg ha ⁻¹)			Available Phosphorus (kg ha ⁻¹)			Available Potassium (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)									
P₁ 15th June	362.70	370.69	366.69	16.95	18.75	17.85	197.81	183.62	190.72
P₂ 30th June	379.36	385.47	382.41	18.04	19.80	18.92	203.80	189.08	196.44
P₃ 15th July	400.14	398.37	399.25	18.28	19.83	19.05	209.25	196.77	203.01
SEm±	9.38	9.23	6.58	0.35	0.40	0.26	3.05	4.67	2.79
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)									
W₁	379.03	385.16	382.09	17.75	19.62	18.68	200.58	188.69	194.63
W₂	377.97	381.51	379.74	17.20	18.98	18.09	199.19	187.64	193.42
W₃	384.69	395.31	390.00	18.26	20.01	19.13	209.30	193.62	201.46
W₄	380.99	388.52	384.76	17.93	19.67	18.80	202.71	190.79	196.75
W₅	383.97	389.94	386.95	18.03	19.88	18.96	207.38	192.73	200.05
W₆	387.13	402.58	394.86	18.48	20.09	19.28	218.43	194.69	206.56
W₇	371.34	350.87	361.10	16.65	17.97	17.31	187.76	180.63	184.19
SEm±	10.50	14.37	8.90	0.53	0.56	0.38	6.84	6.63	4.76
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.52(b): Interaction effect of sowing dates and integrated weed management treatments on soil NPK at harvest

Treatments	Available Nitrogen (kg ha ⁻¹)			Available Phosphorus (kg ha ⁻¹)			Available Potassium (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	359.00	369.36	364.18	17.12	19.25	18.19	193.28	177.97	185.62
P₁W₂	358.18	367.77	362.97	16.35	17.64	17.00	193.20	177.29	185.25
P₁W₃	369.80	376.46	373.13	17.38	19.57	18.48	204.72	190.20	197.46
P₁W₄	362.36	373.78	368.07	17.15	19.51	18.33	194.72	183.34	189.03
P₁W₅	368.73	374.27	371.50	17.15	19.56	18.36	202.17	188.99	195.58
P₁W₆	369.46	378.98	374.22	17.50	19.58	18.54	212.17	191.38	201.77
P₁W₇	351.34	354.21	352.78	16.01	16.11	16.06	184.44	176.19	180.32
P₂W₁	380.65	391.10	385.87	17.97	19.79	18.88	200.46	191.46	195.96
P₂W₂	379.46	385.93	382.70	17.59	19.66	18.62	198.09	191.03	194.56
P₂W₃	381.58	400.19	390.88	18.64	20.14	19.39	207.46	192.93	200.19
P₂W₄	380.67	394.92	387.80	18.38	19.81	19.10	200.50	191.94	196.22
P₂W₅	381.17	395.72	388.45	18.39	19.84	19.12	206.48	192.02	199.25
P₂W₆	381.89	416.83	399.36	18.95	20.20	19.58	226.45	194.65	210.55
P₂W₇	370.09	313.59	341.84	16.36	19.16	17.76	187.13	169.57	178.35
P₃W₁	397.44	395.01	396.22	18.17	19.80	18.98	207.99	196.64	202.31
P₃W₂	396.29	390.84	393.56	17.66	19.64	18.65	206.28	194.61	200.45
P₃W₃	402.68	409.29	405.98	18.74	20.32	19.53	215.72	197.74	206.73
P₃W₄	399.92	396.87	398.40	18.26	19.70	18.98	212.91	197.08	205.00
P₃W₅	401.99	399.83	400.91	18.55	20.24	19.40	213.48	197.18	205.33
P₃W₆	410.06	411.93	410.99	18.98	20.49	19.74	216.67	198.05	207.36
P₃W₇	392.59	384.80	388.69	17.56	18.64	18.10	191.69	196.12	193.91
SEm± (PxW)	18.18	24.88	15.41	0.92	0.96	0.66	11.85	11.48	8.25
SEm± (WxP)	17.68	19.03	12.99	0.72	0.79	0.53	7.36	9.35	5.95
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

4.3.6 Soil available potassium (kg ha⁻¹)

Data pertaining to available potassium as influenced by sowing dates and integrated weed management presented in Table 4.52 (a) and Table 4.52 (b) did not exert a significant effect in both years.

4.4 Plant chemical analysis

4.4.1 NPK depletion by weeds (kg ha⁻¹)

The data on NPK depletion by weeds recorded during 2021 and 2022 are presented in Table 4.53 (a) and Table 4.53 (b).

4.4.1.1 Effect of sowing dates on NPK depletion by weeds

Significant variations in NPK depletion by weeds were observed among the sowing dates. Sowing on 15th June recorded significant minimum pooled values in depletion of nitrogen (11.09 kg ha⁻¹), phosphorus (1.15 kg ha⁻¹), and potassium (4.67 kg ha⁻¹), while the delayed sowing date of 15th July recorded maximum pooled value in depletion of nitrogen (20.13 kg ha⁻¹), phosphorus (2.17 kg ha⁻¹) and potassium (7.70 kg ha⁻¹). The higher depletion of NPK by weeds associated with the delayed sowing date may be attributed to higher weeds density and the buildup of dry matter, facilitated by favourable environmental conditions for weeds growth.

4.4.1.2 Effect of integrated weed management on NPK depletion by weeds

A critical examination of the data revealed that integrated weed management influenced the depletion of NPK by weeds. Maximum pooled values in depletion of nitrogen (50.69 kg ha⁻¹), phosphorus (4.98 kg ha⁻¹), and potassium (20.43 kg ha⁻¹) were observed in the weedy check (W₇). The weedy check treatment has higher weed intensity and biomass due to its dominance in utilizing sunshine, moisture, and CO₂ leading to increased dry matter and nutrient absorption from the soil. Bhimwal *et al.* (2019) and Borje *et al.* (2023) also reported maximum and considerably higher uptake of NPK by weeds in weedy check.

Hand weeding at 20 and 40 DAS (W₆) recorded minimum pooled values in depletion of nitrogen (3.66 kg ha⁻¹), phosphorus (0.45 kg ha⁻¹) and potassium depletion (1.01 kg ha⁻¹) by weeds. It was found to be at par with the application of pendimethalin

Table 4.53(a): Effect of sowing dates and integrated weed management treatments on nutrient depletion by weed (kg ha⁻¹) at 60DAS

Treatments	Nitrogen (kg ha ⁻¹)			Phosphorus (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)									
P₁ 15th June	12.21	9.98	11.09	1.19	1.11	1.15	5.20	4.15	4.67
P₂ 30th June	15.14	13.15	14.15	1.69	1.50	1.59	6.33	5.12	5.73
P₃ 15th July	21.98	18.28	20.13	2.38	1.95	2.17	8.54	6.85	7.70
SEm±	0.71	0.39	0.41	0.04	0.02	0.02	0.25	0.17	0.15
CD at 5%	2.80	1.52	1.32	0.17	0.10	0.08	0.97	0.68	0.49
Integrated weed Management (W)									
W₁	13.43	11.22	12.32	1.57	1.52	1.55	6.25	5.00	5.63
W₂	17.88	15.22	16.55	2.08	1.90	1.99	8.25	6.50	7.38
W₃	5.42	4.78	5.10	0.49	0.62	0.56	1.53	1.15	1.34
W₄	9.76	9.15	9.45	1.20	0.99	1.09	4.19	3.44	3.82
W₅	8.86	7.30	8.08	0.92	0.78	0.85	2.84	2.42	2.63
W₆	3.98	3.34	3.66	0.35	0.54	0.45	1.13	0.88	1.01
W₇	55.78	45.61	50.69	5.68	4.29	4.98	22.62	18.24	20.43
SEm±	1.16	0.89	0.73	0.08	0.06	0.05	0.44	0.25	0.25
CD at 5%	3.34	2.54	2.06	0.22	0.16	0.13	1.27	0.71	0.71

Table 4.53(b): Interaction effect of sowing dates and integrated weed management treatments on nutrient depletion by weed (kg ha⁻¹) at 60DAS

Treatments	Nitrogen (kg ha ⁻¹)			Phosphorus (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	9.18	7.70	8.44	1.06	1.13	1.09	4.65	3.61	4.13
P₁W₂	11.53	9.83	10.68	1.46	1.44	1.45	6.21	4.75	5.48
P₁W₃	3.38	2.65	3.01	0.34	0.52	0.43	1.02	0.75	0.88
P₁W₄	6.66	5.86	6.26	0.80	0.86	0.83	2.89	2.43	2.66
P₁W₅	4.26	3.99	4.13	0.57	0.55	0.56	1.86	1.65	1.76
P₁W₆	2.36	1.76	2.06	0.23	0.44	0.34	0.71	0.57	0.64
P₁W₇	48.14	38.04	43.09	3.89	2.84	3.36	19.04	15.28	17.16
P₂W₁	11.93	10.70	11.31	1.50	1.53	1.52	5.88	4.90	5.39
P₂W₂	16.53	14.86	15.70	1.97	1.82	1.90	7.71	6.24	6.98
P₂W₃	4.53	4.33	4.43	0.45	0.57	0.51	1.38	0.99	1.18
P₂W₄	9.71	8.50	9.10	1.13	0.94	1.04	3.84	3.21	3.52
P₂W₅	8.62	7.13	7.87	0.81	0.71	0.76	2.54	2.24	2.39
P₂W₆	3.89	3.13	3.51	0.32	0.49	0.41	1.02	0.77	0.90
P₂W₇	50.74	43.42	47.08	5.63	4.41	5.02	21.94	17.50	19.72
P₃W₁	19.19	15.25	17.22	2.15	1.90	2.02	8.22	6.49	7.35
P₃W₂	25.57	20.97	23.27	2.80	2.45	2.63	10.83	8.52	9.67
P₃W₃	8.34	7.36	7.85	0.68	0.78	0.73	2.21	1.70	1.96
P₃W₄	12.92	13.08	13.00	1.67	1.15	1.41	5.85	4.69	5.27
P₃W₅	13.70	10.77	12.23	1.37	1.07	1.22	4.13	3.36	3.74
P₃W₆	5.70	5.15	5.43	0.51	0.69	0.60	1.66	1.30	1.48
P₃W₇	68.45	55.35	61.90	7.51	5.62	6.56	26.89	21.94	24.41
SEm± (PxW)	2.02	1.54	1.27	0.13	0.10	0.08	0.76	0.43	0.44
SEm± (WxP)	1.50	0.95	0.88	0.09	0.06	0.05	0.54	0.35	0.32
CD at 5%	5.78	4.40	3.57	0.38	0.28	0.23	2.19	1.23	1.23
CD at 5%	4.77	2.89	2.60	0.29	0.18	0.16	1.69	1.13	0.94

30 EC @ 1 kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃). This could be the result of poor dry matter build-up of weeds caused by broad-spectrum weed control by herbicide at the initial stage, as well as hand removal of weeds. A reduced NPK depletion by weeds under the influence of integrated weed management was also reported by Kumar and Das (2008), Kumari and Sagarka (2014), Dhakad *et al.* (2022) and Dhayal *et al.* (2022).

4.4.1.3 Interaction effect of sowing dates and integrated weed management on NPK depletion by weeds

Table 4.53 (b) indicates that the interaction between sowing dates and IWM significantly affected the depletion of nitrogen, phosphorus, and potassium (NPK) by weeds in both years. The minimal depletion of NPK by weeds was observed when the crop was sown on June 15, with two hand weeding (W₆). Conversely, the maximum depletion occurred when the crop was sown on July 15 with the weedy check treatment (W₇).

4.4.2 NPK content in seed and stover (%)

4.4.2.1 NPK content in seed (%)

The data on NPK content in seed as influenced by sowing dates and integrated weed management are given in Table 4.54 (a) and Table 4.54 (b).

4.4.2.1.1 Effect of sowing dates on NPK content in seed

The data concerning the NPK content in seeds, as appeared in Table 4.54 (a) and Table 4.54 (b), indicate that the sowing dates did not have a statistically significant effect in either year.

