Ph.D

Khrawbor Dkhar

2026

EFFECT OF SOWING DATES AND NUTRIENT MANAGEMENT ON PRODUCTIVITY, PROFITABILITY AND QUALITY OF FINGER MILLET [*Eleusine coracana* (L.) Gaertn.]

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

By

KHRAWBOR DKHAR

Admn. No.: Ph-331/21 Regn. No.: Ph.D/AGR/00624

Department of Agronomy
School of Agricultural Sciences
Nagaland University, Medziphema Campus - 797106
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BY

Name of the Candidate – Khrawbor Dkhar

Name of the Supervisor - Prof. T. Gohain

Submitted

In partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Agronomy of Nagaland University

DEDICATED

TO

MY FAMILY

Nagaland University

December, 2025

I, Khrawbor Dkhar, 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 basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

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

(KHRAWBOR DKHAR)

(Head) (Supervisor)

NAGALAND UNIVERSITY
Medziphema Campus
School of Agricultural Sciences
Medziphema – 797106, Nagaland

Prof. T. Gohain
Professor & Head
Department of Agronomy

CERTIFICATE – I

This is to certify that the thesis entitled **"Effect of sowing dates and nutrient management on productivity, profitability and quality of finger millet [*Eleusine coracana* (L.) Gaertn."** submitted to Nagaland University in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy in Agronomy, is the record of research work carried out by Mr. Khrawbor Dkhar, Registration No. PhD/AGR/00624 under my personal supervision and guidance.

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

Date:

Place: SAS, NU, Medziphema

……………………………

Prof. T. GOHAIN
Supervisor

NAGALAND UNIVERSITY
Medziphema Campus School of Agricultural Sciences
Medziphema – 797 106, Nagaland

CERTIFICATE – II

VIVA VOCE ON THESIS OF DOCTOR OF PHILOSOPHY IN AGRONOMY

This is to certify that the thesis entitled "**Effect of sowing dates and nutrient management on productivity, profitability and quality of finger millet [*Eleusine coracana* (L.) Gaertn.]**" submitted by Khrawbor Dkhar, Admission No. Ph- 331/21, Registration No. Ph.D./AGR/00624, 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.**

Member	**Signature**
1. Prof. T. Gohain (Supervisor)	…………………………...
2. Prof. M. K. Singh (External Examiner)	…………………………...
3. Dean. SAS, NU (Pro-Vice-chancellor Nominee)	…………………………...
4. Dr. A. P Singh	…………………………...
5. Dr. Debika Nongmaithem	…………………………...
6. Prof. P. K. Singh	…………………………...
7. Dr. Imtinaro L.	…………………………...

Head
Department of Agronomy

Dean
School of Agricultural Sciences

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Date:

Place: SAS, NU, Medziphema (Khrawbor Dkhar)

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LIST OF ABBREVIATIONS

%	Percentage
@	at the rate of
°C	Degree celsius
₹/ Rs.	Rupees
$^{-1}$ or /	Per
ANOVA	Analysis of variance
ATER	Area time equivalent ratio
BCR	Benefit Cost ratio
CD	Critical Difference
cm	Centimetre
CR	Competition ratio
DAS	Days after sowing
df	Degree of freedom
et al.	*et allia* (and others/co- workers)
Fig.	Figure
g	Gram
ha^{-1}	Per hectare
i.e.	Id est (that is)
kg	Kilogram
Kg ha^{-1}	Kilogram per hectare
LAI	Leaf area index
m	Meter
m^2	Meter square
Max.	Maximum
Min.	Minimum
mm	Millimeter

MOP	Muriate of Potash
msl	Mean sea level
Mss	Mean sum of squares
mt	Million tonnes
NPK	Nitrogen Phosphorus Potassium
No.	Number
NS	Not significant
NU	Nagaland University
OC	Organic carbon
pH	Negative log of H ion activity
ºC	Degree Celsius
RDF	Recommended Dose of Fertilizers
SAS	School of Agricultural Sciences
SEm±	Standard error of mean
Sl. No.	Serial number
SOV	Source of Variation
ss	Sum of square
SSP	Single Superphosphate
t	Tonnes
viz.	Videlicet (Namely)

A B S T R A C T

A field experiment was conducted to study the **"Effect of sowing dates and nutrient management on productivity, profitability and quality of finger millet [*Eleusine coracana* (L.) Gaertn.]"** at ICAR Research Complex for NEH Region, Umiam, Meghalaya, India, during *kharif* season of 2023 and 2024. The experiment was laid out in 2-Factor Randomized Block Design (FRBD) with three replications. The experiment had three sowing dates: D_1 - 1st June, D_2 - 15th June, D_3 - 1st July; and four nutrient management: N_1 - Control (No fertilizer), N_2 RDF – N, P_2O_5 and K_2O: 40-30-20 kg ha^{-1}, N_3 - 100% Organic through FYM on N equivalent basis (10 t ha^{-1}), N_4 - 50% Inorganic + 50% Organic through FYM. The pooled result of the two years revealed that sowing dates and nutrient management has significant effect on productivity, quality and profitability of finger millet. Results from the experiment revealed that the pooled result of sowing date on 1st July recorded the highest growth parameter, yield and yield attributes, quality parameters and economics, *viz*., plant population (28.66 m^{-2}), germination (85.59%), number of effective tillers (68.33 m^{-2}), fresh weight (126.62 g plant^{-1}), CGR (4.10 g m^{-2} day), number of panicles (202.41 m^{-2}), number of fingers ear^{-1} (7.04), grain finger^{-1} (332.87), length of finger (7.35 cm), grain yield (1567. 58 kg ha^{-1}), straw yield (4220.91 kg ha^{-1}), harvest index (27.11%), crude protein (6.75%), crude fiber (4.07%), calcium content (1.44%), gross return (₹ 94,055.25), net returns (₹ 66,170.25) and B:C ratio (2.32) when compare to the other two sowing dates. Similarly, among nutrient management, the pooled result of N_4 - 50% Inorganic + 50% Organic through FYM recorded the highest growth, yield, quality parameters and economics, *viz*., plant height (143.51cm), plant population (29.38 m^{-2}), germination (88.16%), number of effective tillers (73.50 m^{-2}), fresh weight (129.98 g plant^{-1}), LAI (1.62), CGR (3.95 g m^{-2} day), RGR (0.068 g g^{-1} day), number of panicles (231.66 m^{-2}), number of fingers ear^{-1} (7.85), grain finger^{-1} (346.72), length of finger (8.13 cm), grain yield (1950. 43 kg ha^{-1}), straw yield (5305.66 kg ha^{-1}) and harvest index (26.92%), crude fiber (4.08%), calcium content (1.44%), gross return (₹ 1,17,027.43), net return (₹ 86,477.43) and B:C ratio (2.82). The findings also revealed the pooled results among the interactions, the pooled result revealed that T_{12}

- D_3N_4 (Sowing on 1st July, 50% Inorganic + 50% Organic through FYM) recorded the highest growth, yield and yield attributes, quality parameters and economics. Among the interactions, T_{12} - D_3N_4 recorded the highest yield with 2122.56 kg ha^{-1} and least was recorded in T_1 - D_1N_1 (Sowing on 1st June, Control) with only 705.23 kg ha^{-1}. As grain yield is the ultimate objective of any cultivation practices, hence, only this parameter was considered to identify the best combinations.

***Key words*:** Finger millet, sowing dates, nutrient management, organic, inorganic, economics, interaction, farm yard maure.

CHAPTER I

INTRODUCTION

INTRODUCTION

Finger millet (*Eleusine coracana* L. Gaertn.), locally known as *ragi* or *mandua* in India, is among the oldest cultivated cereal crops and one of the most adaptable to challenging environments. Originating from the East African highlands particularly Ethiopia and Uganda. It has become a vital food grain across many parts of Asia and Africa. Owing to its exceptional tolerance to drought, poor soils, and fluctuating weather, finger millet is widely regarded as a "climate-resilient crop" suited for sustainable farming systems. Finger millet [*Eleusine coracana* (L.) Gaertn.], a coarse cereal of African origin, serves as a staple food in the dry regions of India, Africa, and several Asian countries. The plant's name derives from its seed head, which resembles human fingers. In India, it is popularly known as *ragi* or *mandua* (Anon, 1996), and as *kodo* in Nepal.

Finger millet originated in the highlands of Ethiopia and Uganda and is mainly grown between latitudes 20°N and 20°S, covering the semi-arid to arid tropics. It is even cultivated as far north as 30°N in the Himalayan regions of India and Nepal. Although considered drought-tolerant, it performs best under moderate rainfall (around 500 mm annually) and shows greater tolerance to cooler temperatures compared to other millets like pearl millet and sorghum. The crop grows well at elevations between 500-2400 m above sea level and can be rainfed or irrigated for higher yields.

It adapts to diverse soils, including lateritic ones, and performs well in free-draining soils with moderate moisture. While finger millet can tolerate mild soil salinity and acidity (pH 5-8.2), it is sensitive to waterlogging. Finger millet is a self-pollinating tetraploid species, believed to have evolved from its wild ancestor *Eleusine africana*. Being a short-day crop, most varieties grow best under about 12 hours of daylight.

Finger millet is a hardy, climate-resilient cereal commonly grown in India's semi-arid and rainfed regions, especially across hilly landscapes and nutrient-poor soils (Naresh *et al.*, 2023). Owing to its rich nutritional composition, particularly its high calcium, iron, and dietary fiber. It plays a crucial role in ensuring both food and nutritional security. Millets are acknowledged as super cereals due to their remarkable climate resilience and exceptional nutritional qualities. They play a vital role in ensuring national nutritional security and are expected to endure the impacts of future climate changes. Often called the "crops of the future," millets thrive in harsh, arid, and semi-arid environments (Resmisa, 2012). These small-grained cereals are cultivated worldwide for both food and fodder.

Nutritionally, finger millet stands out as a "nutrient-dense grain"**,** rich in calcium, iron, dietary fiber, and amino acids, offering greater health benefits than common cereals like rice, wheat, and maize. Its slowly digestible carbohydrates help sustain energy for longer durations and make it a suitable food for people with diabetes. Because of its excellent storage quality, it also serves as an important "famine food"**,** ensuring food availability during adverse seasons. Nutritionally, finger millet contains about 9.2% protein, 1.29% fat, 76.32% carbohydrates, 2.2% minerals, 3.9% ash, and 0.33% calcium. It also provides small amounts of vitamins A and B, phosphorus (Watson & Dallwitz, 1992), and the highest iodine content among cereals (Upadhyaya *et al.*, 2001).