4.4.2.1.2 Effect of integrated weed management on NPK content in seed

Integrated weed management showed a significant effect on NPK content in seed. Hand weeding at 20 and 40 DAS (W₆) recorded higher pooled values of nitrogen (6.23%), phosphorus (0.31%), and potassium (1.53%) content in seed and at par with application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) and W₅ (Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS fb interculture at 30 DAS) in both years. Seed is the ultimate sink for the assimilation of nutrients in

Table 4.54(a): Effect of sowing dates and integrated weed management treatments on NPK content in seed

Treatments	N content in seed (%)			P content in seed (%)			K content in seed (%)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)									
P₁ 15th June	5.89	5.95	5.92	0.26	0.30	0.28	1.45	1.48	1.46
P₂ 30th June	5.84	5.89	5.86	0.26	0.29	0.27	1.43	1.46	1.44
P₃ 15th July	5.74	5.81	5.78	0.25	0.27	0.26	1.39	1.41	1.40
SEm±	0.13	0.07	0.07	0.004	0.006	0.004	0.02	0.02	0.01
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)									
W₁	5.69	5.78	5.73	0.25	0.29	0.27	1.39	1.42	1.41
W₂	5.51	5.56	5.54	0.24	0.26	0.25	1.38	1.39	1.38
W₃	6.13	6.19	6.16	0.27	0.31	0.29	1.49	1.52	1.50
W₄	5.89	5.96	5.93	0.25	0.28	0.27	1.41	1.45	1.43
W₅	5.95	6.01	5.98	0.27	0.31	0.29	1.44	1.47	1.46
W₆	6.21	6.25	6.23	0.29	0.32	0.31	1.51	1.54	1.53
W₇	5.38	5.43	5.41	0.21	0.24	0.23	1.35	1.36	1.35
SEm±	0.14	0.12	0.09	0.01	0.01	0.01	0.02	0.02	0.02
CD at 5%	0.41	0.35	0.26	0.02	0.02	0.02	0.07	0.06	0.05

Table 4.54(b): Interaction effect of sowing dates and integrated weed management treatments on NPK content in seed (kg ha⁻¹)

Treatments	N content in seed (%)			P content in seed (%)			K content in seed (%)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	5.77	5.86	5.81	0.25	0.30	0.28	1.41	1.46	1.44
P₁W₂	5.59	5.63	5.61	0.24	0.27	0.25	1.40	1.43	1.41
P₁W₃	6.20	6.28	6.24	0.28	0.32	0.30	1.50	1.53	1.52
P₁W₄	5.91	6.03	5.97	0.26	0.31	0.28	1.45	1.49	1.47
P₁W₅	6.01	6.07	6.04	0.28	0.31	0.29	1.47	1.50	1.49
P₁W₆	6.28	6.31	6.29	0.29	0.33	0.31	1.54	1.57	1.56
P₁W₇	5.47	5.49	5.48	0.22	0.25	0.24	1.36	1.38	1.37
P₂W₁	5.70	5.79	5.74	0.26	0.29	0.28	1.40	1.43	1.42
P₂W₂	5.51	5.55	5.53	0.25	0.25	0.25	1.40	1.38	1.39
P₂W₃	6.12	6.16	6.14	0.27	0.32	0.30	1.47	1.54	1.51
P₂W₄	5.93	5.98	5.95	0.26	0.29	0.27	1.41	1.46	1.43
P₂W₅	5.99	6.04	6.01	0.26	0.30	0.28	1.45	1.48	1.46
P₂W₆	6.23	6.27	6.25	0.30	0.33	0.31	1.51	1.56	1.54
P₂W₇	5.39	5.43	5.41	0.22	0.24	0.23	1.37	1.35	1.36
P₃W₁	5.62	5.68	5.65	0.24	0.27	0.25	1.36	1.37	1.36
P₃W₂	5.45	5.51	5.48	0.24	0.26	0.25	1.34	1.36	1.35
P₃W₃	6.06	6.12	6.09	0.28	0.30	0.29	1.47	1.47	1.47
P₃W₄	5.82	5.89	5.85	0.25	0.25	0.25	1.39	1.41	1.40
P₃W₅	5.85	5.91	5.88	0.27	0.30	0.28	1.40	1.43	1.41
P₃W₆	6.11	6.18	6.15	0.29	0.32	0.30	1.49	1.51	1.50
P₃W₇	5.29	5.36	5.33	0.20	0.23	0.22	1.33	1.33	1.33
SEm± (PxW)	0.245	0.214	0.162	0.015	0.012	0.010	0.042	0.037	0.028
SEm± (WxP)	0.239	0.156	0.143	0.010	0.012	0.008	0.032	0.034	0.023
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

plants. The treated plots exhibited superior weed control from the initial stages, leading to a reduced weed density and dry mass, thereby allowing the crop to thrive in an unimpeded environment and absorb more nutrients from the soil. The results corroborate the findings of Kumari and Sagarka (2014).

In contrast, the weedy check (W₇) consistently showed the lowest NPK content in seeds over both years. Weeds tend to absorb nutrients more quickly than crops due to their rapid growth, storing these nutrients in large quantities within their tissues. This results in a nutrient deficiency for the crops. The reduced NPK levels observed in the weedy check can likely be attributed to the increased nutrient uptake by the unchecked weeds.

4.4.2.1.3 Interaction effect of sowing dates and integrated weed management on NPK content in seed

Data pertaining to NPK content in seed presented in Table 4.54 (b) showed that the interaction effect of sowing dates and integrated weed management on NPK content was found to be non-significant during both years.

4.4.2.2 NPK content in stover (%)

The data on NPK content in stover as influenced by sowing dates and integrated weed management are presented in Table 4.55 (a) and Table 4.55 (b).

4.4.2.2.1 Effect of sowing dates on NPK content in stover

NPK content in stover was not affected significantly by the different sowing dates, as shown in Table 4.55 (a).

4.4.2.2.2 Effect of integrated weed management on NPK content in stover

Integrated weed management, however, significantly influenced the NPK content in Stover. The minimum NPK content in stover was recorded in weedy check (W₇) for both years. Hand weeding at 20 and 40 DAS (W₆) recorded significantly higher pooled values of nitrogen (2.32%), phosphorus (0.26%), and potassium (2.43 %) compared to other weed management treatments. The higher concentration of NPK in stover might be attributed to minimum crop-weed competition, which led to better root development, resulting in higher uptake, absorption and better translocation in the

Table 4.55(a): Effect of sowing dates and integrated weed management treatments on NPK content in stover

Treatments	N content in stover (%)			P content in stover (%)			K content in stover (%)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)									
P₁ 15th June	2.08	2.09	2.09	0.20	0.22	0.21	2.21	2.23	2.22
P₂ 30th June	1.98	2.07	2.02	0.19	0.21	0.20	2.09	2.21	2.15
P₃ 15th July	1.95	1.99	1.97	0.18	0.20	0.19	2.06	2.11	2.08
SEm±	0.04	0.03	0.02	0.004	0.004	0.003	0.04	0.03	0.03
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)									
W₁	1.95	2.01	1.98	0.17	0.18	0.18	2.07	2.14	2.11
W₂	1.89	1.95	1.92	0.15	0.17	0.16	2.02	2.10	2.06
W₃	2.15	2.16	2.15	0.23	0.26	0.24	2.26	2.30	2.28
W₄	2.00	2.06	2.03	0.20	0.22	0.21	2.11	2.17	2.14
W₅	2.05	2.07	2.06	0.21	0.23	0.22	2.17	2.23	2.20
W₆	2.29	2.35	2.32	0.25	0.27	0.26	2.39	2.48	2.43
W₇	1.70	1.75	1.72	0.13	0.14	0.13	1.80	1.87	1.84
SEm±	0.03	0.04	0.03	0.003	0.006	0.003	0.04	0.04	0.03
CD at 5%	0.10	0.11	0.07	0.009	0.016	0.009	0.11	0.12	0.08

Table 4.55(b): Interaction effect of sowing dates and integrated weed management treatments on NPK content in stover

Treatments	N content in stover (%)			P content in stover (%)			K content in stover (%)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	2.04	2.07	2.05	0.18	0.19	0.18	2.18	2.20	2.19
P₁W₂	1.96	1.98	1.97	0.16	0.17	0.16	2.12	2.14	2.13
P₁W₃	2.24	2.21	2.22	0.23	0.26	0.25	2.34	2.35	2.34
P₁W₄	2.12	2.06	2.09	0.20	0.24	0.22	2.23	2.19	2.21
P₁W₅	2.15	2.15	2.15	0.21	0.24	0.23	2.27	2.28	2.27
P₁W₆	2.33	2.37	2.35	0.26	0.28	0.27	2.44	2.50	2.47
P₁W₇	1.75	1.80	1.78	0.14	0.15	0.14	1.86	1.93	1.90
P₂W₁	1.97	2.04	2.00	0.17	0.18	0.17	2.05	2.16	2.10
P₂W₂	1.88	1.97	1.92	0.15	0.17	0.16	2.01	2.14	2.08
P₂W₃	2.05	2.24	2.14	0.24	0.26	0.25	2.24	2.38	2.31
P₂W₄	1.98	2.07	2.02	0.21	0.22	0.21	2.06	2.22	2.14
P₂W₅	1.99	2.10	2.04	0.21	0.23	0.22	2.14	2.25	2.20
P₂W₆	2.28	2.36	2.32	0.25	0.27	0.26	2.37	2.50	2.44
P₂W₇	1.69	1.72	1.71	0.13	0.14	0.13	1.78	1.84	1.81
P₃W₁	1.81	1.93	1.87	0.17	0.17	0.17	1.99	2.06	2.02
P₃W₂	1.82	1.90	1.86	0.15	0.16	0.15	1.94	2.03	1.98
P₃W₃	2.16	2.02	2.09	0.23	0.25	0.24	2.19	2.16	2.18
P₃W₄	1.92	2.04	1.98	0.19	0.21	0.20	2.04	2.11	2.08
P₃W₅	2.00	1.97	1.98	0.20	0.23	0.21	2.12	2.15	2.13
P₃W₆	2.24	2.34	2.29	0.24	0.26	0.25	2.35	2.43	2.39
P₃W₇	1.65	1.72	1.69	0.12	0.12	0.12	1.76	1.84	1.80
SEm± (PxW)	0.061	0.069	0.046	0.006	0.010	0.006	0.069	0.074	0.050
SEm± (WxP)	0.069	0.061	0.046	0.007	0.008	0.005	0.077	0.063	0.050
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

crop. Kumari and Sagarka (2014) also found similar results.

4.4.2.2.3 Interaction effect of sowing dates and integrated weed management on NPK content in stover

According to Table 4.55 (b), the data on NPK content in stover indicated that the interaction effect of sowing dates and IWM on NPK content was not significant in either year.

4.4.3 NPK uptake by seed and stover (kg ha⁻¹)

4.4.3.1 NPK uptake by seed (kg ha⁻¹)

The data on NPK uptake by seed recorded during 2021 and 2022 are presented in Table 4.56 (a) and Table 4.56 (b).

4.4.3.1.1 Effect of sowing dates on NPK uptake by seed

A critical examination of the data revealed that sowing dates influenced the uptake of NPK by seed in both years. Sowing on 15th June recorded significantly the highest pooled value of nitrogen uptake (120.49 kg ha⁻¹), phosphorus uptake (5.73 kg ha⁻¹), and potassium (29.77 kg ha⁻¹). It was followed by 30th June, while sowing on 15th July recorded significantly the lowest uptake of NPK by seed.

Higher NPK uptake by seed in earlier sowing date might be attributed to relatively early crop establishment, more vigorous root growth and more extended growth periods, which in turn result in increased absorption of nutrients and moisture from the soil, substantially improving seed development and nutrient uptake. The declining trend may result from detrimental impact of delayed planting on plant canopy and root development, which hindered the optimum nutrient absorption compared to timely planted crops. The results agree with the studies by Mahesh *et al.* (2017) and Kaur *et al.* (2024).

4.4.3.1.2 Effect of integrated weed management on NPK uptake by seed

The NPK uptake by seed under different integrated weed management also showed significant differences in both years. The weedy check (W₇) consistently demonstrated the lowest NPK uptake by seeds across both years. Significantly, the highest pooled value of nitrogen uptake (138.00 kg ha⁻¹), phosphorus uptake (6.54 kg

Table 4.56(a): Effect of sowing dates and integrated weed management treatments on NPK uptake by seed

Treatments	Nitrogen (kg ha ⁻¹)			Phosphorus (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)									
P₁ 15th June	115.68	125.30	120.49	5.12	6.34	5.73	28.43	31.11	29.77
P₂ 30th June	96.85	107.79	102.32	4.31	5.38	4.84	23.71	26.67	25.19
P₃ 15th July	66.62	80.09	73.36	2.97	3.85	3.41	16.13	19.43	17.78
SEm±	1.65	1.65	1.17	0.16	0.13	0.10	0.91	0.22	0.47
CD at 5%	6.48	6.47	3.80	0.63	0.52	0.34	3.56	0.85	1.52
Integrated weed Management (W)									
W₁	81.67	94.06	87.87	3.60	4.71	4.16	20.02	23.19	21.61
W₂	69.81	83.04	76.42	3.04	3.87	3.45	17.48	20.80	19.14
W₃	121.21	131.97	126.59	5.76	6.93	6.34	29.34	32.38	30.86
W₄	97.13	110.21	103.67	4.18	5.32	4.75	23.40	26.90	25.15
W₅	108.71	120.05	114.38	4.90	6.10	5.50	26.39	29.41	27.90
W₆	132.97	143.02	138.00	5.87	7.22	6.54	32.52	35.35	33.94
W₇	39.87	48.42	44.15	1.60	2.17	1.88	10.12	12.12	11.12
SEm±	3.21	2.89	2.16	0.17	0.16	0.12	0.71	0.74	0.51
CD at 5%	9.20	8.30	6.09	0.49	0.47	0.34	2.05	2.11	1.44

Table 4.56(b): Interaction effect of sowing dates and integrated weed management treatments on NPK uptake by seed

Treatments	Nitrogen (kg ha ⁻¹)			Phosphorus (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	111.34	121.41	116.38	4.82	6.25	5.53	27.26	30.38	28.82
P₁W₂	91.06	101.25	96.15	3.90	4.83	4.37	22.78	25.61	24.20
P₁W₃	143.86	154.23	149.05	6.73	8.01	7.37	34.97	37.65	36.31
P₁W₄	121.10	132.92	127.01	5.26	6.77	6.02	29.76	32.81	31.29
P₁W₅	129.62	143.32	136.47	5.96	7.35	6.66	31.75	35.44	33.60
P₁W₆	156.76	162.87	159.81	6.91	8.34	7.63	38.48	40.45	39.46
P₁W₇	56.02	61.15	58.59	2.27	2.80	2.54	13.99	15.42	14.70
P₂W₁	82.76	97.08	89.92	3.78	4.91	4.34	20.52	23.88	22.20
P₂W₂	72.75	88.22	80.49	3.24	3.94	3.59	18.50	21.91	20.20
P₂W₃	128.74	134.94	131.84	6.21	7.26	6.74	30.97	33.79	32.38
P₂W₄	103.68	115.39	109.54	4.50	5.64	5.07	24.61	28.20	26.40
P₂W₅	116.35	124.76	120.56	5.06	6.24	5.65	28.15	30.59	29.37
P₂W₆	141.29	146.42	143.86	6.07	7.50	6.78	34.38	36.43	35.41
P₂W₇	32.38	47.71	40.05	1.32	2.16	1.74	8.81	11.87	10.34
P₃W₁	50.91	63.68	57.30	2.22	2.97	2.59	12.27	15.32	13.80
P₃W₂	45.61	59.65	52.63	1.97	2.84	2.40	11.17	14.88	13.02
P₃W₃	91.01	106.75	98.88	4.32	5.53	4.92	22.07	25.68	23.88
P₃W₄	66.61	82.32	74.46	2.80	3.55	3.17	15.83	19.69	17.76
P₃W₅	80.15	92.08	86.11	3.67	4.70	4.19	19.28	22.21	20.75
P₃W₆	100.85	119.78	110.32	4.63	5.82	5.22	24.71	29.16	26.94
P₃W₇	31.22	36.39	33.81	1.19	1.55	1.37	7.57	9.08	8.33
SEm± (PxW)	5.56	5.01	3.74	0.30	0.28	0.21	1.24	1.27	0.89
SEm± (WxP)	3.72	3.55	2.57	0.30	0.26	0.20	1.62	0.67	0.88
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

ha⁻¹) and potassium uptake (33.94 kg ha⁻¹) was observed with two hand weeding (W₆), followed by treatment W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) consistently across both years.

The increased uptake of NPK in seed can be attributed to the effective control and suppression of weed growth, providing a weed-free environment for a longer time to utilize the available and applied nutrients, due to better root growth and establishment and ultimately resulting in higher content and an increased yield, as observed in W₆ (Two hand weeding). These findings are consistent with the studies by Kumari and Sagarka (2014), Bali *et al.* (2017), and Vishwakarma *et al.* (2023).

4.4.3.1.3 Interaction effect of sowing dates and integrated weed management on NPK uptake by seed

Table 4.56 (b) indicates that the interaction effect of sowing dates and integrated weed management on NPK uptake by seed was not significant in either year.

4.4.3.2 NPK uptake by stover (kg ha⁻¹)

Observations on NPK uptake by stover as influenced by sowing dates and integrated weed management recorded during 2021 and 2022 are presented in Table 4.57 (a) and Table 4.57 (b).

4.4.3.2.1 Effect of sowing dates on NPK uptake by stover

The differences in uptake of NPK by stover among the sowing dates were found to be significant. Significantly, the highest pooled value of nitrogen uptake (51.98 kg ha⁻¹), phosphorus uptake (5.23 kg ha⁻¹), and potassium uptake (55.04 kg ha⁻¹) by stover was observed when the crop was sown on 15th June and at par with the sowing date of 30th June in both years. Sowing on 15th July recorded the lowest pooled value uptake of NPK by stover in both years. The decrease in uptake of NPK during delayed sowing may be due to the absence of rainfall during the crop growing period. Higher NPK uptake in stover at earlier sowing compared to late sowing was also mentioned by Mahesh *et al.* (2017), and Kaur *et al.* (2024).

4.4.3.2.2 Effect of integrated weed management on NPK uptake by stover

Data presented in Table 4.28 (a) revealed that the variations in uptake of NPK

Table 4.57(a): Effect of sowing dates and integrated weed management treatments on NPK uptake by stover

Treatments	Nitrogen (kg ha ⁻¹)			Phosphorus (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)									
P₁ 15th June	51.44	52.52	51.98	4.92	5.54	5.23	54.20	55.89	55.04
P₂ 30th June	45.67	50.17	47.92	4.60	5.16	4.88	48.39	53.60	50.99
P₃ 15th July	42.21	43.28	42.74	4.08	4.49	4.28	44.49	45.87	45.18
SEm±	1.76	1.65	1.21	0.11	0.05	0.06	1.83	1.71	1.25
CD at 5%	6.90	6.48	3.97	0.44	0.19	0.20	7.19	6.73	4.09
Integrated weed Management (W)									
W₁	41.93	45.22	43.58	3.67	4.07	3.87	44.56	48.06	46.31
W₂	36.60	41.42	39.01	2.90	3.54	3.22	39.16	44.66	41.91
W₃	56.92	63.30	60.11	6.18	6.89	6.53	59.65	61.87	60.76
W₄	47.52	50.23	48.88	4.74	5.42	5.08	50.03	52.99	51.51
W₅	52.55	54.40	53.47	5.32	6.07	5.69	55.84	58.37	57.11
W₆	64.01	59.92	61.97	6.95	7.41	7.18	66.82	68.59	67.70
W₇	25.54	26.11	25.82	1.95	2.03	1.99	27.10	27.98	27.54
SEm±	1.84	2.16	1.42	0.14	0.27	0.15	1.89	2.10	1.41
CD at 5%	5.06	6.20	3.93	0.41	0.77	0.43	5.43	6.02	3.99

Table4.57(b): Interaction effect of sowing dates and integrated weed management treatments on NPK uptake by stover

Treatments	Nitrogen (kg ha ⁻¹)			Phosphorus (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	50.77	51.89	51.33	4.35	4.85	4.60	53.55	55.16	54.35
P₁W₂	42.25	43.77	43.01	3.32	3.68	3.50	45.29	47.34	46.32
P₁W₃	60.14	66.55	63.35	6.24	7.30	6.77	62.48	66.01	64.24
P₁W₄	54.20	53.31	53.75	5.20	6.12	5.66	57.11	56.79	56.95
P₁W₅	55.73	58.34	57.03	5.52	6.41	5.96	58.80	61.90	60.35
P₁W₆	66.91	64.62	65.77	7.45	8.07	7.76	70.11	72.78	71.44
P₁W₇	30.07	29.17	29.62	2.35	2.35	2.35	32.03	31.27	31.65
P₂W₁	41.90	45.37	43.64	3.65	3.92	3.78	43.70	47.98	45.84
P₂W₂	36.89	43.00	39.94	2.93	3.80	3.36	39.55	46.66	43.10
P₂W₃	54.87	65.12	60.00	6.39	7.08	6.74	59.84	65.73	62.78
P₂W₄	46.93	52.23	49.58	4.99	5.44	5.22	48.94	55.78	52.36
P₂W₅	51.55	56.24	53.89	5.42	6.22	5.82	55.52	60.44	57.98
P₂W₆	63.88	63.03	63.46	6.96	7.53	7.24	66.29	70.55	68.42
P₂W₇	23.68	26.20	24.94	1.84	2.11	1.98	24.88	28.04	26.46
P₃W₁	33.12	38.40	35.76	3.01	3.43	3.22	36.44	41.04	38.74
P₃W₂	30.66	37.48	34.07	2.46	3.14	2.80	32.64	39.99	36.32
P₃W₃	55.74	58.23	56.98	5.90	6.29	6.10	56.62	53.87	55.24
P₃W₄	41.43	45.16	43.30	4.04	4.71	4.37	44.02	46.39	45.21
P₃W₅	50.37	48.62	49.49	5.02	5.58	5.30	53.22	52.77	52.99
P₃W₆	61.25	52.10	56.67	6.44	6.61	6.52	64.06	62.44	63.25
P₃W₇	22.87	22.95	22.91	1.66	1.64	1.65	24.40	24.62	24.51
SEm± (PxW)	3.19	3.75	2.46	0.25	0.46	0.26	3.28	3.64	2.45
SEm± (WxP)	3.27	3.23	2.30	0.22	0.22	0.16	3.40	3.30	2.37
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

by stover due to integrated weed management were statistically significant. The highest pooled nutrient uptake values of nitrogen (61.97 kg ha^{-1}), phosphorus (7.18 kg ha^{-1}) and potassium (67.70 kg ha^{-1}) were observed with hand weeding twice (W_6) which was at par with the application of pendimethalin 30 EC @ 1 kg ha^{-1} fb imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS (W_3). The significantly lowest NPK uptake by stover was observed under the weedy check (W_7). Better weed control might have resulted in less nutrient depletion by weeds and higher nutrient uptake by soybean. The results are in corroboration with those of Kumari and Sagarka (2014), Bali *et al.* (2017), and Vishwakarma *et al.* (2023).

4.4.3.2.3 Interaction effect of sowing dates and integrated weed management on NPK uptake by stover

Data with respect to NPK uptake by stover presented in Table 4.57 (b) showed that interaction effects of sowing dates and integrated weed management were not statistically significant in either year.

4.4.4 Total NPK uptake (kg ha^{-1})

4.4.4.1 Total uptake of NPK (kg ha^{-1})

Data pertaining to total NPK uptake by crop as influenced by different sowing dates and integrated weed management are presented in Table 4.58 (a) and Table 4.58 (b).

4.4.4.1.1 Effect of sowing dates on total uptake of NPK

The data clearly revealed that the sowing dates showed significant variation in total NPK uptake in both years. Sowing on 15th June was found to have a significantly higher pooled value of nitrogen total uptake ($172.47 \text{ kg ha}^{-1}$), phosphorus total uptake (10.96 kg ha^{-1}) and potassium total uptake (84.81 kg ha^{-1}) followed by the sowing date of 30th June, while the lowest total NPK uptake was recorded under the 15th July sowing date.