The grain is rich in calcium (344 mg/100 g), 8 to 10 times higher than that of rice or wheat making it nutritionally superior and ideal for long-term sustenance due to its slow-digesting carbohydrates. Because of its long storage life, finger millet is often referred to as a "famine reserve" (Sakamma *et al.*, 2018). Beyond its nutritional and ecological importance, finger millet supports the livelihoods of small and tribal farmers, particularly in marginal and hilly regions. In an era of increasing climate variability and food insecurity, the promotion of finger millet cultivation and consumption can significantly contribute to sustainable agriculture, nutritional well-being, and climate-resilient food systems.

India is the leading producer of various types of millets, commonly known as coarse cereals. Among rainfed crops, millets form a major group. The principal millets cultivated in India include sorghum (*jowar*), pearl millet (*bajra*), and finger millet (*ragi*), along with several small millets such as kodo millet, foxtail millet, and barnyard millet. Their cultivation extends from the coastal plains of Andhra Pradesh at sea level to elevations of about 8,000 feet in the hilly regions of Uttar Pradesh. These crops thrive under diverse soil types, rainfall patterns, and varying thermo- and photoperiodic conditions. Their remarkable resilience enables them to adapt to a wide range of ecological niches, making them indispensable for rainfed, tribal, and hill agriculture where crop substitution is often limited. Therefore, enhancing the production and productivity of these crops is essential to ensure food and nutritional security not only for populations in challenging and marginal environments but also across other regions of the country.

After sorghum and pearl millet, finger millet ranks third among Indian millets in both production (1.98 million tons) and area (2 million ha) (Anon, 2014). It occupies about 1.61 million hectares with an average yield of 1661 kg/ha, producing roughly 2.1 million tons annually (AICSMIP, 2013-14). Major producing states include Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, Jharkhand, Uttarakhand, Maharashtra, and Gujarat. Since it is mostly cultivated on marginal, rainfed lands, the yield gap remains wide. Still, millets have the potential to contribute to food production in both developing and developed nations (Bhagat *et al*., 2019).

In India's north-eastern region, finger millet cultivation remains limited, with low area, production, and productivity. It is mainly grown by tribal and smallholder farmers for preparing traditional foods such as *pithas*, *laddoos*, and local wines. In this region, finger millet is the third most important cereal (Abraham *et al*., 1989). Local alcoholic beverages like *apong* are often prepared from millet. The crop adapts well to diverse climatic and soil conditions, including hilly slopes, shallow gravelly soils, and areas with minimal moisture or nutrients (Seetharam *et al*., 1994). These characteristics make it a key crop in tribal and hill farming systems.

Unlike major cereals that demand high inputs, finger millet flourishes under rainfed conditions with minimal management, making it an essential crop in arid, semi-arid, and hilly regions. It grows successfully over a wide altitudinal range from coastal plains to mountain slopes demonstrating its versatility across diverse agro-climatic zones of India. Despite its adaptability, finger millet's yield is generally low because it is cultivated with minimal inputs and outdated methods (Rurinda *et al.*, 2014). This is largely due to gaps in agronomic management, especially with respect to the choice of sowing time and nutrient application. Sowing time is one of the most influential factors in crop production, as it aligns the crop with favourable weather conditions during its key developmental stages.

Likewise, balanced and timely nutrient supply enhances plant growth, yield performance, and the nutritional value of the harvested grains. Modern agro-management practices especially proper sowing time and nutrient application are vital for boosting productivity. Delayed or inappropriate sowing, poor seedbed preparation, lack of fertilizers, and unfavourable soil conditions hinder successful crop establishment (Van Osterom *et al.*, 1996).

Sowing time significantly influences growth and yield. Properly timed sowing enhances productivity without additional costs or soil degradation by ensuring suitable growing conditions throughout the crop cycle. In recent years, erratic rainfall, heat stress, and extreme weather events have disrupted the crop's growth, flowering, and maturity patterns, underscoring the need to determine optimal sowing dates under changing climates. Experimental data on this aspect remain scarce in the North Eastern region, where fertilizers and improved cultivars are seldom used.

Nutrient management also plays a crucial role in improving yields. Integrated use of organic manures and fertilizers sustains both soil health and crop productivity. For instance, the application of neem cake with FYM increased finger millet yield by 12.8% compared to inorganic fertilizers alone (Shivkumar *et al.*, 1999). Combined use of organic and inorganic nutrients enhances yield, nutrient uptake, and economic returns while minimizing environmental risks (Pallavi *et al.*, 2016; Hebbal, 2017). Balanced nutrient supply through FYM, bio-fertilizers, and micronutrients supports sustainable production (Nevse *et al.*, 2013). Overreliance on chemical fertilizers has depleted soil micronutrients and harmed soil health (Anon, 2005).

Therefore, Integrated Nutrient Management (INM)**,** which optimizes all nutrient sources in harmony with crop demand, offers a sustainable approach to achieving higher and stable yields of finger millet under rainfed conditions. An experiment was therefore undertaken to study the combined effect of sowing time and nutrient management on the growth, nutrient uptake, and yield of finger millet [*Eleusine coracana* (L.) Gaertn.]

Taking into account the above mentioned details, an experiment entitled "**Effect of sowing dates and nutrient management on productivity, profitability and quality of finger millet [*Eleusine coracana* (L.) Gaertn.]"** will be carried out with the following objectives:-

1. To study the effect of sowing dates and nutrient management on growth, yield and quality of finger millet.
2. To find out suitable sowing dates and nutrient management for finger millet.
3. To find out the economics of various treatments.

CHAPTER II

REVIEW OF LITERATURE

REVIE W OF LITERATURE

A brief review or findings on the research work done by various individuals on the topic, "**Effect of sowing dates and nutrient management on productivity, profitability and quality of finger millet [*Eleusine coracana* (L.) Gaertn.]**" and related aspect has been discussed below under the different headings:

2.1 Sowing dates

2.1.1 Effect sowing dates on the growth attributes:

Amanullah *et al.* (2015) reported that crop sown on 20th June had the maximum leaves plant^{-1} (93), plant height (230 cm), panicle length (26.3 cm), panicle weight (14.3 cm), grains panicle^{-1} (73.4), thousand grains weight (12.3 g) and grain yield (398 kg ha^{-1}) as compared with other sowing dates but panicle weight and grains panicle^{-1} were statistically at par with 10th July sowing. It was concluded from this study that millet sown on 20th June with transplanted method seems to the best choice for millet producer under rainfed condition in Peshawar valley.

Upadhyay *et al.* (2015) reported that finger millet yield and its attributes were significantly affected by different dates of sowing and different varieties during the study period. Crop growth, yield and yield attributing characters in terms of number of effective tillers m^{-2} , number of grains plant^{-1}, number of grains m^{-2} , test weight, straw yield, biological yield and grain yields of finger millet crop were recorded significantly. After comparative study of different sowing dates of finger millet it was found that variety PRM-1 sown on 23rd May provided best results. Results also revealed that 23rd May was the suitable planting date of finger millet followed by 30th May.

Maurya *et al*. (2016) reported that treatment 23rd July + Ganga kaveri-22 was recorded highest plant height (177.21cm), plant dry weight (78.25 g), grain yield (3.579 t ha^{-1}) and stover yield (10.225 t ha^{-1}).

Jidda *et al.* (2018) revealed that both incidence and severity of ergot decreased with delayed sowing irrespective seed treatment. Pearl millet grain yield increased with early sowing. Early sowing of primed seeds reduced ergot severity by 15.8 % and increased yield by 15.0 % over micro doses seeds sown during the same period. Sowing date had greater influence on the parameters tested than the seed treatment in the interactions.

Shoman *et al.* (2018) revealed that there were significant increases in values of studied parameters with increasing nitrogen fertilizer rate up to 150 Kg N fed^{-1} but without significant in number of inflorescence plant^{-1} and saponin % during both seasons. The interaction between different sowing dates and nitrogen fertilizer levels had a significant effect on yield and quality of quinoa except, number of inflorescence plant^{-1} and saponin % which did not any significant by the interaction between sowing dates and nitrogen fertilizer during the two growing seasons.

Mofeeda *et al.* (2019) reported that first sowing dates and first seeding rate A_1 B_1 (15 April and 10 kg fed^{-1}) significantly availability increased growth plant height (cm), fresh yield (ton fed^{-1}) and dry yield (ton fed^{-1}). In addition, the highest value in treatment A1B2 (15 April and 15 kg fed^{-1}) was recorded in leaf/stem ratio, crude protein (CP) content and digestible crude protein (DCP). Meanwhile, the interaction between treatments was insignificant.

Muhammad Ahmad *et al.* (2019) reported that the grain weight per panicle, panicle length, panicle girth, 1000 grain weight (g), grain yield (t ha^{-1}) and biological yield (t ha^{-1}) increased in sowing time 20th June-2015 with 15 cm plant to plant distance. The maximum value of these parameters was observed in sowing time 20th June, 2015 with 15 cm plant spacing.

Nandini and Sridhara (2019) reported that June 30 found significantly higher plant height (114.63), number of leaves plant^{-1} (49.38), leaf area (738.95 plant cm^{-2}), grain yield (2049.25 kg ha^{-1}), straw yield (4261.56 kg ha^{-1}) and harvest index (0.33) as compared to July 30 and August 30 dates of sowing.

Shinggu *et al.* (2019) reported that planting the crop on the 25 June and 9 July at a spacing of 10 and 15cm gave heavier un-threshed panicles with consequent higher grain yield.

Srikanya *et al.* (2020) reported that the crop sown on 30th August performed significantly higher stature of plant growth parameters; yield attributes and yields, while they were found to be at their lower level when sown on 10th September. The results concluded that sowing of foxtail millet variety Sia 3085 up to last fort night of August was profitable to the farmers in sandy loam soils of Northern Agro-climatic zone of Telangana.

Triveni *et al.* (2020) reported that hat all the millet crops have performed best at July 1st FN sowing; however, kodo millet at July 1st FN sowing has shown maximum growth attributes, yield attributes and grain yield. Gross income, net income and benefit cost ratio were also found significantly higher for the same treatment as compared to other millets crops at other sowing windows.