The more distributed rainfall during the early sowing, the more soil moisture and nutrient uptake might be supplied during the early crop development. This may be the reason for the higher uptake of NPK in the early sowing dates. On the delayed sowing dates, the plants may have experienced low rainfall, light interception,

Table 4.58(a): Effect of sowing dates and integrated weed management treatments on Total NPK uptake by soybean

Treatments	Nitrogen (kg ha ⁻¹)			Phosphorus (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)									
P₁ 15th June	167.12	177.83	172.47	10.04	11.88	10.96	82.62	87.00	84.81
P₂ 30th June	142.52	157.96	150.24	8.91	10.53	9.72	72.09	80.26	76.18
P₃ 15th July	108.83	123.37	116.10	7.05	8.34	7.69	60.62	65.30	62.96
SEm±	1.73	2.80	1.65	0.17	0.13	0.11	1.50	1.77	1.16
CD at 5%	6.80	10.99	5.37	0.67	0.51	0.35	5.90	6.96	3.79
Integrated weed Management (W)									
W₁	123.60	139.28	131.44	7.27	8.77	8.02	64.58	71.25	67.92
W₂	106.41	124.46	115.43	5.94	7.41	6.67	56.64	65.46	61.05
W₃	178.12	195.27	186.70	11.93	13.82	12.88	88.98	94.24	91.61
W₄	144.65	160.44	152.54	8.93	10.74	9.84	73.43	79.89	76.66
W₅	161.26	174.45	167.85	10.22	12.17	11.19	82.24	87.78	85.01
W₆	196.98	202.94	199.96	12.82	14.62	13.72	99.34	103.94	101.64
W₇	65.41	74.52	69.97	3.55	4.20	3.88	37.23	40.10	38.66
SEm±	3.49	3.96	2.64	0.24	0.36	0.21	2.06	2.30	1.55
CD at 5%	10.02	11.37	7.45	0.68	1.02	0.60	5.92	6.61	4.36

Table 4.58(b): Interaction effect of sowing dates and integrated weed management treatments on total NPK uptake by soybean

Treatments	Nitrogen (kg ha ⁻¹)			Phosphorus (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	162.11	173.30	167.71	9.17	11.10	10.13	80.81	85.53	83.17
P₁W₂	133.31	145.02	139.16	7.22	8.51	7.86	68.07	72.96	70.51
P₁W₃	204.00	220.78	212.39	12.97	15.31	14.14	97.45	103.66	100.55
P₁W₄	175.30	186.23	180.76	10.46	12.89	11.68	86.88	89.60	88.24
P₁W₅	185.35	201.65	193.50	11.48	13.76	12.62	90.55	97.34	93.95
P₁W₆	223.68	227.49	225.58	14.36	16.41	15.39	108.59	113.23	110.91
P₁W₇	86.09	90.32	88.20	4.63	5.15	4.89	46.02	46.69	46.35
P₂W₁	124.67	142.45	133.56	7.43	8.82	8.13	64.23	71.86	68.04
P₂W₂	109.64	131.22	120.43	6.17	7.74	6.95	58.04	68.56	63.30
P₂W₃	183.61	200.06	191.84	12.61	14.34	13.47	90.81	99.52	95.17
P₂W₄	150.61	167.62	159.12	9.49	11.08	10.28	73.55	83.98	78.77
P₂W₅	167.90	181.00	174.45	10.48	12.46	11.47	83.66	91.03	87.35
P₂W₆	205.17	209.45	207.31	13.03	15.03	14.03	100.66	106.98	103.82
P₂W₇	56.07	73.92	64.99	3.16	4.27	3.72	33.69	39.91	36.80
P₃W₁	84.03	102.08	93.06	5.22	6.40	5.81	48.71	56.36	52.54
P₃W₂	76.27	97.13	86.70	4.43	5.98	5.21	43.82	54.87	49.34
P₃W₃	146.75	164.98	155.86	10.22	11.82	11.02	78.69	79.55	79.12
P₃W₄	108.04	127.48	117.76	6.83	8.26	7.55	59.85	66.08	62.96
P₃W₅	130.52	140.69	135.61	8.70	10.28	9.49	72.49	74.98	73.74
P₃W₆	162.10	171.88	166.99	11.07	12.43	11.75	88.77	91.60	90.19
P₃W₇	54.09	59.34	56.72	2.86	3.19	3.02	31.97	33.70	32.83
SEm± (PxW)	6.05	6.86	4.58	0.41	0.62	0.37	3.58	3.99	2.68
SEm± (WxP)	3.97	5.60	3.43	0.34	0.35	0.24	2.98	3.46	2.28
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

photoperiod and high temperatures in the later growing seasons, which could influence plant growth and biomass production and reduce NPK uptake. Nawale *et al.* (2018), Basavaraj *et al.* (2020), and Kaur *et al.* (2024) also reported similar results with a higher total uptake of NPK under early sowing of crops.

4.4.4.1.2 Effect of integrated weed management on total NPK uptake

Significant variations in NPK uptake were observed due to integrated weed management. Hand weeding at 20 and 40 DAS (W_6) significantly recorded the highest pooled value of total N uptake ($199.96 \text{ kg ha}^{-1}$), total P uptake (13.72 kg ha^{-1}) and total K uptake ($101.64 \text{ kg ha}^{-1}$) and at par with the application of pendimethalin 30 EC @ 1 kg ha^{-1} fb imazethapyr 10 SL @ 100 g ha^{-1} at 20 DAS (W_3) in both years. The lowest total uptake of NPK was recorded in the weedy check (W_7) in both years. The reduced weed density and weed dry mass in the treated plots likely facilitated improved soybean growth and nutrient uptake. A similar observation was also made by Younesabadi *et al.* (2013), Kumari and Sagarka (2014), Sharma *et al.* (2016) Raj *et al.* (2020) and Dhakad *et al.* (2022).

4.4.4.1.3 Interaction effect of sowing dates and integrated weed management on total NPK uptake

Table 4.58 (b) revealed that there was no significant effect on the total uptake of NPK due to the interaction of the sowing dates and integrated weed management during both years.

4.5 Herbicide residue in soil by bioassay test

Bioassay remains a major tool for qualitative and quantitative determination of herbicides. Bioassay tests on the persistent effect of herbicide applied on the soybean field were carried out on different indicator plants such as maize, cucumber, mustard and pea in petri dishes with soil obtained from the field under regular observation in laboratory conditions. The study revealed that herbicides applied to soybean had no negative effect on the four crops under investigation, as all herbicidal treatments were effective. Sangwan

et al. (2016) also reported that imazethapyr and pendimethalin effectively control weeds without phytotoxicity.

4.5.1 Root and Shoot length of maize

Scrutiny of data presented in Table 4.59 and Table 4.60 revealed that the residue of different herbicides did not significantly influence shoot and root length at 30, 60, and 90 DAS and harvest in both years.

4.5.2 Root and Shoot length of cucumber

Data presented in Table 4.61 and Table 4.62 revealed that the residue of different applied herbicides did not show any significant effect on shoot and root length at 30, 60, and 90 DAS and harvest in both years.

4.5.3 Root and Shoot length of mustard

Scrutiny of data presented in Table 4.63 and Table 4.64 revealed that herbicide residue did not significantly influence shoot and root length at 30, 60, and 90 DAS and harvest in both years.

4.5.4 Root and Shoot length of pea

Scrutiny of data presented in Table 4.65 and Table 4.66 revealed that the residue of different herbicides did not significantly influence the shoot and root length of peas at 30, 60, and 90 DAS and harvest in both years.

4.6 Residual effect on succeeding french bean

The persistence of herbicides in soil is a critical factor to consider when recommending their use to farmers, as it pertains to the duration of herbicidal activity under prevailing climatic and edaphic conditions. These conditions interact significantly, potentially resulting in either antagonistic or synergistic effects. This section presents data on the growth and yield characteristics of french beans, as influenced by sowing dates and integrated weed management practices in soybean cultivation.

Table 4.59: Persistence effect of different herbicides in bioassay test on root length (cm) of maize

Treatments	Root length (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	7.02	7.10	7.06	6.91	7.16	7.03	6.39	6.62	6.51	6.37	6.72	6.54
P₂ 30th June	6.70	6.96	6.83	6.66	6.95	6.80	6.17	6.41	6.29	6.19	6.51	6.35
P₃ 15th July	6.54	6.59	6.56	6.46	6.73	6.59	6.11	6.22	6.17	6.11	6.13	6.12
SEm±	0.14	0.15	0.10	0.25	0.14	0.14	0.17	0.12	0.10	0.18	0.18	0.13
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)												
W₁	6.62	6.85	6.74	6.77	6.90	6.84	6.27	6.50	6.38	6.14	6.31	6.22
W₂	6.51	6.79	6.65	6.74	6.75	6.75	6.20	6.37	6.29	5.96	6.19	6.07
W₃	6.87	7.10	6.99	6.56	6.87	6.71	6.33	6.37	6.35	6.38	6.65	6.52
W₄	6.79	6.98	6.89	6.66	6.90	6.78	6.03	6.40	6.22	6.23	6.52	6.38
W₅	6.43	6.35	6.39	6.29	6.65	6.47	6.10	5.93	6.01	5.59	5.92	5.76
W₆	6.95	6.95	6.95	6.86	7.24	7.05	6.42	6.55	6.48	6.62	6.80	6.71
W₇	7.10	7.16	7.13	6.82	7.30	7.06	6.22	6.80	6.51	6.66	6.80	6.73
SEm±	0.20	0.22	0.15	0.20	0.21	0.15	0.26	0.19	0.16	0.32	0.27	0.21
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.60: Persistence effect of different herbicides n bioassay test on Shoot length (cm) of maize

Treatments	Shoot length (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	7.32	7.48	7.40	7.01	7.28	7.15	7.20	7.34	7.27	7.18	7.56	7.37
P₂ 30th June	6.96	7.59	7.28	6.96	7.12	7.04	6.90	7.37	7.13	7.08	7.23	7.16
P₃ 15th July	6.88	7.46	7.17	6.75	6.91	6.83	6.87	6.85	6.86	7.00	7.05	7.02
SEm±	0.12	0.13	0.09	0.14	0.13	0.10	0.20	0.15	0.12	0.14	0.15	0.10
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)												
W₁	7.16	7.51	7.33	7.00	7.22	7.11	7.07	7.30	7.18	7.12	7.31	7.22
W₂	7.04	7.46	7.25	6.94	7.18	7.06	7.05	7.20	7.12	7.09	7.23	7.16
W₃	6.81	7.11	6.96	6.59	6.67	6.63	6.71	6.65	6.68	6.51	7.02	6.76
W₄	6.87	7.26	7.06	6.78	7.00	6.89	6.88	7.08	6.98	6.99	7.16	7.07
W₅	6.90	7.39	7.14	6.87	7.07	6.97	6.90	7.15	7.03	7.10	7.17	7.13
W₆	7.41	8.15	7.78	7.12	7.33	7.23	7.19	7.50	7.35	7.66	7.60	7.63
W₇	7.21	7.70	7.45	7.03	7.26	7.15	7.12	7.42	7.27	7.15	7.47	7.31
SEm±	0.26	0.34	0.21	0.18	0.16	0.12	0.19	0.24	0.15	0.34	0.19	0.20
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.61: Persistence effect of different herbicides in bioassay test on root length (cm) of cucumber

Treatments	Root length (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	3.86	3.98	3.92	3.44	4.05	3.74	3.29	3.46	3.38	3.66	4.07	3.87
P₂ 30th June	3.76	3.94	3.85	3.34	3.93	3.64	3.19	3.32	3.26	3.61	3.94	3.78
P₃ 15th July	3.65	3.88	3.77	3.20	3.70	3.45	2.99	3.17	3.08	3.07	3.78	3.42
SEm±	0.11	0.12	0.08	0.11	0.13	0.08	0.11	0.15	0.09	0.27	0.12	0.15
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)												
W₁	3.79	3.94	3.87	3.39	3.98	3.68	3.21	3.28	3.24	3.34	3.90	3.62
W₂	3.74	3.97	3.86	3.36	3.92	3.64	2.92	3.27	3.10	3.30	3.90	3.60
W₃	3.67	3.94	3.80	3.19	3.78	3.48	3.18	3.21	3.19	3.55	3.89	3.72
W₄	3.68	3.90	3.79	3.30	3.84	3.57	3.30	3.32	3.31	3.00	3.91	3.45
W₅	3.62	3.65	3.64	3.05	3.63	3.34	3.22	3.05	3.14	3.26	3.56	3.41
W₆	3.99	4.09	4.04	3.59	4.06	3.83	3.15	3.72	3.44	3.97	4.22	4.09
W₇	3.82	4.02	3.92	3.44	4.03	3.74	3.12	3.38	3.25	3.72	4.13	3.92
SEm±	0.15	0.14	0.10	0.18	0.14	0.12	0.14	0.17	0.11	0.42	0.20	0.23
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.62: Persistence effect of different herbicides in bioassay test on shoot length (cm) of cucumber

Treatments	Shoot length (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	5.07	5.36	5.22	4.83	5.30	5.07	4.59	5.46	5.03	4.22	5.13	4.67
P₂ 30th June	4.85	5.15	5.00	4.40	5.05	4.72	4.49	5.17	4.83	4.01	4.94	4.47
P₃ 15th July	4.75	4.81	4.78	4.49	4.92	4.71	4.19	5.09	4.64	3.90	4.86	4.38
SEm±	0.16	0.30	0.17	0.11	0.13	0.08	0.11	0.17	0.10	0.11	0.10	0.07
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)												
W₁	4.99	5.21	5.10	4.63	5.18	4.91	4.47	5.20	4.84	4.08	4.89	4.49
W₂	4.95	5.20	5.07	4.60	5.11	4.86	4.19	5.15	4.67	3.96	4.90	4.43
W₃	4.79	5.03	4.91	4.43	4.98	4.71	4.45	5.07	4.76	3.94	4.95	4.44
W₄	4.92	5.13	5.02	4.55	5.04	4.80	4.22	5.06	4.64	3.87	4.97	4.42
W₅	4.11	4.54	4.33	4.30	4.83	4.56	4.35	5.21	4.78	3.97	4.91	4.44
W₆	5.37	5.37	5.37	4.84	5.26	5.05	4.76	5.68	5.22	4.29	5.11	4.70
W₇	5.11	5.27	5.19	4.68	5.23	4.96	4.54	5.32	4.93	4.20	5.09	4.64
SEm±	0.28	0.23	0.18	0.18	0.14	0.12	0.14	0.18	0.11	0.13	0.13	0.09
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.63: Persistence effect of different herbicides in bioassay test on root length (cm) of mustard

Treatments	Root length (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	3.27	3.74	3.50	3.80	3.96	3.88	4.88	5.60	5.24	4.47	4.79	4.63
P₂ 30th June	3.13	3.70	3.41	3.66	3.74	3.70	4.65	5.30	4.98	4.29	4.66	4.48
P₃ 15th July	2.99	3.68	3.33	3.51	3.67	3.59	4.56	5.29	4.92	4.13	4.45	4.29
SEm±	0.08	0.10	0.06	0.06	0.11	0.06	0.12	0.15	0.09	0.12	0.12	0.09
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)												
W₁	3.22	3.76	3.49	3.63	3.81	3.72	4.48	5.05	4.76	4.32	4.33	4.32
W₂	3.16	3.74	3.45	3.63	3.81	3.72	4.51	5.39	4.95	4.50	4.62	4.56
W₃	2.85	3.60	3.22	3.53	3.54	3.54	4.54	5.27	4.91	4.40	4.66	4.53
W₄	2.90	3.63	3.26	3.60	3.65	3.63	4.70	5.43	5.07	4.07	4.71	4.39
W₅	3.07	3.70	3.38	3.62	3.78	3.70	4.65	5.33	4.99	4.13	4.74	4.44
W₆	3.44	3.78	3.61	3.93	4.05	3.99	4.86	5.58	5.22	4.41	4.68	4.55
W₇	3.26	3.76	3.51	3.67	3.88	3.77	5.12	5.73	5.43	4.24	4.69	4.47
SEm±	0.15	0.15	0.11	0.15	0.11	0.09	0.19	0.18	0.13	0.13	0.13	0.09
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.64: Persistence effect of different herbicides in bioassay test on Shoot length (cm) of mustard

Treatments	Shoot length (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	5.15	5.49	5.32	5.21	5.54	5.38	5.47	5.81	5.64	5.36	5.50	5.43
P₂ 30th June	5.03	5.47	5.25	5.18	5.38	5.28	5.41	5.52	5.47	5.28	5.40	5.34
P₃ 15th July	4.77	5.26	5.02	4.97	5.23	5.10	5.36	5.27	5.31	5.04	5.14	5.09
SEm±	0.14	0.12	0.09	0.14	0.15	0.10	0.12	0.16	0.10	0.11	0.12	0.08
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)												
W₁	4.83	5.25	5.04	5.00	5.25	5.12	5.27	5.55	5.41	4.92	5.07	5.00
W₂	5.00	5.53	5.27	5.29	5.38	5.34	5.50	5.63	5.56	5.04	5.16	5.10
W₃	4.98	5.38	5.18	5.13	5.40	5.26	5.41	5.62	5.51	5.10	5.19	5.15
W₄	5.21	5.37	5.29	5.39	5.59	5.49	5.53	5.53	5.53	5.45	5.32	5.38
W₅	4.84	5.07	4.96	4.84	5.15	5.00	5.29	5.21	5.25	5.21	5.27	5.24
W₆	4.93	5.34	5.14	4.98	5.35	5.17	5.35	5.65	5.50	5.42	5.66	5.54
W₇	5.10	5.90	5.50	5.20	5.56	5.38	5.55	5.55	5.55	5.45	5.76	5.61
SEm±	0.13	0.22	0.13	0.16	0.14	0.11	0.16	0.20	0.13	0.19	0.23	0.15
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.65: Persistence effect of different herbicides in bioassay test on root length (cm) of pea

Treatments	Root length (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	4.39	4.53	4.46	4.12	4.03	4.07	4.85	4.94	4.90	4.90	5.29	5.10
P₂ 30th June	4.31	4.43	4.37	3.95	3.99	3.97	4.68	4.93	4.80	4.73	5.11	4.92
P₃ 15th July	4.10	4.32	4.21	3.89	3.91	3.90	4.60	4.89	4.75	4.69	5.06	4.88
SEm±	0.10	0.12	0.08	0.07	0.05	0.05	0.09	0.12	0.07	0.08	0.09	0.06
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)												
W₁	4.45	4.46	4.46	3.94	3.98	3.96	4.51	4.80	4.66	4.74	5.11	4.93
W₂	4.37	4.46	4.42	4.09	3.84	3.96	4.80	4.92	4.86	4.96	5.28	5.12
W₃	4.49	4.55	4.52	3.99	3.99	3.99	4.72	4.91	4.82	4.90	5.20	5.05
W₄	4.13	4.34	4.24	4.08	4.07	4.08	4.89	5.04	4.96	4.94	5.40	5.17
W₅	4.27	4.45	4.36	3.71	3.98	3.84	4.45	4.73	4.59	4.43	4.82	4.62
W₆	4.41	4.54	4.47	3.89	3.97	3.93	4.73	4.92	4.82	4.59	4.95	4.77
W₇	3.75	4.17	3.96	4.23	4.00	4.11	4.89	5.12	5.01	4.88	5.32	5.10
SEm±	0.21	0.11	0.12	0.14	0.11	0.09	0.14	0.19	0.12	0.16	0.17	0.12
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.66: Persistence effect of different herbicides in bioassay test on shoot length (cm) of pea

Treatments	Shoot length (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	4.45	4.60	4.52	4.08	4.19	4.13	4.83	5.00	4.92	4.59	4.76	4.67
P₂ 30th June	4.28	4.42	4.35	4.07	4.13	4.10	4.69	4.85	4.77	4.46	4.72	4.59
P₃ 15th July	4.19	4.36	4.28	3.91	4.04	3.97	4.55	4.70	4.63	4.41	4.52	4.47
SEm±	0.08	0.08	0.06	0.07	0.05	0.04	0.08	0.10	0.06	0.08	0.07	0.05
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Integrated weed Management (W)												
W₁	4.34	4.50	4.42	3.84	4.07	3.95	4.74	5.15	4.95	4.38	4.59	4.49
W₂	4.33	4.44	4.38	4.15	4.16	4.16	4.72	4.79	4.76	4.45	4.71	4.58
W₃	4.00	4.48	4.24	4.14	4.10	4.12	4.34	4.80	4.57	4.29	4.37	4.33
W₄	4.35	4.41	4.38	4.09	4.30	4.19	4.73	4.80	4.76	4.61	4.75	4.68
W₅	4.29	4.54	4.41	3.77	3.78	3.78	4.69	4.77	4.73	4.33	4.40	4.36
W₆	4.43	4.46	4.44	3.98	4.19	4.09	4.73	4.79	4.76	4.61	4.82	4.72
W₇	4.42	4.38	4.40	4.17	4.23	4.20	4.89	4.85	4.87	4.75	5.03	4.89
SEm±	0.12	0.08	0.07	0.13	0.14	0.09	0.13	0.24	0.14	0.15	0.18	0.12
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

4.6.1 Residual effect of sowing dates and IWM in soybean on plant population of succeeding crop of french bean

The residual effect on the subsequent french bean crop, as influenced by sowing dates and integrated weed management are presented in Table 4.67 (a) and Table 4.67 (b), with specific attention to plant population data.

4.6.1.1 Effect of sowing dates on plant population of succeeding french bean

Scrutiny of data presented in Table 4.67 (a) revealed that variation in the sowing dates did not significantly influence the plant population of french bean at 30 DAS and harvest in both years.

4.6.1.2 Effect of integrated weed management on plant population of succeeding french bean

Data presented in Table 4.67 (a) revealed that integrated weed management did not show any significant influence on the plant population of french bean at 30 DAS and harvest in both years. The reason might be the complete degradation of those used herbicides in the soil or the presence of those herbicides below the detectable level that might had not adversely affected the germination and population of the succeeding crops.

4.6.1.3 Interaction effect of sowing dates and integrated weed management on plant population of succeeding french bean

The data on the plant population of french bean presented in Table 4.67 (b) showed that the residual effect of the interaction effect of sowing dates and integrated weed management was found to be non-significant during both years.

4.6.2 Residual effect of sowing dates and integrated weed management in soybean on plant height of succeeding crop of french bean

The data on plant height as influenced by sowing dates and integrated weed management are presented in Table 4.67 (a) and Table 4.67 (b).

4.6.2.1 Effect of sowing dates on plant height of succeeding french bean

The data on plant height of french beans as residual crops, as presented in Table 4.67 (a and b), indicated a continuous increase with the advancement of crop age.

Table 4.67(a): Residual effect of sowing dates and integrated weed management treatments in soybean on plant population and plant height of succeeding crop of french bean

Treatments	Plant population (m ²)						Plant height (cm)					
	30 DAS			At harvest			30 DAS			60 DAS		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)												
P₁ 15th June	29.15	30.76	29.96	27.37	30.00	28.68	9.46	10.00	9.73	28.70	31.70	30.20
P₂ 30th June	28.91	29.95	29.43	27.09	29.46	28.28	9.32	9.72	9.52	26.37	30.47	28.42
P₃ 15th July	28.03	29.10	28.56	26.69	27.87	27.28	8.95	9.13	9.04	26.12	28.58	27.35
SEm±	0.41	0.59	0.36	0.62	0.57	0.42	0.18	0.20	0.14	0.53	0.59	0.40
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.09	2.33	1.30
Integrated weed Management (W)												
W₁	28.20	29.34	28.77	26.56	28.86	27.71	9.17	9.33	9.25	26.50	29.20	27.85
W₂	27.85	28.95	28.40	26.36	28.06	27.21	9.16	9.17	9.16	25.39	28.23	26.81
W₃	29.50	30.89	30.20	27.71	30.02	28.87	9.41	9.95	9.68	28.29	32.31	30.30
W₄	28.87	29.97	29.42	27.10	29.17	28.14	9.22	9.64	9.43	27.41	29.50	28.45
W₅	29.36	30.19	29.77	27.54	29.46	28.50	9.27	9.86	9.56	27.94	31.35	29.64
W₆	29.59	31.74	30.66	27.86	30.43	29.15	9.62	10.36	9.99	28.86	34.25	31.55
W₇	27.49	28.49	27.99	26.21	27.77	26.99	8.86	8.99	8.93	25.07	26.94	26.00
SEm±	0.67	0.85	0.54	0.72	0.87	0.57	0.27	0.38	0.23	0.81	0.93	0.62
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.33	2.67	1.74

Table 4.67(b): Residual interaction effect of sowing dates and integrated weed management treatments in soybean on plant population and plant height of succeeding crop of french bean

Treatments	Plant population (m ²)						Plant height (cm)					
	30 DAS			At harvest			30 DAS			60 DAS		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	29.24	30.21	29.73	27.43	30.17	28.80	9.44	9.78	9.61	27.34	30.45	28.90
P₁W₂	28.44	30.10	29.27	26.84	28.65	27.75	9.43	9.57	9.50	27.15	29.03	28.09
P₁W₃	29.62	31.26	30.44	27.65	30.67	29.16	9.55	10.27	9.91	30.19	34.21	32.20
P₁W₄	29.50	30.35	29.93	27.48	30.30	28.89	9.46	10.12	9.79	28.64	30.71	29.68
P₁W₅	29.53	30.87	30.20	27.66	30.57	29.12	9.54	10.14	9.84	29.80	34.01	31.91
P₁W₆	29.67	33.37	31.52	27.73	30.98	29.36	9.58	10.73	10.16	30.75	36.70	33.73
P₁W₇	28.04	29.15	28.59	26.77	28.64	27.70	9.24	9.37	9.31	27.04	26.80	26.92
P₂W₁	28.69	30.04	29.37	26.95	29.52	28.24	9.35	9.17	9.26	26.21	29.82	28.01
P₂W₂	28.65	29.23	28.94	26.95	28.69	27.82	9.34	8.88	9.11	24.17	29.06	26.62
P₂W₃	29.23	30.38	29.80	27.34	29.84	28.59	9.48	10.34	9.91	27.79	31.54	29.67
P₂W₄	29.02	30.13	29.57	27.10	29.57	28.33	9.38	9.68	9.53	27.24	30.15	28.70
P₂W₅	29.13	30.22	29.68	27.16	29.73	28.44	9.39	10.24	9.82	27.42	31.35	29.38
P₂W₆	29.38	30.53	29.96	27.36	30.69	29.02	9.59	11.04	10.32	28.02	33.28	30.65
P₂W₇	28.24	29.14	28.69	26.78	28.17	27.48	8.67	8.66	8.67	23.72	28.10	25.91
P₃W₁	26.67	27.77	27.22	25.31	26.87	26.09	8.73	9.05	8.89	25.95	27.31	26.63
P₃W₂	26.45	27.50	26.98	25.30	26.82	26.06	8.71	9.04	8.88	24.84	26.59	25.71
P₃W₃	29.66	31.03	30.34	28.14	29.56	28.85	9.19	9.23	9.21	26.89	31.17	29.03
P₃W₄	28.09	29.43	28.76	26.72	27.64	27.18	8.81	9.13	8.97	26.36	27.62	26.99
P₃W₅	29.42	29.46	29.44	27.81	28.08	27.95	8.88	9.20	9.04	26.60	28.69	27.64
P₃W₆	29.71	31.32	30.51	28.50	29.63	29.06	9.67	9.32	9.50	27.79	32.79	30.29
P₃W₇	26.20	27.18	26.69	25.06	26.50	25.78	8.68	8.95	8.82	24.44	25.92	25.18
SEm± (PxW)	1.16	1.48	0.94	1.25	1.51	0.98	0.47	0.66	0.40	1.41	1.61	1.07
SEm± (WxP)	0.86	1.19	0.73	1.18	1.17	0.83	0.37	0.45	0.29	1.09	1.23	0.82
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

However, the effect of the sowing dates on soybeans failed to exert a significant difference in plant height of french beans at 30 DAS during both years.