Phom *et al*, (2024) revealed that finger millet yield and its attributing character were significantly affected by different dates of sowing and varieties. The result showed that the first date of sowing (20th June) recorded the highest growth and yield attributes at all the growth stages. Among the three varieties used, number of tillers plant-1 (2.96) number of green leaves (24.04) and length of finger (7.39 cm) were higher in variety CO-15. However, plant height (93.53cm), dry weight (21.37 g plant^{-1}), LAI (5.02), number of ear heads plant-1 (3.76) and harvest index (34.94) were maximum with the variety Simhadri. The result also revealed that among the varieties, Simhadri recorded the highest straw yield (4641.69 kg ha^{-1}) and grain yield (2506.96 kg ha-^{1}) followed by variety CO-15 (4517.32 kg ha^{-1}, 2347.11 kg ha^{-1}). Among the sowing dates, crop sown on 20th June produced the highest grain yield followed by the 30th June. After a comparative study of different sowing dates and varieties of finger millet, it was found that variety Simhadri sown on 20th June was most suitable followed by variety CO-15.

2.1.2 Effect sowing dates on the yield attributes and yield:

Pandiselvi *et al.* (2010) reported that finger millet sown on May 17th produced highest grain yield of 1827 kg ha^{-1} as compared to other sowing dates. Hence, for achieving increasing yield in finger millet choice of sowing window (May

17th) played a key role.

Bijender Kumar and Shukla (2011) reported that the highest grain yields have been recorded when the crop was sown in early planting (7th June 2007 and 12th June 2006) window and decreased gradually in crops sown in mid and late planting window. On the basis of disease incidence and grain yield of two year's results the optimum time of sowing for all the four varieties is early planting window.

Netam *et al.* (2013) reported that minimum leaf blast severity and neck and finger blast incidence as well as highest grain yields were recorded from 1st June sown crop during both the years. The weather parameters recorded and correlated with disease development, in two years indicated that the average minimum and maximum temperatures of 21^{0}C and 29^{0}C respectively a 70-81% relative humidity were along with the most important factors favouring blast disease development.

Soler *et al.* (2013) reported that the optimum planting date to obtain the maximum yield was between 13 and 23 May for variety Heini Kirei, while for the other varieties the planting dates were between 23 May and 2 June.

Amanullah *et al.* (2015) reported that crop sown on 20th June had the maximum leaves plant^{-1} (93), plant height (230 cm), panicle length (26.3 cm), panicle weight (14.3 cm), grains panicle^{-1} (73.4), thousand grains weight (12.3 g) and grain yield (398 kg ha^{-1}) as compared with other sowing dates but panicle weight and grains panicle^{-1} were statistically at par with 10th July sowing. It was concluded from this study that millet sown on 20th June with transplanted method seems to the best choice for millet producer under rainfed condition in Peshawar valley.

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Mubeena *et al.* (2019) reported that early sowing during second fortnight of June recorded significantly higher uptake of nitrogen (112.12 kg ha^{-1}), phosphorus (10.82 kg ha^{-1}), potassium (60.66 kg ha^{-1}), grain yield (2368 kg ha^{-1}), stover yield (8916 kg ha^{-1}). A higher nutrient uptake, yield and economics were recorded by the application of 100% RDF (nitrogen, phosphorus, potassium, grain yield, stover yield, net return, benefit cost ratio; 99.74 kg ha^{-1}, 9.19 kg ha^{-1}, 44.86 kg ha^{-1}, 2140 kg ha^{-1}, 7176 kg ha^{-1} and it was in turn on par with 125% RDF.

Nandini *et al.* (2019) reported that June 30 found significantly higher plant height (114.63), number of leaves plant^{-1} (49.38), leaf area (738.95 plant cm^{-2}), grain yield (2049.25 kg ha^{-1}), straw yield (4261.56 kg ha^{-1}) and harvest index (0.33) as compared to July 30 and August 30 dates of sowing.

Shinggu *et al.* (2019) reported that planting the crop on the 25 June and 9 July at a spacing of 10 and 15cm gave heavier un-threshed panicles with higher grain yield.

Vishwanath *et al.* (2019) reported that effect of sowing time on seed yield of finger millet varieties, GPU-28 recorded maximum seed yield in month of August 18 (40.67), GPU-48 in July-18 (38.10 q ha^{-1}), GPU-67 in April-18 (37.78 q ha^{-1}), Indaf-7 in Dec-17 (42.38), ML-365 in July-18 (45.52), MR-1 in June-18 (51.75 q ha^{-1}) and MR-6 in Dec-17 (51.75 q ha^{-1}). Hence, increasing yield in finger millet choice of variety and sowing time played a key role.

Muhammad Ahmad *et al.* (2019) reported that the grain weight per panicle, panicle length, panicle girth, 1000 grain weight (g), grain yield (t ha^{-1}) and biological yield (t ha^{-1}) increased in sowing time 20^{th} June-2015 with 15 cm plant to plant distance. The maximum value of these parameters was observed in sowing time 20^{th} June, 2015 with 15 cm plant spacing.

Bhavna *et al.* (2020) reported that first sowing date (20^{th} July) statistically showed maximum grain yield 1976.94 kg ha^{-1} followed by second date of sowing (30^{th} July) 1737.82 kg ha^{-1} and third date of sowing (9^{th} August) 1318.45 kg ha^{-1} respectively.

Heba *et al.* (2020) reported that dry matter yield of the local cv. Shandaweel-1 was moderate (3.2 t ha^{-1}), it was inferior regarding all the tested quality attributes. Altering the sowing date exerted a limited effect on the studied parameters; early sowing on 15^{th} May was superior to later sowing on 1^{st} and 15^{th} June. The superiority of the second cut over the first and third cuts in forage production highlights the success of pearl millet as a multi-cut crop in similar environments.

Srikanya *et al.* (2020) reported that the crop sown on 30^{th} August performed significantly higher stature of plant growth parameters; yield attributes and yields, while they were found to be at their lower level when sown on 10th September. The results concluded that sowing of foxtail millet variety Sia 3085 up to last fort night of August was profitable to the farmers in sandy loam soils of Northern Agro-climatic zone of Telangana.

Triveni *et al.* (2020) reported that hat all the millet crops have performed best at July 1^{st} FN sowing; however, kodo millet at July 1^{st} FN sowing has shown maximum growth attributes, yield attributes and grain yield. Gross income, net income and benefit cost ratio were also found significantly higher for the same treatment as compared to other millets crops at other sowing windows.

Nwajei *et al.* (2022) reported that the forage and dry matter yields, crude protein and nutrient uptake of pearl millet were significantly affected by sowing dates. The highest and least forage and dry matter yields were obtained from Gero Badeggi sown in April-May. Millet sown in April to August had sufficient crude protein content when compared with the established critical levels. Gero Badeggi sown in April had the highest CP content (26.63%) while Gero Bida sown in July had the least (21.31%). Early sown crops (April-May) had the higher uptake of both the macro-and micro-nutrients than other dates.

Phom *et al*, (2024) revealed that finger millet yield and its attributing character were significantly affected by different dates of sowing and varieties. The result showed that the first date of sowing (20th June) recorded the highest growth and yield attributes at all the growth stages. Among the three varieties used, number of tillers plant^{-1} (2.96) number of green leaves (24.04) and length of finger (7.39 cm) were higher in variety CO-15. However, plant height (93.53cm), dry weight (21.37 g plant-1), LAI (5.02), number of ear heads plant^{-1} (3.76) and harvest index (34.94) were maximum with the variety Simhadri. The result also revealed that among the varieties, Simhadri recorded the highest straw yield (4641.69 kg ha^{-1}) and grain yield (2506.96 kg ha^{-1}) followed by variety CO-15 (4517.32 kg ha^{-1}, 2347.11 kg ha^{-1}). Among the sowing dates, crop sown on 20th June produced the highest grain yield followed by the 30th June. After a comparative study of different sowing dates and varieties of finger millet, it was found that variety Simhadri sown on 20th June was most suitable followed by variety CO-15.

2.1.3 Effect sowing dates on quality, nutrient and soil:

Jidda *et al.* (2017) revealed that both incidence and severity of ergot decreased with delayed sowing irrespective seed treatment. Pearl millet grain yield increased with early sowing. Early sowing of primed seeds reduced ergot severity by 15.8 % and increased yield by 15.0 % over micro doses seeds sown during the same period. Sowing date had greater influence on the parameters tested than the seed treatment in the interactions.

Shoman *et al.* (2018) revealed that the effect of sowing dates on all studied parameters was significant, except number of inflorescence plant^{-1}, carbohydrates % and oil % don't affect significantly by sowing dates during the two growing seasons. Sowing date in 1st December had the highest values for all studied traits as compared with the rest dates during the two growing seasons. Cultivation of quinoa on 1st December and fertilization by 150 kg N fad^{-1} gave maximum values of studying parameters during the two growing seasons at the desert area under New Valley conditions.

Mubeena *et al.* (2019) reported that early sowing during second fortnight of June recorded significantly higher uptake of nitrogen (112.12 kg ha^{-1}), phosphorus (10.82 kg ha^{-1}), potassium (60.66 kg ha^{-1}), grain yield (2368 kg ha^{-1}), stover yield (8916 kg ha^{-1}). A higher nutrient uptake, yield and economics were recorded by the application of 100% RDF (nitrogen, phosphorus, potassium, grain yield, stover yield, net return, benefit cost ratio; 99.74 kg ha^{-1}, 9.19 kg ha^{-1}, 44.86 kg ha^{-1}, 2140 kg ha^{-1}, 7176 kg ha^{-1} respectively) and it was in turn on par with 125% RDF.

Mofeeda *et al.* (2019) reported that first sowing dates and first seeding rate A_1 B_1 (15 April and 10 kg fed^{-1}) significantly availability increased growth plant height (cm), fresh yield (ton fed^{-1}) and dry yield (ton fed^{-1}). In addition, the highest value in treatment A1B2 (15 April and 15 kg fed^{-1}) was recorded in leaf/stem ratio, crude protein (CP) content and digestible crude protein (DCP). Meanwhile, the interaction between treatments was insignificant.