At 60 DAS, the effect of the sowing dates of the soybean crop has a significant impact on the plant height of succeeding french beans. Early sowing of soybeans on 15th June and succeeding french beans recorded higher plant heights of 28.70 and 31.70 cm in both years. It was at par with the sowing date of 30th June only in the first year (2021), while the lowest plant height of succeeding french bean was observed under late sowing of the previous crop, soybean, i.e., 15th of July in both years.

4.6.2.2 Effect of integrated weed management on plant height of succeeding french bean

The data revealed that the residual effect on plant height of french beans shows significant variation among treatments. At 30 DAS, plant height was found to be non-significant. However, at 60 DAS, effect of hand weeding at 20 and 40 DAS (W_6) recorded significantly higher plant height (28.86, 34.25 cm), which was at par with the application of pendimethalin 30 EC @1kg ha⁻¹ *fb* imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W_3) in both years and pooled values and W_4 (imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS *fb* interculture at 20 DAS) during the first year only. And the lowest plant height (25.07, 26.94 cm) was registered in W_7 (Weedy check) across both years of the study. This outcome is likely attributable to the reduction in crop-weed competition, as the predominant weeds were effectively suppressed or completed their life cycle. Such observation is similar to the result of Yadav and Bhullar (2014) and Deore and Patil (2016).

4.6.2.3 Interaction effect of sowing dates and integrated weed management on plant height of succeeding french bean

Table 4.67 (b) shows that no interaction effect was found to be significant during both years.

4.6.3 Residual effect of sowing dates and integrated weed management on dry matter production of succeeding crop french bean (g plant⁻¹)

The data on the dry matter production of the succeeding crop was recorded at 60 DAS, which is presented in Table 4.68 and depicted in Figure 4.7.

4.6.3.1 Effect of sowing dates on dry matter production of succeeding french bean

Data pertaining to the dry matter production of succeeding french bean are presented in Table 4.68 (a) were found significant at 60 DAS. Significantly, the maximum dry weight of 13.26 g plant⁻¹ and 17.74 g plant⁻¹ was recorded on 15th June in both years and was at par with 30th June in the first year only. The minimum values of 10.07 g plant⁻¹ and 12.34 g plant⁻¹ were obtained on 15th July in both years.

Higher dry weight at earlier sowing date may result from a larger leaf area and more leaves on the plant, which boosts photosynthetic activity and the concentration of carbohydrates in the plant, both of which increase the amount of dry matter produced.

4.6.3.2 Effect of integrated weed management on the dry matter production of succeeding french bean

The approach of integrated weed management also had a significant effect on the dry matter production of subsequent french bean crops. Among the different weed management treatments, W₆ (Hand weeding at 20 and 40 DAS) recorded the highest pooled value with 15.22 g plant⁻¹. This result was statistically at par to the application of pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ *fb* imazethpyr 10SL @ 100g a.i ha⁻¹ at 20 DAS (W₃) in both years and W₅ (imazethpyr 10SL @ 100g a.i ha⁻¹ at 20 DAS *fb* hand weeding at 30 DAS) in the first year. The lowest pooled values of 11.64 g plant⁻¹ were obtained in the weedy check during both years of experimentations. This result of the present study agreed with Sangeetha *et al.* (2012), Zahan *et al.* (2018), and Rana *et al.* (2019).

4.6.3.3 Interaction effect of sowing dates and integrated weed management on dry matter production on succeeding french bean

The interaction between sowing dates and integrated weed management did not result in a significant residual effect on the dry matter yield of succeeding french beans in both individual years and the pooled data [Table 4.68 (b)].

4.6.4 Residual effect of sowing dates and integrated weed management in soybean on seed yield of succeeding french bean (kg ha⁻¹)

Table 4.68(a): Residual effect of sowing dates and integrated weed management treatments in soybean on dry matter production and seed yield of succeeding crop of french bean

Treatments	Dry matter production (g) at 60DAS			Seed yield (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled
Sowing dates (P)						
P₁ 15th June	13.26	17.74	15.50	335.39	347.60	341.49
P₂ 30th June	12.39	14.92	13.65	316.33	328.98	322.66
P₃ 15th July	10.07	12.34	11.20	285.72	296.78	291.25
SEm±	0.30	0.32	0.22	6.18	5.61	4.18
CD at 5%	1.18	1.24	0.71	24.28	22.05	13.62
Integrated weed Management (W)						
W₁	11.47	14.37	12.92	299.53	304.17	301.85
W₂	10.92	14.30	12.61	287.47	291.53	289.50
W₃	12.77	16.23	14.50	341.50	369.95	355.72
W₄	12.19	14.80	13.50	315.01	329.64	322.32
W₅	12.44	15.10	13.77	329.40	338.09	333.75
W₆	13.27	17.18	15.22	362.92	384.40	373.66
W₇	10.28	13.01	11.64	251.52	253.40	252.46
SEm±	0.40	0.55	0.34	9.91	9.60	6.90
CD at 5%	1.14	1.58	0.96	28.42	27.54	19.45

Table 4.68(b): Residual interaction effect of sowing dates and integrated weed management treatments in soybean on dry matter and seed yield of succeeding crop of french bean

Treatments	Dry matter (g)			Seed yield (kg ha ⁻¹)		
	2021	2022	Pooled	2021	2022	Pooled
P₁W₁	12.72	17.18	14.95	319.74	321.99	320.86
P₁W₂	12.36	17.05	14.70	317.56	320.14	318.85
P₁W₃	14.28	19.19	16.73	373.18	395.35	384.27
P₁W₄	13.52	17.45	15.49	332.42	353.98	343.20
P₁W₅	14.12	18.09	16.10	349.04	357.86	353.45
P₁W₆	14.30	20.09	17.20	387.63	412.20	399.92
P₁W₇	11.55	15.17	13.36	268.13	271.64	269.89
P₂W₁	12.05	14.19	13.12	308.28	313.53	310.90
P₂W₂	11.02	14.15	12.59	291.32	295.36	293.34
P₂W₃	13.35	15.98	14.66	334.37	370.30	352.34
P₂W₄	12.81	14.68	13.74	316.20	331.60	323.90
P₂W₅	12.93	14.78	13.86	330.42	340.83	335.63
P₂W₆	13.84	17.38	15.61	379.97	391.90	385.94
P₂W₇	10.71	13.24	11.97	253.76	259.34	256.55
P₃W₁	9.65	11.76	10.71	270.56	276.98	273.77
P₃W₂	9.39	11.70	10.54	253.53	259.09	256.31
P₃W₃	10.69	13.52	12.11	316.95	344.18	330.57
P₃W₄	10.25	12.26	11.25	296.40	303.33	299.87
P₃W₅	10.28	12.44	11.36	308.75	315.57	312.16
P₃W₆	11.66	14.07	12.87	321.16	349.09	335.12
P₃W₇	8.57	10.63	9.60	232.66	229.23	230.94
SEm± (PxW)	0.69	0.95	0.59	17.16	16.63	11.95
SEm± (WxP)	0.59	0.68	0.45	12.88	11.98	8.80
CD at 5%	NS	NS	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS	NS	NS

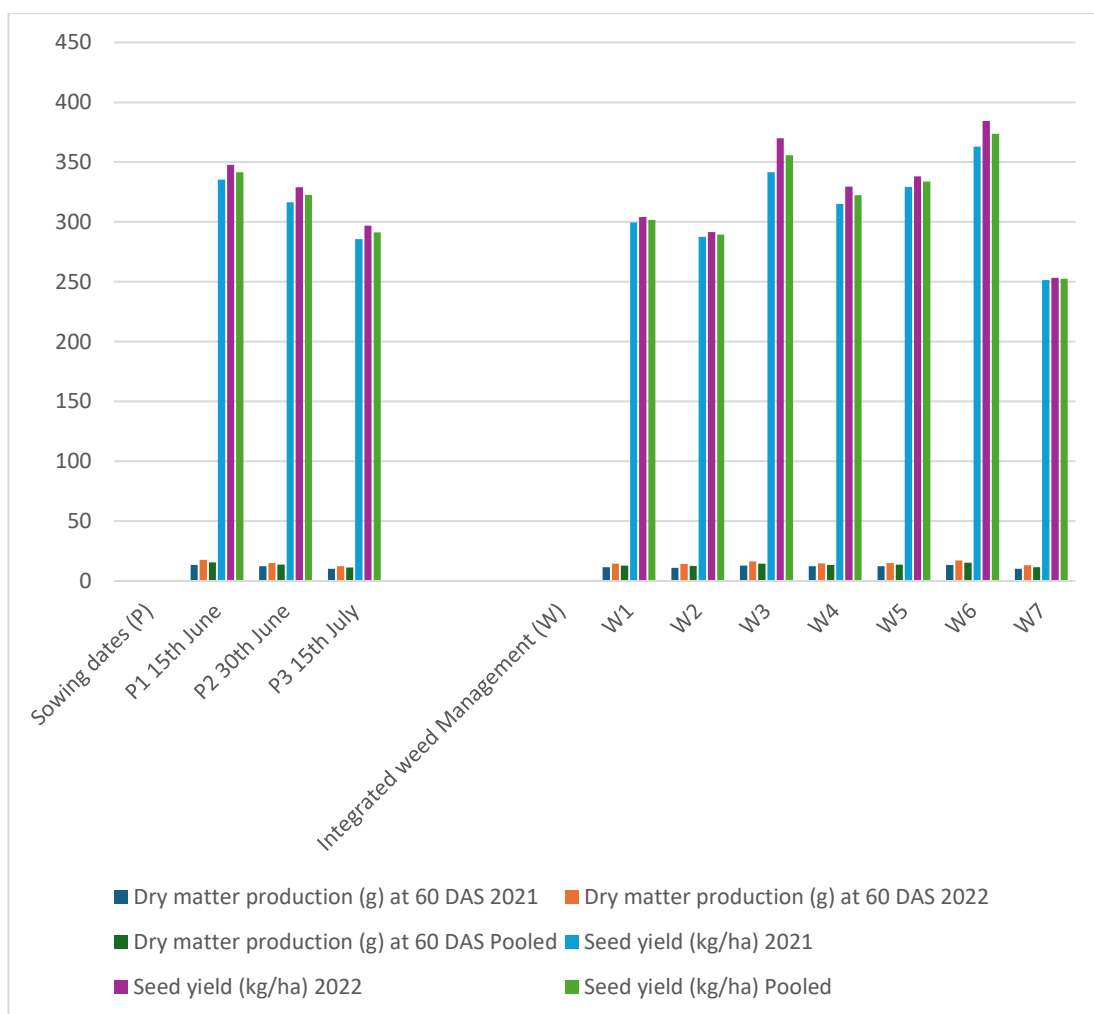


Fig 4.7 Effect of sowing dates and integrated weed management in soybean on dry matter production and seed yield of succeeding crop of french bean



Plate 20. Field of succeeding French bean



Plate 21. Flowering stage



Plate 22. Pods of French bean



Plate 23. Harvest of French bean



Plate 24. Seed of French bean

The data on seed yield of succeeding crops, french bean as influenced by sowing dates and integrated weed management in soybean are presented in Table 4.68 (a), Table 4.68 (b) and Figure 4.7.