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Vijay Kumar *et al.* (2025) revealed that sowing on 30th June (D_2) facilitated early emergence, flowering, and maturity. VL Mandua 382 matured earlier, whereas

VL Mandua 379 recorded higher grain yield and growth attributes. Nutrient application at 60:30:30 kg NPK/ha significantly improved protein, fiber, calcium, and iron content. The study emphasizes that appropriate sowing time, improved genotype, and balanced nutrition are key to optimizing yield and quality of finger millet under rainfed ecosystems.

2.1.4 Economics

Mubeena *et al.* (2019) reported that early sowing during second fortnight of June recorded significantly higher net returns (₹ 24978 ha^{-1}) and benefit cost ratio (2.46). A higher nutrient uptake, yield and economics were recorded by the application of 100% RDF (net return, benefit cost ratio; 99.74 kg ha^{-1}, 9.19 kg ha^{-1}, 44.86 kg ha^{-1}, 2140 kg ha^{-1}, 7176 kg ha^{-1}, ₹ 19394 ha^{-1} and 2.13, respectively) and it was in turn on par with 125% RDF.

Bhavna *et al.* (2020) reported that first sowing date (20th July) statistically showed maximum grain yield 1976.94 kg ha^{-1} followed by second date of sowing (30th July) 1737.82 kg ha^{-1} and third date of sowing (9th August) 1318.45 kg ha^{-1} respectively. Similarly first sowing date (20th July) statistically showed maximum Net Return (₹ 17941 ha^{-1}) followed by second date of sowing (30th July) (₹ 14919 ha^{-1}) and third date of sowing (9th August) (₹ 7770 ha^{-1}) respectively.

Triveni *et al.* (2020) reported that hat all the millet crops have performed best at July 1st FN sowing; however, kodo millet at July 1st FN sowing has shown maximum gross income, net income and benefit cost ratio were also found significantly higher for the same treatment as compared to other millets crops at other sowing windows.

2.2 Nutrient management

2.2.1 Effect of nutrient management on the growth attributes:

Gavade *et al.* (2010) revealed that, growth characters *viz.*, plant height, number of leaves, number of tillers, leaf area $hill^{-1}$ and dry matter accumulation $hill^{-1}$ of finger millet were significantly increased due to application of 100 per cent RDF (60:30:00 kg NPK ha^{-1}) over 75 per cent RDF, 50 per cent RDF and organic manures.

Giribabu *et al.* (2010) revealed that application of 100% RDF (60:30:20 kg NPK ha^{-1}) + FYM @ 3t ha^{-1} significantly increased the plant height (93.9 cm) of finger millet over 75% RDF + FYM @ 3 t ha^{-1} (88.8 cm) and individual application of FYM (84.3 cm) and 100% RDF (88.5 cm) in a study conducted at Bapatla, Dist-Guntur, State- Andhra Pradesh.

Nigade and More (2013) revealed that, significantly the highest plant height (87.4 cm) and number of tillers (3.2) were recorded due to application of recommended dose of fertilizers (60:30:00 kg NPK ha^{-1}). However, it was at par with the application of 75 per cent recommended dose of fertilizers.

Patil *et al.* (2015) studied that the effect of different levels of fertilizers on growth and yield of finger millet. The RDF through briquettes (60:30:00 kg NPK ha^{-1}) shows significantly higher results regarding different growth attributes like plant height, number of functional leaves $plant^{-1}$, number of tillers $hill^{-1}$, leaf area $plant^{-1}$ and dry matter production $plant^{-1}$. The treatment RDF through briquettes (60:30:00 kg NPK ha^{-1}) also recorded significantly higher yield attributing characters like number of fingers $earhead^{-1}$ and 1000 grain weight.

Patil *et al.* (2018) revealed that the RDF through briquettes (60:30:00 Kg NPK ha^{-1}) shows significantly higher results regarding different growth attributes like plant height, number of functional leaves $plant^{-1}$, number of tillers $hill^{-1}$, leaf area $plant^{-1}$ and dry matter production $plant^{-1}$. The treatment T_2 also recorded significantly higher yield attributing characters like number of fingers $earhead^{-1}$ and 1000 grain weight. The higher yield attributing characters resulted into significant increase in grain yield (25.20 q ha^{-1}) and straw yield (32.72 q ha^{-1}) with the application of RDF through briquettes in treatment T_2.

Raman and Krishnamoorthy (2016) reported that the highest grain yield, productive tillers m^{-2} and number of grains $earhead^{-1}$ was recorded in genotype CO 14 with the treatment S7 (vermicompost to substitute 50% N +

50% fertilizer N + P and K + biofertilizers (Azospirillum and phosphobacteria soil application).

Ashwani *et al.* (2016) reported that N4-[N2+N3 (125 kg Neem cake + 12.50 tons FYM +50 kg urea + 50 kg superphosphate and 50 kg murate of potash per ha + top dressing urea at 3-4 weeks after transplanting + 2% Borax spray at flowering)] was recorded tallest plant, maximum number of tillers, highest number of seeds per finger, yield q ha^{-1} and economics.

Thimmaiah *et al.* (2016) revealed that among the different nutrient management practices, Recommended NPK + FYM at 7.5 t ha + PGPR at 2 kg ha + vermicompost and Frond compost both at 3.75 t ha as top dress at 25 DAT recorded significantly higher plant height (145.27 cm), leaf area (1177.30 cm $plant^{-1}$), number of tillers (4.07 plant) and total dry matter accumulation (59.13 g plant) and growth computed parameters. The same treatment obtained higher grain yield (63.50 q ha^{-1}), straw yield (86.67 q ha^{-1}). The application of organic manures as top dress at 25 DAT has given better yields and paved way for more soil sustainability.

Khandelwal *et al.* (2017) reported that higher growth, yield attribute and yield of pearl millet over control treatment under guava based agri-horti system. Significantly highest plant height (205.67 cm), number of tillers plant-1 (3.80), dry matter accumulation plant-1 (159.77 g) were recorded under 50 % RDF + 50 % Poultry Manure. This might be due to better nutrient supply. Yield attributes such as diameter of the ear (6.99 cm), ear perimeter (10.92 cm), length of ear (24.63 cm), 1000- seed weight (9.43 g) and yield [Grain yield (22.40 q ha^{-1}), Stover yield (56.71 q ha^{-1}) were recorded highest under 50 % RDF + 50 % Poultry Manure while, harvest index(31.48 %) was maximum in control and minimum (26.60%) in 100% vermicompost.

Patil *et al.* (2018) reported that the application of 75 % RDF + Poultry Manure (PM) @ 2 t ha^{-1} + Azospirillum @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} produced higher yield attributes (number of earheads m^{-2}, length of earhead, weight of grains $earhead^{-1}$, 1000 grain weight), yield (Grain yield, stover yield and harvest index) and quality parameters (protein, carbohydrate). However, it was comparable with application of 75 % RDF + FYM @ 5 t ha^{-1} + Azospirillum @ 5 kg ha^{-1}+ PSB @ 5 kg ha^{-1}. Application of 50 % RDF + FYM @ 7.5 t ha^{-1}, registered the lowest values of yield attributes, yield and quality parameters.

Shoman *et al.* (2018) revealed that there were significant increases in values of studied parameters with increasing nitrogen fertilizer rate up to 150 Kg N fed^{-1} but without significant in number of inflorescence plant^{-1} and saponin % during both seasons. The interaction between different sowing dates and nitrogen fertilizer levels had a significant effect on yield and quality of quinoa except, number of inflorescence plant^{-1} and saponin % which did not any significant by the interaction between sowing dates and nitrogen fertilizer during the two growing seasons.

Narayan *et al.* (2018) reported that higher growth parameters *viz.*, leaf area of 1934 cm^2 hill^{-1}, total dry matter production hill^{-1} of 39.74 g hill^{-1}, grain yield of 2701 kg ha^{-1}, straw yield of 4901 kg ha^{-1}, gross returns of ₹ 108242 and net returns of ₹ 78326 were recorded with application of recommended dose of FYM 7.5 t ha^{-1} + RDF (50:40:37.5 kg N, P_2O_5 and K_2O ha^{-1}).

Patel *et al*. (2018) reported that the general RDF (RDF + FYM @ 10 t ha^{-1}) applied to finger millet reported the significant residual effect on growth, yield attributes, seed and stover yields of succeeding green gram crop followed by 75% RDN through chemical fertilizer + 25% RDN through vermicompost. Thus, application of RDF i.e. 40 kg nitrogen and 20 kg P_2O_5 through chemical fertilizer along with 10 t ha^{-1} FYM reported promising residual effect on yield and yield attributing characters of succeeding green gram crop in finger millet-green gram cropping sequence under hilly area of south Gujarat.

Patil *et al.* (2018) revealed that the nutrient management with organic (Neem+vermicompost) and inorganic (recommended NPK) recorded higher seed yield than other nutrient treatments.

Verma *et al.* (2019) revealed that application of 50% recommended dose of fertilizer + 50% poultry manure resulted higher growth [plant height (151.9 cm), dry weight (79.7 g), and number of tillers plant^{-1} (2.22)], yield attributes[effective tillers hill^{-1} (2.0), panicle length (18.8 cm), grains panicle^{-1} (1615.6), grains weight panicle^{-1}

(14.5), and test weight (9.76 g)], grain yield (1552 kg ha^{-1}), and stover yield (4360 kg ha^{-1}) and net returns (₹ 38227 ha^{-1}), and B:C ratio (1.77) than remaining integrated nutrient management practices.

Aliveni *et al.* (2021) reported that higher growth attributes and grain yield were recorded with the application of FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment.

Manish *et al.* (2021) reported that a significant higher growth and yield parameters enhancement with the application of 100% RDF + 15 t FYM ha^{-1} + Bio NP Consortia was recorded in plant height, number of tillers, length of ear head, protein content and biological yield. The treatment T_5 produced maximum (91.5 q ha^{-1}) biological yield and statistically it was on par with T_9 and T_5. Protein content of pearl millet was increased from 7.5% to 9.06% under different nutrient management practices.

Manojgowda *et al.* (2021) reported that the spacing 20 cm x 10 cm + 50% RDN + 50% N through vermicompost also recorded significantly higher number of grains $earhead^{-1}$ (1912.35), number of fingers $earhead^{-1}$ (6.41), fingers length (9.04 cm), grain yield (2.74 t ha^{-1}) and biological yield (7.41 t ha^{-1}) as compared to all the treatment combinations.

Patel *et al.* (2023) revealed that application of 100% RDF + Banana pseudo stem sap 1% at tillering and panicle initiation stage (T_3) recorded significantly higher growth, yield attributes and yields of finger millet, but it remained statistically at par with treatments T_1, T_2 and T_6. Gross realizations, net returns and BCR were also obtained higher under the treatment of 100% RDF + Banana pseudo stem sap 1% at tillering and panicle initiation stage followed by treatments T_1, T_2 and T_6.

Mathyam *et al.* (2023) revealed that among the varieties, MR-6 outperformed MR-1 in terms of growth, yield, N use efficiency and N uptake. The yield enhancement was up to 22.6% in MR-6 compared to MR-1 across the nutrient management practices. Substituting FYM completely or half of the fertilizer dose increased the growth and yield of finger millet compared to application of chemical fertilizers alone. Similarly, the average biomass yield, ears m^{-2}, grain yield, total N uptake and N use efficiency in response to nutrient management practices followed the order of 100% RDN as FYM > 50% RDF + 50% RDN as FYM > 100% RDF. The soil organic carbon, available N, P, K, and S improved by 25.0, 12.9, 5.7, 6.1, and 22.6%, respectively in the plots under higher rate of FYM application (8 Mg ha^{-1}) compared to plots under chemical fertilizers alone. We conclude that substituting chemical fertilizers either completely or by up to 50% with organic manures supplies adequate amounts of nutrients, improves the yield of finger millet, economic returns, and soil properties.

2.2.2 Effect of nutrient management on the yield attributes and yield:

Gavade (2010) revealed that grain as well as straw yields were significantly higher due to application of 100 percent RDF through broadcasting (60:30:00 kg NPK ha^{-1}), 100 % RDF through Urea-DAP briquettes, 75 % RDF through broadcasting, 100 % RDF through Urea-Suphala briquettes over control.

Jagadeesha *et al.* (2010) revealed that application of either sewage sludge or poultry manure compost produced significantly higher grain yield (2498 and 2475 kg ha^{-1}, respectively) and straw yield of finger millet (4065 and 4009 kg ha^{-1}, respectively) and red gram grain and stalk yield (370 and 355 kg ha^{-1}, respectively). The study clearly revealed that sewage sludge and poultry manure compost application at equivalent recommended nitrogen dose could be successfully used for finger millet and red gram intercropping system to substitute the chemical fertilizers and found to be sustainable.

Islam *et al.* (2011) showed that NPK briquettes, USG and PU produced statistically similar grain yield. N-treated plots (briquettes, USG and PU) gave significantly higher grain yield than N control. The highest grain yield (7.47tha^{-1}) was observed in NPK briquette (2.4 g × 2) followed by PU.

Dass *et al*. (2013) studies on effective integrated nutrient management (INM) modules for marginal landholders of eastern India relying upon crops, such as finger millet (*Eleusine coracana* L. Gaertn) are lacking. Thus, an experiment was conducted on farmer's field for three years (2002−2004) at Malipungar watershed in the Koraput district of Odisha, India, to evaluate various INM combinations and select the most remunerative INM option relative to productivity and profitability of finger millet crop and soil properties. The seven INM treatments consisted of different combinations of Gliricidia green-leaf manure, farmyard manure (FYM), synthetic fertilizers and bio-fertilizers and compared with farmer's practice. The treatments were arranged in a randomized complete-block design replicated three times. Yield and net returns from Gliricidia-amended plots were greater than those from the FYM-amended plots.

Nigade *et al.* (2013) studied that the response of finger millet varieties to different levels of fertilizer on crop yield and soil properties. The results revealed that, on shallow and lighter type of soils in IX rainfall situation under sub-montane zone of Maharashtra, for obtaining highest grain and straw yield, the long duration varieties should be fertilized with the 11 recommended dose of fertilizer (60:30:00 kg NPK ha^{-1}). The medium duration varieties showed good response to application of 75 per cent of recommended dose.

Patil *et al.* (2015) revealed that the RDF through briquettes (60:30:00 Kg NPK ha^{-1}) shows significantly higher results regarding different growth attributes like plant height, number of functional leaves plant^{-1}, number of tillers hill^{-1}, leaf area plant^{-1} and dry matter production plant^{-1}. The treatment T_2 also recorded significantly higher yield attributing characters like number of fingers earhead^{-1} and 1000 grain weight. The higher yield attributing characters resulted into significant increase in grain yield (25.20 q ha^{-1}) and straw yield (32.72 q ha^{-1}) with the application of RDF through briquettes in treatment T_2.

Ashwani *et al.* (2016) reported that N4-[N2+N3 (125 kg Neem cake + 12.50 tons FYM +50 kg urea + 50 kg superphosphate and 50 kg murate of potash per ha + top dressing urea at 3-4 weeks after transplanting + 2% Borax spray at flowering)] was recorded tallest plant, maximum number of tillers, highest number of seeds per finger, yield q ha^{-1} and economics.

Hatti *et al.* (2016) reported that application of 100% recommended NPK + 7.5 t FYM ha^{-1} yielded significantly higher grain and straw yields (3.03 and 4.69 t ha^{-1}) due to improved soil physico-chemical and biological properties as compared to other nutrient management's treatments.

Raman and Khrishnamoorthy (2016) reported that the highest grain yield, productive tillers m^{-2} and number of grains $earhead^{-1}$ was recorded in genotype CO 14 with the treatment S7 (vermicompost to substitute 50% N + 50% fertilizer N + P and K + biofertilizers (Azospirillum and phosphobacteria soil application).

Pallavi *et al.* (2016) reported that the highest grain (2681 kg ha^{-1}) and straw yield (5063 kg ha^{-1}) resulted with sole crop on par with 75% RD N + 25% N poultry manure (2405 and 4733 kg ha^{-1}) and 100% RDF (2393 and 4745 kg ha^{-1}). Gross monetary returns (₹ 42,747 ha^{-1}), net monetary returns (₹ 26,987 ha^{-1}) and B:C ratio (2.71) were highest with sole crop followed by 100% RDF and 75% RD N + 25% N poultry manure compared to other treatment combinations.

Tsado *et al.* (2016) reported that the application of recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1}) produced the longest leaves, tallest plants, widest leaves, highest leaf area index, longest internodes, shortest number of days to 50% heading, longest fingers, highest number of fingers, highest number of seeds, heaviest spikes and highest grain yield. Application of poultry droppings (2 t ha^{-1}) produced the heaviest seeds

Thimmaiah *et al*. (2016) recorded significantly higher plant height (145.27 cm), leaf area (1177.30 cm $plant^{-1}$), number of tillers (4.07 $plant^{-1}$) and total dry matter accumulation (59.13g $plant^{-1}$) and growth computed parameters. The same treatment obtained higher grain yield (63.50 q ha^{-1}), straw yield (86.67 q ha^{-1}) and gross returns (₹ 1,03,000) and value added cost ratio (2.22). It registered 118.9 and 87 per cent higher over farmers practice yield and recommended NPK alone. The application of organic manures as top dress at 25 DAT has given better yields and paved way for more soil sustainability.

Keziah *et al.* (2017) reported that yield was increased with P and K application at two of four production areas of Uganda. Yield was increased by 20% with application n of Mg–S–Zn–B in addition to N–P–K for all sites in Uganda with foliar concentrations indicating possible S and B deficiency. There is great profit potential in Uganda, and less for Kenya for N, but not for P and K, application to finger millet. Response to S and B needs further exploration.

Khandelwal *et al.* (2017) reported that significantly highest plant height (205.67 cm), number of tillers plant^{-1} (3.80), dry matter accumulation plant^{-1} (159.77 g) were recorded under 50 % RDF + 50 % Poultry Manure. This might be due to better nutrient supply. Yield attributes such as diameter of the ear (6.99 cm), ear perimeter (10.92 cm), length of ear (24.63 cm), 1000-seed weight (9.43 g) and yield [Grain yield (22.40 q ha^{-1}), Stover yield (56.71 q ha^{-1}) were recorded highest under 50 % RDF + 50 % Poultry Manure while, harvest index (31.48 %) was maximum in control and minimum (26.60%) in 100% vermicompost.

Tapkeer *et al.* (2017) concluded that the application of Urea-10:26:26 briquettes @ one briquette in between two plants was found promising in enhancing the green pod yield of Konkan bhushan variety in lateritic soils of Konkan. fifty per cent recommended dose of NPK fertilizer was reducing by the application of nutrients in the form of Urea-10:26:26 briquettes.

Dougbedji and Ali (2018) revealed that application of manure before planting increased on an average millet grain yield by 16 and 20% and N utilization efficiency by 25 and 31% compared to application of manure at planting and 15 days after planting respectively. Millet grain yields increased on average by 5, 17 and 57% when 6 g per pit of NPK fertilizer were added to plots receiving manure application before planting, at planting and 15 days after planting, respectively.

Patil *et al.* (2018) reported that the application of 75 % RDF + Poultry Manure (PM) @ 2 t ha^{-1} + Azospirillum @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} produced higher yield attributes (number of earheads m^{-2}, length of earhead, weight of grains earhead^{-1}, 1000 grain weight), yield (Grain yield, stover yield and harvest index) and quality parameters (protein, carbohydrate). However, it was comparable with application of 75 % RDF + FYM @ 5 t ha^{-1} + Azospirillum @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}. Application of 50 % RDF + FYM @ 7.5 t ha^{-1}, registered the lowest values of yield attributes, yield and quality parameters.

Rekha *et al.* (2018) revealed that the soil health parameters like soil available N, P, K were found to be maximum in the treatments with microbial consortia MC1 along with recommended dose of FYM and 75% recommended dose of chemical fertilizers compared to other treatments. Maximum yield parameters like seed yield and straw yield of bajra were recorded in the treatments applied with microbial consortia MC1 along with recommended dose of FYM and 75% recommended dose of chemical fertilizers compared to other treatments.

Patel *et al*. (2018) reported that the general RDF (RDF + FYM @ 10 t ha^{-1}) applied to finger millet reported the significant residual effect on growth, yield attributes, seed and stover yields of succeeding green gram crop followed by 75% RDN through chemical fertilizer + 25% RDN through vermicompost. Thus, application of RDF i.e. 40 kg nitrogen and 20 kg P_2O_5 through chemical fertilizer along with 10 t ha^{-1} FYM reported promising residual effect on yield and yield attributing characters of succeeding green gram crop in finger millet-green gram cropping sequence under hilly area of south Gujarat.