4.6.4.1 Effect of sowing dates on seed yield of succeeding french bean (kg ha⁻¹)

The variations in seed yield among the sowing dates were found to be significant. The pooled value of seed yield 341.49 kg ha⁻¹ was recorded highest on 15th June and was at par with 30th June in both the years. The lowest pooled value of seed yield 291.25 kg ha⁻¹ was recorded on 15th July. The increase in yield due to early sowing on 15th June was 5.52 % and 14.71 % higher over 30th June and 15th July, respectively.

4.6.4.2 Effect of integrated weed management on seed yield of succeeding french bean (kg ha⁻¹)

The adoption of integrated weed management also had a significant effect on the seed yield of the residual crop, the french bean. Among the weed management treatments, hand weeding at 20 and 40 DAS (W₆) recorded the highest pooled value of seed yield 341.49 kg ha⁻¹ and at par with the application of pendimethalin 30EC @ 1.0 kg a.i ha⁻¹ fb imazethapyr 10SL @ 100g a.i ha⁻¹ at 20 DAS (W₃) in both years and pooled values. The lowest seed yield of 291.25 kg ha⁻¹ (pooled value) was obtained in W₇ (weedy check). Such comparable findings have been reported by Santin *et al.* (2019) and Sridhara *et al.* (2019).

4.6.4.3 Interaction effect of sowing dates and integrated weed management on seed yield of succeeding french bean

The data on the seed yield of french beans indicated in Table 4.68 (b) shows that the interaction between sowing dates and IWM did not exhibit a statistically significant residual effect in either of the years examined.

4.7 Economic analysis

4.7.1 Cost of cultivation (₹ ha⁻¹)

The data on the cost of cultivation of soybeans- french bean cropping system was computed and recorded for both cropping seasons, as presented in Table 4.69 (a)

and Table 4.69 (b).

Analysis of the data reveals that the cultivation expenses for all three sowing dates was consistent across both years, amounting to ₹ 61391.00 ha⁻¹.

Among the integrated weed management, the highest cost of cultivation was recorded in W₁ (soil solarization with black polythene for 25 days before sowing *fb* hand weeding at 30 DAS) with ₹ 84124.89 ha⁻¹ in both the year. Conversely, the lowest cost of cultivation was incurred by weedy check (W₇) with ₹ 61391.00 ha⁻¹. The higher cost of cultivation associated with the treatment W₁ (soil solarization with black polythene 25 days before sowing *fb* hand weeding at 30 DAS) was due to additional cost of plastic sheet.

4.7.2 Gross returns (₹ ha⁻¹)

The data on gross returns for the two cropping seasons were calculated and presented in Table 4.69 (a) and Table 4.69 (b).

The data indicated that among the sowing dates, maximum gross returns were obtained from the 15th June sown date with ₹ 204885.00 ha⁻¹ and ₹ 217942.00 ha⁻¹ for the years 2021 and 2022, respectively, while the lowest was recorded when the crop was sown on 15th July with ₹ 133737.00 ha⁻¹ and ₹ 152523.00 ha⁻¹, respectively in 2021 and 2022.

Among integrated weed management, hand weeding at 20 and 40 DAS (W₆) recorded highest gross returns with ₹ 225252.00 ha⁻¹ and ₹ 239394.00 ha⁻¹ in 2021 and 2022, respectively followed by W₃ (Pendimethalin 30 EC @1kg ha⁻¹ *fb* imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) and the lowest was obtained from weedy check (W₇) with gross returns of ₹ 95805.00 ha⁻¹ and ₹ 108244.00 ha⁻¹ in 2021 and 2022, respectively. The higher gross returns associated with the hand weeding treatment can be attributed to enhanced seed and stover yields, which result from more effective weed control throughout the crop growth period. These findings are consistent with those reported by Samim *et al.* (2023).

4.7.3 Net returns (₹ ha⁻¹)

The net returns data were calculated during both cropping seasons and is presented in Table 4.69 (a) and Table 4.69 (b).

Among the sowing dates, the highest net returns of ₹ 143494.00 ha⁻¹ during 2021 and ₹ 156551.00 ha⁻¹ during 2022 were recorded under the 15th June sowing date, while sowing on 15th July gave the lowest net returns with ₹ 72346.00 ha⁻¹ and ₹ 91132.00 ha⁻¹ for the year 2021 and 2022, respectively. The result conforms to Tomar *et al.* (2014) and Rajasekhar *et al.* (2021).

Regarding integrated weed management, hand weeding at 20 and 40 DAS (W₆) recorded maximum net returns with ₹ 154861.00 ha⁻¹ and ₹ 169003.00 ha⁻¹ followed by W₃ (Pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS) in the years 2021 and 2022, respectively, while the lowest was obtained from weedy check with ₹ 34415.00 ha⁻¹ and ₹ 46853.00 ha⁻¹. The application of led to higher net returns mainly due to enhanced yields, which were comparable with weed-free and reduced costs of cultivation, along with the control of monocot and dicot weeds. Lower net returns in the weedy check might be due to reduced seed and stover yield as a result of full-season weed infestation. These findings are consistent with those reported by Sepata *et al.* (2017), Roy *et al.* (2023) and Samim *et al.* (2023).

4.7.4 Benefit: Cost ratio (B: C ratio)

The data on the B: C ratio for the two-cropping season was calculated and presented in Table 4.69 (a) and Table 4.69 (b).

The data indicated that among the dates of sowing, sowing on 15th June recorded the highest B: C ratio of 2.34 and 2.55, while sowing on 15th July gave the lowest B: C ratio. Similar results in a higher B: C ratio in early sowing date were also mentioned by Tomar *et al.* (2014) and Rajasekhar *et al.* (2021).

With the integrated weed management, weedy check (W₇) recorded a minimum B: C ratio. In contrast, the application of pendimethalin 30 EC @1kg ha⁻¹ fb imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (W₃) recorded a maximum B: C ratio of 2.32 and 2.58, respectively in 2021 and 2022. The higher B: C ratio found in W₃ could be attributed to higher yield due to effective weed management and lesser cost of herbicide usage compared to hand weeding. The result is in agreement with the results of Vijay *et al.* (2018), Roy *et al.* (2023) and Samim *et al.* (2023).

Table 4.69(a): Effect of sowing dates and integrated weed management treatments on economics of soybean-french bean cropping system

Treatment	Cost of Cultivation (Soybean + French bean) ₹ ha ⁻¹		Gross Return (₹ ha ⁻¹)		Net Return (₹ ha ⁻¹)		B:C Ratio	
	2021	2022	2021	2022	2021	2022	2021	2022
Sowing dates								
P₁ -15th June	61391.00	61391.00	204885.00 (157931 + 46954)	217942.00 (169279 + 48663)	143494	156551	2.34	2.55
P₂ -30th June	61391.00	61391.00	177310.00 (133023 + 44287)	193191.00 (147134 + 46057)	115918	131800	1.89	2.15
P₃ -15th July	61391.00	61391.00	133737.00 (93737 + 40000)	152522.00 (110973 + 41549)	72346	91132	1.18	1.48
Integrated weed Management (W)								
W₁	84124.00	84124.00	158621.00 (116687 + 41934)	174703.00 (132120 + 42583)	74496	90580	0.89	1.08
W₂	71491.00	71491.00	143108.00 (102862 + 40246)	162267.00 (121453 + 40814)	71617	90776	1.00	1.27
W₃	62802.00	62802.00	208526.00 (160716 + 47810)	224921.00 (173129 + 51792)	145724	162119	2.32	2.58
W₄	64767.00	64767.00	178177.00 (134076 + 44101)	196210.00 (150061 + 46149)	113410	131443	1.75	2.03
W₅	64226.00	64226.00	194350.00 (148233 + 46117)	209457.00 (162125 + 47332)	130124	145231	2.03	2.26
W₆	70391.00	70391.00	225252.00 (174443 + 50809)	239394.00 (185578 + 53816)	154861	169003	2.20	2.40
W₇	61391.00	61391.00	95805.00 (60593 + 35212)	108244.00 (727678 + 35476)	34415	46853	0.56	0.76

Fixed cost of cultivation: ₹ 43891.00 (Soybean)+ ₹ 17500.00 (French bean) = ₹ 61391.00

Selling price of Soybean seed @ ₹ 80 kg⁻¹, Selling price of Soybean stover: ₹ 1 kg⁻¹,

Selling price of French bean seed @ ₹ 140 kg⁻¹

Table 4.69(b): Effect of sowing dates and integrated weed management treatments combination on economics of soybean + french bean cropping system

Treatment	Cost of Cultivation (Soybean + French bean) (₹ ha ⁻¹)		Gross Return (₹ ha ⁻¹)		Net Return (₹ ha ⁻¹)		B:C Ratio	
	2021	2022	2021	2022	2022	2022	2021	2022
P₁W₁	84124	84124	201602.00 (156839 + 44763)	213593.00 (168514 + 45079)	117478	129469	1.40	1.54
P₁W₂	71491	71491	177009.00 (132550 + 44459)	190889.00 (146070 + 44820)	105518	119398	1.48	1.67
P₁W₃	62802	62802	240739.00 (188493 + 52246)	254688.00 (199339 + 55349)	177937	191886	2.83	3.06
P₁W₄	64767	64767	213175.00 (166637 + 46538)	228677.00 (179120 + 49557)	148408	163910	2.29	2.53
P₁W₅	64226	64226	223614.00 (174748 + 48866)	241657.00 (191557 + 50100)	159388	177431	2.48	2.76
P₁W₆	70391	70391	256749.00 (202481 + 54268)	267276.00 (209567 + 57709)	186358	196885	2.65	2.80
P₁W₇	61391	61391	121304.00 (83765 + 37539)	128814.00 (90785 + 38029)	59913	67423	0.98	1.10
P₂W₁	84124	84124	162129.00 (118970 + 43159)	180179.00 (136286 + 43894)	78005	96055	0.93	1.14
P₂W₂	71491	71491	148316.00 (107532 + 40785)	170699.00 (129349 + 41350)	76825	99208	1.07	1.39
P₂W₃	62802	62802	217707.00 (170895 + 46812)	229876.00 (178035 + 51842)	154905	167074	2.47	2.66
P₂W₄	64767	64767	186437.00 (142169 + 44268)	203410.00 (156986 + 46424)	121670	138643	1.88	2.14
P₂W₅	64226	64226	204121.00 (157862 + 46259)	215619.00 (167902 + 47717)	139895	151393	2.18	2.36
P₂W₆	70391	70391	237469.00 (184272 + 53196)	244474.00 (189608 + 54866)	167078	174083	2.37	2.47

P₂W₇	61391	61391	84986.00 (49459 + 35527)	108077.00 (71769 + 36308)	23595	46686	0.38	0.76
P₃W₁	84124	84124	112131.00 (74252 + 37879)	130338.00 (91560 + 38778)	28007	46214	0.33	0.55
P₃W₂	71491	71491	103998.00 (68504 + 35494)	125212.00 (88939 + 36272)	32507	53721	0.45	0.75
P₃W₃	62802	62802	167133.00 (122759 + 44373)	190198.00 (142012 + 48186)	104331	127396	1.66	2.03
P₃W₄	64767	64767	134918.00 (93422 + 41497)	156543.00 (114076 + 42467)	70151	91776	1.08	1.42
P₃W₅	64226	64226	155315.00 (112090 + 43225)	171096.00 (126916 + 44180)	91089	106870	1.42	1.66
P₃W₆	70391	70391	181539.00 (136576 + 44962)	206432.00 (157559 + 48872)	111148	136041	1.58	1.93
P₃W₇	61391	61391	81127.00 (48555 + 32572)	87842.00 (55750 + 32092)	19736	26451	0.32	0.43

Fixed cost of cultivation: ₹ 43891.00 (Soybean)+ ₹ 17500.00 (French bean) = ₹ 61391.00

Selling price of Soybean seed @ ₹ 80 kg⁻¹,

Selling price of Soybean stover: ₹ 1 kg⁻¹,

Selling price of French bean seed @ ₹140 kg⁻¹

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

A field experiment entitled “**Effect of sowing date and integrated weed management in soybean (*Glycine max* L.) and their residual effect on succeeding french bean (*Phaseolus vulgaris*)**” was conducted at the experimental farm of School of Agricultural Sciences (SAS), Nagaland University, Medziphema during *kharif* seasons of 2021 and 2022 with the following objectives:

1. To study the effect of sowing dates and integrated weed management on the growth and yield of soybean
2. To find out appropriate integrated weed management practices for soybean
3. To evaluate the effect of integrated weed management on density and dry matter accumulation of associated weed flora in soybean
4. To find out the residual effect of sowing dates and integrated weed management in soybean on the growth and yield of succeeding french bean, and
5. To find out the economics of the treatments under study.