Roy *et al.* (2018) conducted experiment at College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh and revealed that the addition of organics in urea briquettes and deep placement of briquettes exhibited higher nitrogen, phosphorus and potassium use efficiency which might be attributed to slow release of nitrogen and deep placement of fertilizer, thus reducing the losses and thereby higher nutrients uptake and ultimately higher yield. Nitrogen losses in irrigated rice were significantly influenced by the treatments.

Mubeena *et al.* (2019) reported that higher nutrient uptake, yield and economics were recorded by the application of 100% RDF (nitrogen, phosphorus, potassium, grain yield, stover yield, net return, benefit cost ratio; 99.74 kg ha^{-1}, 9.19

kg ha^{-1}, 44.86 kg ha^{-1}, 2140 kg ha^{-1} 7176 kg ha^{-1}, ₹ 19394 ha^{-1} and 2.13, respectively) and it was in turn on par with 125% RDF.

Verma *et al.* (2019) revealed that application of 50% recommended dose of fertilizer + 50% poultry manure resulted higher growth [plant height (151.9 cm), dry weight (79.7 g), and number of tillers plant^{-1} (2.22)], yield attributes[effective tillers hill^{-1} (2.0), panicle length (18.8 cm), grains panicle^{-1} (1615.6), grains weight panicle^{-1} (14.5), and test weight (9.76 g)], grain yield (1552 kg ha^{-1}), and stover yield (4360 kg ha^{-1}) and net returns (₹ 38227 ha^{-1}), and B:C ratio (1.77) than remaining integrated nutrient management practices.

Sagar *et al.* (2020) reported that incorporation of N fertilizer during seeding stage increased yield as compared to broadcasting of fertilizer. The continuous application of inorganic N fertilizer reduced the soil organic carbon level. The foliar application of 2% urea produced higher grain and straw yield. Application of fertilizer P @ 125% recommended dose of phosphorus (RDP) with recommended N, K and FYM in different fertility soils recorded higher grain and straw yield. Nutrient management for targeting production and sustainability, integrated nutrient management (INM) will be the most suitable option. Application of 100% NPK along with FYM @ 10 t ha^{-1} recorded significantly higher grain and straw yield and enriched the soil organic carbon. Application of farmyard manure (FYM) alone or in a combination with chemical fertilizers contributed to higher amounts of carbon inputs and build up a higher soil organic carbon pool in rain fed groundnut–finger millet rotation in alfisol of semi-arid region.

Aliveni *et al.* (2021) reported that higher growth attributes and grain yield were recorded with the application of FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment.

Manish *et al.* (2021) reported that a significant higher growth and yield parameters enhancement with the application of 100% RDF + 15 t FYM ha^{-1} + Bio NP Consortia was recorded in plant height, number of tillers, length of ear head, protein content and biological yield. The treatment T_5 produced maximum (91.5 q ha^{-1}) biological yield and statistically it was on par with T_9 and T_5. Protein content of pearlmillet was increased from 7.5% to 9.06% under different nutrient management practices.

Manojgowda *et al.* (2021) reported that the spacing 20 cm x 10 cm + 50% RDN + 50% N through vermicompost also recorded significantly higher number of grains earhead^{-1} (1912.35), number of fingers earhead^{-1} (6.41), fingers length (9.04 cm), grain yield (2.74 t ha^{-1}) and biological yield (7.41 t ha^{-1}) as compared to all the treatment combinations.

Patel *et al* 2023 s revealed that application of 100% RDF + Banana pseudo stem sap 1% at tillering and panicle initiation stage (T3) recorded significantly higher growth, yield attributes and yields of finger millet, but it remained statistically at par with treatments T1, T2 and T6. Gross realizations, net returns and BCR were also obtained higher under the treatment of 100% RDF + Banana pseudo stem sap 1% at tillering and panicle initiation stage followed by treatments T1, T2 and T6.

Mathyam *et al*. (2023) revealed that among the varieties, MR-6 outperformed MR-1 in terms of growth, yield, N use efficiency and N uptake. The yield enhancement was up to 22.6% in MR-6 compared to MR-1 across the nutrient management practices. Substituting FYM completely or half of the fertilizer dose increased the growth and yield of finger millet compared to application of chemical fertilizers alone. Similarly, the average biomass yield, ears m^{-2}, grain yield, total N uptake and N use efficiency in response to nutrient management practices followed the order of 100% RDN as FYM > 50% RDF + 50% RDN as FYM > 100% RDF. The soil organic carbon, available N, P, K, and S improved by 25.0, 12.9, 5.7, 6.1, and 22.6%, respectively in the plots under higher rate of FYM application (8 mg ha^{-1}) compared to plots under chemical fertilizers alone. We conclude that substituting chemical fertilizers either completely or by up to 50% with organic manures supplies adequate amounts of nutrients, improves the yield of finger millet, economic returns, and soil properties.

Aliveni *et al*. (2025) reported that significantly higher grain and straw yields with good quality grain of finger millet were recorded in the spacing of 30 x 10 cm fb

30 x 30 cm spacing and among the nutrient management approaches application of FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment (S6) recorded the highest yield and however was statistically comparable with 125% of RDF + FYM (S5).

Gautam *et al.* (2025) in the North-Western Himalayas reported that combined treatments (NPK + FYM + Azospirillum) achieved highest yields and net returns, underscoring the practical value of integrated nutrient management in climate-challenged zones.

2.2.3 Effect of nutrient management on quality, nutrient and soil:

Nigade and More (2013) conducted field experiment on finger millet at Zonal Agricultural Research Station, Shenda Park, Kolhapur, Maharashtra during *kharif* season. The results revealed that, significantly the highest NPK uptake were observed with the application of 100 per cent recommended dose of fertilizers (60:30:00 kg NPK ha^{-1}).

Jagathjothi and Ramamoorthy (2015) conducted field experiment at Tamil Nadu Agricultural University, Coimbatore they revealed that the higher nutrient (NPK) uptake in finger millet was observed under broadcasting enriched FYM 4 t ha^{-1} + 100 % recommended N and K at all the stages of observation *viz.*, 30 DAS, 60 DAS and at harvest. This was on par with band placement of enriched FYM 2 t ha^{-1}+ 100% recommended N and K and band placement of 2 FYM ha^{-1} + 100% recommended dose of NPK. Regarding finger millet yield, the band placement of enriched farm yard manure (enriched FYM) 2.0 t ha^{-1} with 100% recommended N and K recorded higher grain yield.

Pallavi *et al.* (2015) at Jayashankar, Telangana State Agricultural University, Hyderabad studied that, it was inferred that integrated use of 75% RD N + 25% N through poultry manure and 100% RDF is the best nutrient management practice that can be adopted for agri-silvisystem on par with sole crop, which was significantly superior over 75% RD N + 25% N through FYM, 75% RD N + 25% N through Vermicompost, 75% RD N + Azospirillum @ 5 kg ha^{-1}, 75% RD N + PSB, 75% RD N + Azospirillum + PSB and control in red sandy loam soils to obtain higher nutrient content, uptake and available nutrient status of NPK.

Pallavi *et al.* (2016) conducted experiment at agroforestry research block, Acharya N.G Ranga Agricultural University campus, Rajendranagar and reported that the nutrient content and uptake (NPK) by grain and straw were significantly higher with 100% RDF, 75% RD N + 25% N poultry manure on par with sole crop compared to other nutrient combinations and control. Organic carbon was also significantly influenced by sole crop on par with 100% RDF, 75% RD N + 25% N poultry manure and 75% RD N + 25% N vermicompost over control. Available nitrogen, phosphorus and potassium were found highest with 100% RDF and 75% RD N + 25% N poultry manure on par with sole crop.

Prakasha *et al.* (2017) at Zonal Agricultural Research Station, UAS, GKVK, Bengaluru, during *kharif* season of 2014 reported that significantly higher NPK uptake was recorded in spacing of 60 cm X 60 cm with 100 % recommended dose of fertilizers (152.10, 24.42 and 94.37 kg NPK ha^{-1} respectively) and found superior over other treatments, followed by spacing of 60 x 60cm with 75 percent recommended dose of fertilizers. Increased available nitrogen, phosphorus and potassium (248.40, 49.07, and 249.90 kg NPK ha^{-1}, respectively) was recorded in spacing of 60 x 60 cm with 100 per cent recommended dose of fertilizers and found superior over other treatments, followed by spacing of 60 cm x 60 cm with 75 per cent recommended dose of fertilizers.

Patil *et al.* (2018) revealed that the nutrient management with organic (Neem+vermicompost) and inorganic (recommended NPK) recorded higher seed yield than other nutrient treatments.

Roy *et al.* (2018) conducted experiment at College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh and revealed that the addition of organics in urea briquettes and deep placement of briquettes exhibited higher nitrogen, phosphorus and potassium use efficiency which might be attributed to slow release of nitrogen and deep placement of fertilizer, thus reducing the losses and thereby higher nutrients uptake and ultimately higher yield. Nitrogen losses in irrigated rice were significantly influenced by the treatments.

Rekha *et al.* (2018) revealed that the soil health parameters like soil available N, P, K were found to be maximum in the treatments with microbial consortia MC1 along with recommended dose of FYM and 75% recommended dose of chemical fertilizers compared to other treatments. Maximum yield parameters like seed yield and straw yield of bajra were recorded in the treatments applied with microbial consortia MC1 along with recommended dose of FYM and 75% recommended dose of chemical fertilizers compared to other treatments.

Mubeena *et al.* (2019) reported that higher nutrient uptake, yield and economics were recorded by the application of 100% RDF (nitrogen, phosphorus, potassium, grain yield, stover yield, net return, benefit cost ratio; 99.74 kg ha^{-1}, 9.19 kg ha^{-1}, 44.86 kg ha^{-1}, 2140 kg ha^{-1} 7176 kg ha^{-1}, ₹ 19394 ha^{-1} and 2.13, respectively) and it was in turn on par with 125% RDF.

Harika *et al*. (2020) assessed the energetics of finger millet cultivation under INM and noted the favourable energy balance when organic and inorganic inputs were combined, especially in resource-poor soils.

Mahapatra *et al*. (2020) investigated various organic nutrient management practices and found that the highest grain yield and economic returns were achieved with FYM + seed-treatment + jeevamruta (a microbial/organic solution) prior to harvest and during cropping.

Sagar Maitra (2020) reported that incorporation of N fertilizer during seeding stage increased yield as compared to broadcasting of fertilizer. The continuous application of inorganic N fertilizer reduced the soil organic carbon level. The foliar application of 2% urea produced higher grain and straw yield. Application of fertilizer P @ 125% recommended dose of phosphorus (RDP) with recommended N, K and FYM in different fertility soils recorded higher grain and straw yield. Nutrient management for targeting production and sustainability, integrated nutrient management (INM) will be the most suitable option. Application of 100% NPK along with FYM @ 10 t ha^{-1} recorded significantly higher grain and straw yield and enriched the soil organic carbon. Application of farmyard manure (FYM) alone or in a combination with chemical fertilizers contributed to higher amounts of carbon inputs and build up a higher soil organic carbon pool in rain fed groundnut–finger millet rotation in alfisol of semi-arid region.

Shilpa *et al.* (2021) conducted a long-term experiment in Alfisols under different cropping systems and found that over time INM improved growth, yield and nutrient uptake in rain-fed finger millet.

Kejiya *et al.* (2022) explored phosphorus-management practices and found that RDF (recommended dose fertilizer) + PSB + VAM (vesicular arbuscular mycorrhiza) produced the best nutrient content, uptake and yield in finger millet grown on sandy-loam soil.

Amarjeet *et al.* (2021) revealed that N, P, K, Fe and Ca content in grain and straw, N, P and K uptake in grain and straw, total N, P and K uptake and yield of finger millet and green pea were influenced by different treatments of seed rate and organic nutrient management. In grain of finger millet, N (1.40%), P (0.416%), K (0.364%), Fe (4.89 mg/100g grain) and Ca (351.60 mg/100g grain) were maximum with 125% seed rate and 50% N through FYM + 50% N through vermicompost. In straw of finger millet N (0.173%), P (0.080%) and K (1.138%) were maximum with 125% seed rate and 50% N through FYM + 50% N through vermicompost. Yield of finger millet (25.1 q ha^{-1}) and green pea (94.4 q ha^{-1}) were also recorded maximum in the same treatment.

Rabeen *et al.* (2021) revealed that INM had significant effect on finger millet in terms of growth and growth attributes, yield attributes and yield, nutritional quality of the grains, nutrient uptake, nitrogen use efficiency indices, soil nutrient status and economics. Several studies have also brought out the positive effects of adopting organic nutrition in finger millet.

Ashokh *et al.* (2022) reported that the application of 100 percent of nitrogen through poultry with foliar application of panchagavya at 30 and 45 DAT gave better yield and also enriched the soil fertility status

Mathyam *et al*. (2023) revealed that among the varieties, MR-6 outperformed MR-1 in terms of growth, yield, N use efficiency and N uptake. The yield enhancement was up to 22.6% in MR-6 compared to MR-1 across the nutrient management practices. Substituting FYM completely or half of the fertilizer dose increased the growth and yield of finger millet compared to application of chemical fertilizers alone. Similarly, the average biomass yield, ears m^{-2}, grain yield, total N uptake and N use efficiency in response to nutrient management practices followed the order of 100% RDN as FYM > 50% RDF + 50% RDN as FYM > 100% RDF. The soil organic carbon, available N, P, K, and S improved by 25.0, 12.9, 5.7, 6.1, and 22.6%, respectively in the plots under higher rate of FYM application (8 Mg ha^{-1}) compared to plots under chemical fertilizers alone. We conclude that substituting chemical fertilizers either completely or by up to 50% with organic manures supplies adequate amounts of nutrients, improves the yield of finger millet, economic returns, and soil properties.

Sulochna *et al*. (2023) studied finger millet in a finger millet–French bean cropping system under organic nutrient management and found improved nutrient uptake, grain quality and yield under organic nutrient packages.

Vijay Kumar *et al* 2025 revealed that sowing on 30th June (D2) facilitated early emergence, flowering, and maturity. VL Mandua 382 matured earlier, whereas VL Mandua 379 recorded higher grain yield and growth attributes. Nutrient application at 60:30:30 kg NPK ha^{-1} significantly improved protein, fiber, calcium, and iron content. The study emphasizes that appropriate sowing time, improved genotype, and balanced nutrition are key to optimizing yield and quality of finger millet under rainfed ecosystems.

Aliveni *et al*. 2025 reported that significantly higher grain and straw yields with good quality grain of finger millet were recorded in the spacing of 30 x 10 cm fb 30 x 30 cm spacing and among the nutrient management approaches application of

FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment (S6) recorded the highest yield and however was statistically comparable with 125% of RDF + FYM (S5).

2.2.4 Economics

Sagar *et al.* (2000) reported that the application of 60: 13.3: 25 kg NPK ha^{-1} recorded maximum productivity and the highest net returns followed by the application of 30: 6.7: 12.5 kg NPK ha^{-1}. However, the highest benefit: cost ratio was obtained from application of 30: 6.7: 12.5 kg NPK ha^{-1}.

Shivakumar (2001) reported that the benefit cost ratio of dryland finger millet with bioagro rich at 50 per cent recommended N was the highest (2.90), followed by recommended NPK and bioagro at 50 per cent recommended N. It is concluded that row placement of bioagro rich at 50 per cent recommended N at sowing and the rest of NPK increased productivity and profitability of dryland finger millet.

Singh *et al.* (2002) conducted experiments in Uttaranchal, India to investigate the effect of improved and local package of practices on the economics of ragi (*Eleusine coracana*) under rainfed conditions. Application of N:P:K at 60:40:20 kg ha^{-1} recorded higher net return (₹ 5280) than the farmers practice (FYM at 5 t ha^{-1}).

Naiyar and Ahmad (2004) revealed that, the net return increased with the increase in the N rate; thus, N at 60 kg ha-1 resulted in the highest net return (₹ 4720 ha^{-1}). The optimum economic yield response was obtained with 45 kg N ha^{-1}.

Gavade *et al.* (2010) reported that, the application of 100 per cent RDF through broadcasting realized the maximum net returns of ₹ 9488.78 ha^{-1} with B: C ratio of 1.32 from finger millet.

Dass *et al.* (2013) studies on effective integrated nutrient management (INM) modules for marginal landholders of eastern India relying upon crops, such as finger millet (*Eleusine coracana* L. Gaertn) are lacking. Thus, an experiment was conducted on farmer's field for three years (2002−2004) at Malipungar watershed in the Koraput district of Odisha, India, to evaluate various INM combinations and select the most remunerative INM option relative to productivity and profitability of finger millet crop and soil properties. The seven INM treatments consisted of different combinations of Gliricidia green-leaf manure, farmyard manure (FYM), synthetic fertilizers and bio-fertilizers and compared with farmer's practice. The treatments were arranged in a randomized complete-block design replicated three times. Yield and net returns from Gliricidia-amended plots were greater than those from the FYM-amended plots.

Ashwani *et al.* (2016) reported that N4- [N2+N3 (125 kg Neem cake + 12.50 tons FYM +50 kg urea + 50 kg superphosphate and 50 kg murate of potash ha^{-1} + top dressing urea at 3-4 weeks after transplanting + 2% Borax spray at flowering)] was recorded tallest plant, maximum number of tillers, highest number of seeds per finger, yield q ha^{-1} and economics.

Pallavi *et al.* (2016) reported that the highest grain (2681 kg ha^{-1}) and straw yield (5063 kg ha^{-1}) resulted with sole crop on par with 75% RD N + 25% N poultry manure (2405 and 4733 kg ha^{-1}) and 100% RDF (2393 and 4745 kg ha-^{1}). Gross monetary returns (₹ 42,747 ha^{-1}), net monetary returns (₹ 26,987 ha^{-1}) and B:C ratio (2.71) were highest with sole crop followed by 100% RDF and 75% RD N + 25% N poultry manure compared to other treatment combinations.

Thimmaiah *et al.* (2016) revealed that among the different nutrient management practices, Recommended NPK + FYM at 7.5 t ha^{-1} + PGPR at 2 kg ha^{-1} + vermicompost and Frond compost both at 3.75 t ha^{-1} as top dress at 25 DAT recorded significantly higher plant height (145.27 cm), leaf area (1177.30 cm plant^{-1}), number of tillers (4.07 plant^{-1}) and total dry matter accumulation (59.13 g plant^{-1}) and growth computed parameters. The same treatment obtained higher grain yield (63.50 q ha^{-1}), straw yield (86.67 q ha^{-1}) and gross returns (₹ 1,03,000) and value added cost ratio (2.22). The application of organic manures as top dress at 25 DAT has given better yields and paved way for more soil sustainability.

Narayan *et al.* (2018) reported that higher growth parameters viz., leaf area of 1934 cm^2 $hill^{-1}$, total dry matter production $hill^{-1}$ of 39.74 g $hill^{-1}$, grain yield of 2701 kg ha^{-1}, straw yield of 4901 kg ha^{-1}, gross returns of ₹ 108242 and net returns of ₹ 78326 were recorded with application of recommended dose of FYM 7.5 t ha^{-1} + RDF (50:40:37.5 kg N, P_2O_5 and K_2O ha^{-1}).

Roy *et al.* (2018) field experiment was conducted during kharif 2016 at Agronomical Research Farm, Western Section, Birsa Agricultural University, Ranchi and reported that the highest gross returns (72740 ha^{-1}), net returns (₹ 52272 ha^{-1}) and B: C (2.55) ratio was observed with the application of FYM (10 t/ha) + Biofertilizer + ZnSO4 (12.5 kg ha^{-1}) + Borax (5 kg ha^{-1}) + 75 % RDF.

Mubeena *et al.* (2019) reported that higher nutrient uptake, yield and economics were recorded by the application of 100% RDF (nitrogen, phosphorus, potassium, grain yield, stover yield, net return, benefit cost ratio; 99.74 kg ha^{-1}, 9.19 kg ha^{-1}, 44.86 kg ha^{-1}, 2140 kg ha^{-1} 7176 kg ha^{-1}, ₹ 19394 ha^{-1} and 2.13, respectively) and it was in turn on par with 125% RDF.