The experiment consisted of twenty-one treatment combinations, was laid out in ‘split-plot design,’ and was replicated thrice with three dates of sowing viz. 15th June, 30th June, and 15th July in main plots and seven integrated weed management viz. W₁: Soil solarization with black polythene (25 days before sowing) *fb* Hand weeding at 30 DAS, W₂: Mulching with paddy straw 5 t ha⁻¹ *fb* Hand weeding at 30 DAS, W₃: Pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) - *fb* Imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS (post-emergence), W₄: Pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) - *fb* Interculture at 30 DAS, W₅: Imazethapyr 10 SL @ 100 g ha⁻¹ at 20 DAS (post-emergence) *fb* Interculture at 30 DAS, W₆: Hand weeding at 20 and 40 DAS, W₇: weedy check (Control).

The soybean variety “JS-97 52” was sown with a seed rate of 70 kg ha⁻¹ in a row, 30 cm apart, with fertilizer dose of 20-60-50 kg NPK ha⁻¹. The response of soybean to various treatments was evaluated using growth, yield attribute and yield, weeds, soil nutrient availability, nutrient depletion and uptake by weeds, crop,

economics, bioassay test and succeeding french bean which were recorded as per standard procedures.

The prominent findings drawn from the experiment are summarized as follows:

5.1 Effect of sowing dates and integrated weed management in soybean

5.1.1 Growth attributes

1. The results revealed that early sowing of soybean on June 15th recorded significantly higher plant height, number of branches plant⁻¹, dry matter accumulation, leaf area index (LAI), number of root nodules, dry weight of root nodules, crop growth rate, relative growth rate and net assimilation rate compared to 30th June and 15th July sowing. Among the integrated weed management practices, maximum plant height, number of branches plant⁻¹, dry matter accumulation, leaf area index (LAI), crop growth rate, relative growth rate and net assimilation rate were recorded with hand weeding at 20 and 40 DAS (W₆) followed by W₃: Pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) *fb* Imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS (post-emergence) and minimum value were recorded in weedy check. The interaction effect of sowing dates and integrated weed management was found non-significant.

5.1.2 Yield attributes and yield

1. Early sowing of soybean on 15th June resulted significantly higher number of pods plant⁻¹, test weight, seed yield, stover yield, biological yield and harvest index compared to sowing dates of 30th June and 15th July .
2. Among integrated weed management, hand weeding at 20 and 40 DAS recorded the highest value of pods plant⁻¹, seed yield, stover yield, biological yield and harvest index and was found at par with W₃: Pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) *fb* Imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS (post-emergence). The interaction effect of sowing dates and integrated weed management was found to be significant in the case of seed yield only.
3. Protein content was found to be non-significant due to the date of sowing, while integrated weed management practices showed significant effect. The higher protein content and protein yield were recorded with hand weeding at 20 and 40 DAS in both years, followed by W₃: Pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-

emergence) fb Imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS (post-emergence).

5.2 Effect of sowing dates and integrated weed management on weeds

1. The dominant weeds species associated with soybean in the experimental plot comprised of grasses were *Cynodon dactylon*, *Digitaria sanguinalis*, and *Eleusine indica*, sedges were *Cyperus iria* and *Cyperus rotundus* and broad-leaved weeds were *Ageratum conyzoides*, *Amaranthus viridis*, *Borreria latifolia*, *Cleome rutidosperma*, *Mimosa pudica* L., *Mollugo pentaphylla*, *Scorparia dulcis*, *Alternanthera sessilis*, *Commelina benghalensis*.
2. Weed density and dry weight of grasses, sedges, broad-leaved weeds and total weeds were recorded significantly lowest when soybean were sown on 15th June compared to 30th June and 15th July in both years. For integrated weed management practices, hand weeding at 20 and 40 DAS significantly recorded the lowest weed population and dry weight and was found at par with W₃: Pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) - fb Imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS (post-emergence), while the weedy check recorded the highest values.
3. The highest weed control efficiencies of grasses, sedges, broad-leaved weeds and total weeds were recorded when soybean were sown on 15th June and lowest on 15th July. Among the integrated weed management methods, hand weeding at 20 and 40 DAS significantly recorded the highest weed control efficiency, followed by W₃: Pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) fb Imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS (post-emergence) and the lowest WCE values were observed with weedy check.
4. Soybean sown on June 15th recorded significantly lower weed index than on June 30th and July 15th. Integrated weed management of application of pendimethalin 30 EC @ 1 kg ha⁻¹ fb imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS recorded a lower weed index, i.e., minimum reduction in yield.

5.3 Soil nutrient status

1. The soil pH, electrical conductivity, organic carbon and available NPK after harvest were non-significant to different sowing dates and integrated weed

management.

2. NPK content in grain and stover was not affected significantly by the different dates of sowing in both years. Integrated weed management, however, influenced the NPK content in grain and straw. Maximum NPK content was recorded in hand weeding at 20 and 40 DAS, followed by application of pendimethalin 30 EC @ 1 kg ha⁻¹ *fb* imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS.
3. Maximum and minimum depletion of NPK by weeds were observed with the sowing date of the 15th of July and the 15th of June, respectively. Among the integrated weed management practices, hand weeding at 20 and 40 DAS recorded minimum NPK depletion by weeds followed by application of pendimethalin 30 EC @ 1 kg ha⁻¹ *fb* imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS.

The interaction of the dates of sowing and integrated weed management also influenced the depletion of NPK by weeds. Sowing of soybean on 15th June along with weed management of hand weeding at 20 and 40 DAS recorded lower depletion of NPK while sowing of soybean on 15th July in combination with a weedy check (control) recorded significantly highest NPK depletion by weeds.

4. Significant differences in NPK uptake in both seed and stover were observed across various sowing dates and integrated weed management strategies. The highest uptake occurred with the sowing date of June 15th, particularly when integrated weed management involved two hand weeding (W₆).

5.4 Herbicide residue (bioassay test)

Herbicide applied to soybean crops did not show any phytotoxic effect on the shoot growth and root length of the test crop, i.e., maize, pea, cucumber, and mustard.

5.5 Residue effect of sowing dates and integrated weed management on succeeding french bean

1. Due to different sowing dates and integrated weed management, the emergence, plant population and plant height at 30 DAS showed no

significant effect on succeeding french beans. However, plant height at 60 DAS was significantly higher with an early sowing date of 15th June compared to 30th June and 15th July. Additionally, under integrated weed management practices, hand weeding at 20 and 40 recorded higher plant height.

2. Dry matter production at 60 DAS and seed yield of french bean were found to be higher with early sowing date of 15th June than the other sowing dates. Integrated weed management in soybeans, involving two hand weeding (W₆), resulted in higher dry matter production and seed yield of succeeding crop french bean compared to control (weedy check) .

5.6 Economics analysis

1. Data indicated that the soybean crop sown on 15th June recorded maximum gross returns and net returns, along with the benefit-cost (B: C) ratio. This was followed by 30th June and 15th July. Among the integrated weed management practices, the highest gross return and net returns were obtained in hand weeding at 20 and 40 DAS. However, B: C ratio was obtained highest with application of pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) *fb* imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS (post-emergence) in both the years.

Conclusion:

1. In soybean 15th June was found to be the best date of sowing, resulting in higher growth, yield attributes and yield. Among the integrated weed management practices, application of pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) *fb* imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS recorded higher growth, yield attributes, yield and protein content after hand weeding at 20 and 40 DAS.
2. Hand weeding at 20 and 40 DAS was found to be the appropriate integrated weed management practice, with the next best approach being with the application of pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) *fb* imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS (post-emergence).
3. Minimum weed density, weed dry weight and higher weed control efficiency were recorded with a sowing date of 15th June. The most effective methods for

weed control was two hand weeding at 20 and 40 DAS, which resulting in lower values. It was followed by the application of pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) *fb* imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS (post-emergence).

4. Higher growth and yield of succeeding french bean were found after soybean sown on 15th June compared to other sowing dates. Additionally, in terms of integrated weed management practices, hand weeding at 20 and 40 DAS recorded higher growth and yield.
5. Sowing of soybean on 15th June along with the application of pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) *fb* imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS (post-emergence) contributed highest gross returns, net returns and B: C ratio.

Recommendation

In light of the findings, it is recommended that soybean be sown on 15th June accompanied by two hand weeding to achieve effective weed control and enhanced productivity. However, considering the challenges of labour scarcity and high cost, sowing of soybean on 15th June in conjunction with the use of pendimethalin 30 EC @ 1 kg ha⁻¹ (pre-emergence) *fb* imazethapyr 10 SL @ 100 g a.i. ha⁻¹ at 20 DAS (post-emergence) could be recommended for higher income and profitable soybean production. The application of herbicide, both pre- and post-emergence, did not exhibit any significant persistence effects or residual toxicity, as demonstrated through bioassays test conducted on maize, cucumber, mustard, and pea. This approach also offers a significant residual effect on subsequent french bean crops, maximizing net returns and benefit-cost ratio in a soybean-based cropping system, and is recommended for cultivation in the mid-hill regions of Nagaland.

CHAPTER VI
APPENDICES

APPENDIX-I

Common cost of cultivation

(A) Soybean

Sl. No.	Operations	Qty/units	Rate ₹	Cost ₹ ha ⁻¹
1	Field operation			
	a. Ploughing	1	₹ 1000	1000
	b. Harrowing	1	₹ 1000	1000
	c. Bed preparation	3 man days	₹ 300/man/day	900
2	Manures and Fertilizer			
	a. FYM	10 t	₹ 1	10000
	b. Nitrogen (Urea)	43.38 kg	₹ 320/50 kg bag	278
	c. Phosphorus (SSP)	374.93 kg	₹ 420/50 kg bag	3149
	d. Potassium (MOP)	82.48 kg	₹ 980/50 kg bag	1617
	e. Application of manures and fertilizer	2 man days	₹ 300/man/day	600
3	Seed	70 kg	₹ 40	2800
4	Sowing	15 labours	₹ 300	4500
5	Plant protection			
	a. Labour charges	12 man days	₹ 300/man/day	3600
	b. Insecticide			
	Chlorpyrifos	4 litre	₹ 550/500 ml	4400
	c. Fungicide			
	Carbendazim 50% WP	2 kg	₹ 200/100 g	4000
	d. <i>Rhizobium japonicum</i> for seed treatment	350g	₹ 135/kg	47
6	Harvesting, threshing drying and winnowing	15 man days	₹ 300/man/day	6000
Total				43891.00

(B) French bean

Sl. No.	Operations	Qty/units	Rate ₹	Cost ₹ ha ⁻¹
1	Seed	50 kg	₹140	7000
2	Sowing of French bean	15 labours	₹ 300	4500
5	Harvesting, threshing drying and winnowing	15 man days	₹ 300/man/day	6000
Total				17500.00

APPENDEX-II

Cost of cultivation for different weed management practices

Treatment	Operation	Qty/units	Rate ₹	Cost ₹ ha ⁻¹
W₁	a. Soil solarization with black polythene (25 DBS)	2666 m ²	₹ 6.5/m ²	17333
	b. Labour required for lying of polythene	3 labours	₹ 300	900
	c. Hand weeding at 30 DAS	15 labours	₹ 300	4500
	Total			22733
W₂	a. Mulching with paddy straw	5t/ha	₹ 1/kg	5000
	b. Hand weeding at 30 DAS	15 labours	₹ 300	4500
	c. Labour required for mulching	2 labours	₹ 300	600
	Total			10100
W₃	a. Pendimethalin	1liter	₹ 676/ lit	676
	b. Imazethapyr	100g	₹1350/lit	135
	c. Labours required for herbicide application	2 labours	₹ 300	600
	Total			1411
W₄	a. Pendimethalin	1liter	₹ 676/ kg	676
	b. Interculture at 30 DAS	7 labours	₹ 300	2100
	c. Labours required for herbicide application	2 labours	₹ 300	600
	Total			3376
W₅	a. Imazethapyr	100 g	₹1350/lit	135
	b. Interculture at 30 DAS	7 labours	₹ 300	2100
	c. Labours required for herbicide application	2 labours	₹ 300	600
	Total			2835
W₆	a. HW at 20	15 labours	₹ 300	4500
	b HW at 40	15 labours	₹ 300	4500
	Total			9000
W₇	Weedy check			

CHAPTER VII

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