Verma *et al.* (2019) revealed that application of 50% recommended dose of fertilizer + 50% poultry manure resulted higher growth [plant height (151.9 cm), dry weight (79.7 g), and number of tillers $plant^{-1}$ (2.22)], yield attributes [effective tillers $hill^{-1}$ (2.0), panicle length (18.8 cm), grains $panicle^{-1}$ (1615.6), grains weight $panicle^{-1}$ (14.5), and test weight (9.76 g)], grain yield (1552 kg ha^{-1}), and stover yield (4360 kg ha^{-1}) and net returns (₹ 38227 ha^{-1}), and B:C ratio (1.77) than remaining integrated nutrient management practices.

Mahapatra *et al*. (2020) investigated various organic nutrient management practices and found that the highest grain yield and economic returns were achieved with FYM + seed-treatment + jeevamruta (a microbial/organic solution) prior to harvest and during cropping.

Shilpa *et al*. (2021) conducted a long-term experiment in Alfisols under different cropping systems and found that over time INM improved growth, yield and nutrient uptake in rain-fed finger millet.

Kejiya *et al*. (2022) explored phosphorus-management practices and found that RDF (recommended dose fertilizer) + PSB + VAM (vesicular arbuscular mycorrhiza) produced the best nutrient content, uptake and yield in finger millet grown on sandy-loam soil.

Sulochna *et al*. (2023) studied finger millet in a finger millet–French bean cropping system under organic nutrient management and found improved nutrient uptake, grain quality and yield under organic nutrient packages.

Mathyam *et al*. (2023) conclude that substituting chemical fertilizers either completely or by up to 50% with organic manures supplies adequate amounts of nutrients, improves the yield of finger millet, economic returns, and soil properties.

Gautam *et al*. (2025) in the North-Western Himalayas reported that combined treatments (NPK + FYM + Azospirillum) achieved highest yields and net returns, underscoring the practical value of integrated nutrient management in climate-challenged zones.

Patel *et al.* 2023 s revealed that application of 100% RDF + Banana pseudo stem sap 1% at tillering and panicle initiation stage recorded significantly higher growth, yield attributes and yields of finger millet. Gross realizations, net returns and BCR were also obtained higher under the treatment of 100% RDF + Banana pseudo stem sap 1% at tillering and panicle initiation stage.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiment entitled "**Effect of sowing dates and nutrient management on productivity, profitability and quality of finger millet [*Eleusine coracana* (L.) Gaertn.]**" were conducted in the *kharif* season of 2023 and 2024, at the research farm (agronomy field) of the ICAR Research Complex for NEH Region, Umiam, Meghalaya. The details of the materials used and the methodologies followed during the course of experimentation are described below:

3.1 General information

3.1.1 Location

The experiment was conducted at the research farm (Agronomy field) of the ICAR Research Complex for NEH Region, Umiam, Meghalaya at an altitude of 295 m above the mean sea level and is positioned geographically at Latitude of 25° 45' 24" N and a Longitude of 95° 50' 26" E, under sub-tropical climatic condition with the mean minimum and maximum temperature ranges from 12°C to 21.5°C and from 22°C to 29.4°C, respectively.

3.1.2 Climatic condition

Figure 3.1(a) & 3.1(b) showed the monthly average atmospheric temperature, rainfall, relative humidity during the period of field experiments. The North-Eastern Hill Region of India, as a whole, falls in humid Sub-tropical climate category with hot summers and cool winters. The region receives enough rainfall due to localized pre-monsoon rainfall activities during April-May.

Normally, the monsoon season starts from the first week of June and extends till end of September. During the post-monsoon period of October-November, the rainfall reduces considerably. Daily meteorological data for the experimentation period were collected from the Agrometeorological observatory of ICAR Research Complex for NEH Region, Umiam and averaged over standard meteorological weeks. The meteorological parameters presented here are: weekly average of maximum and minimum temperature (°C), average relative humidity (%),rainfall (mm).

3.1.2.1 Rainfall

From the recorded meteorological data, it has been found that the crop received total rainfall of 1867.8 mm and 1909.6 mm in the year of 2023 and 2024, respectively during the period of experimentation. However, maximum rainfall occurred in June (616.6 mm) during 2023 and 2024 (548.8 mm) respectively throughout the crop-growing season.

3.1.2.2 Temperature

During the period of field experiment, highest monthly average maximum temperature was recorded in the month of September (29.3°C) and lowest in the month of December (22.1°C) during the first experimentation year (2023). In 2022, highest average maximum temperature was recorded in the month August (20.5°C) and lowest in the month of December (10.5°C). The maximum monthly average temperature ranged between 22.1˚C – 29.3˚C and minimum monthly average temperature ranged between 8.1˚C – 20.8˚C during the study period.

3.1.2.3 Relative Humidity

Regarding relative humidity (RH) it was found that the highest monthly relative humidity was recorded in August, 2023 89.4 %) while, the lowest monthly mean minimum relative humidity was in December, 2023 (79.1 %) during the first study year. However, during second year, the highest monthly mean maximum relative humidity was in June (90.2 %) and the lowest monthly mean minimum relative humidity was in December (76.5 %).

Table 3.1(a) Meteorological data recorded during the cropping season (2023)

Months	Temperature		Relative Humidity (%)	Rainfall (mm)
	Max (˚C)	Min (˚C)	Average	
May	28.20	16.90	79.40	230.10
June	27.80	19.50	87.60	616.60
July	28.20	20.40	87.90	230.50
August	28.30	20.50	89.40	350.90
September	29.30	19.80	84.90	206.10
October	26.50	16.10	83.70	170.40
November	25.20	12.70	79.60	24.00
December	22.10	10.50	79.10	39.20
Total/Average	26.95	17.05	83.95	2097.90

Table 3.1(b) Meteorological data recorded during the cropping season (2024)

Months	Temperature		Relative Humidity (%)	Rainfall (mm)
	Max (˚C)	Min (˚C)	Average	
May	28.40	18.80	83.00	411.50
June	27.10	20.40	90.20	548.80
July	28.70	21.60	87.50	255.20
August	28.10	20.80	89.10	335.20
September	29.30	20.40	87.00	133.60
October	25.80	17.50	87.70	175.00
November	25.00	12.40	79.80	50.30
December	22.10	8.10	76.50	0.00
Total/Average	26.81	17.50	85.10	2321.10

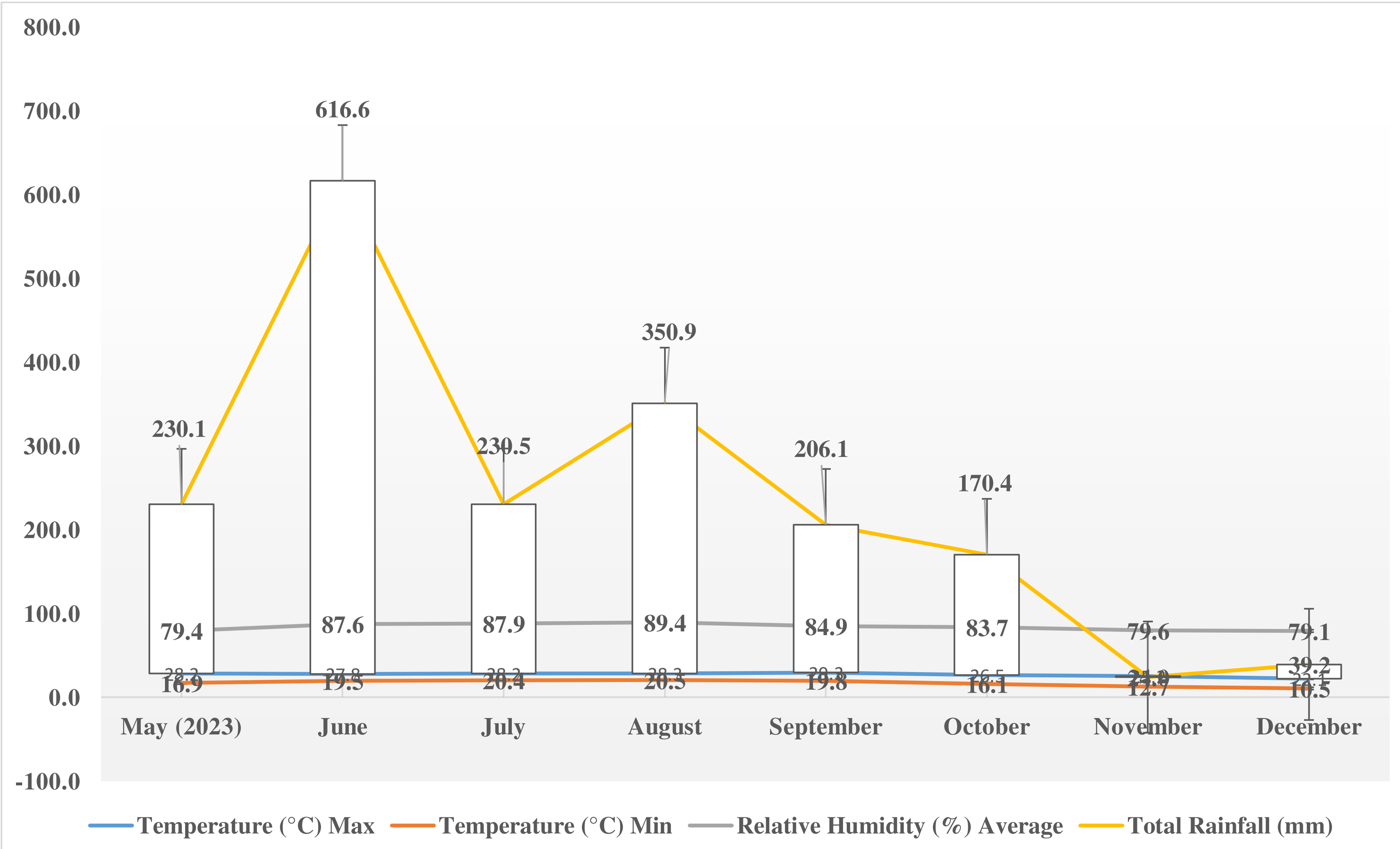


Fig 3.1(a): Meteorological data recorded during the cropping season May- December, 2023

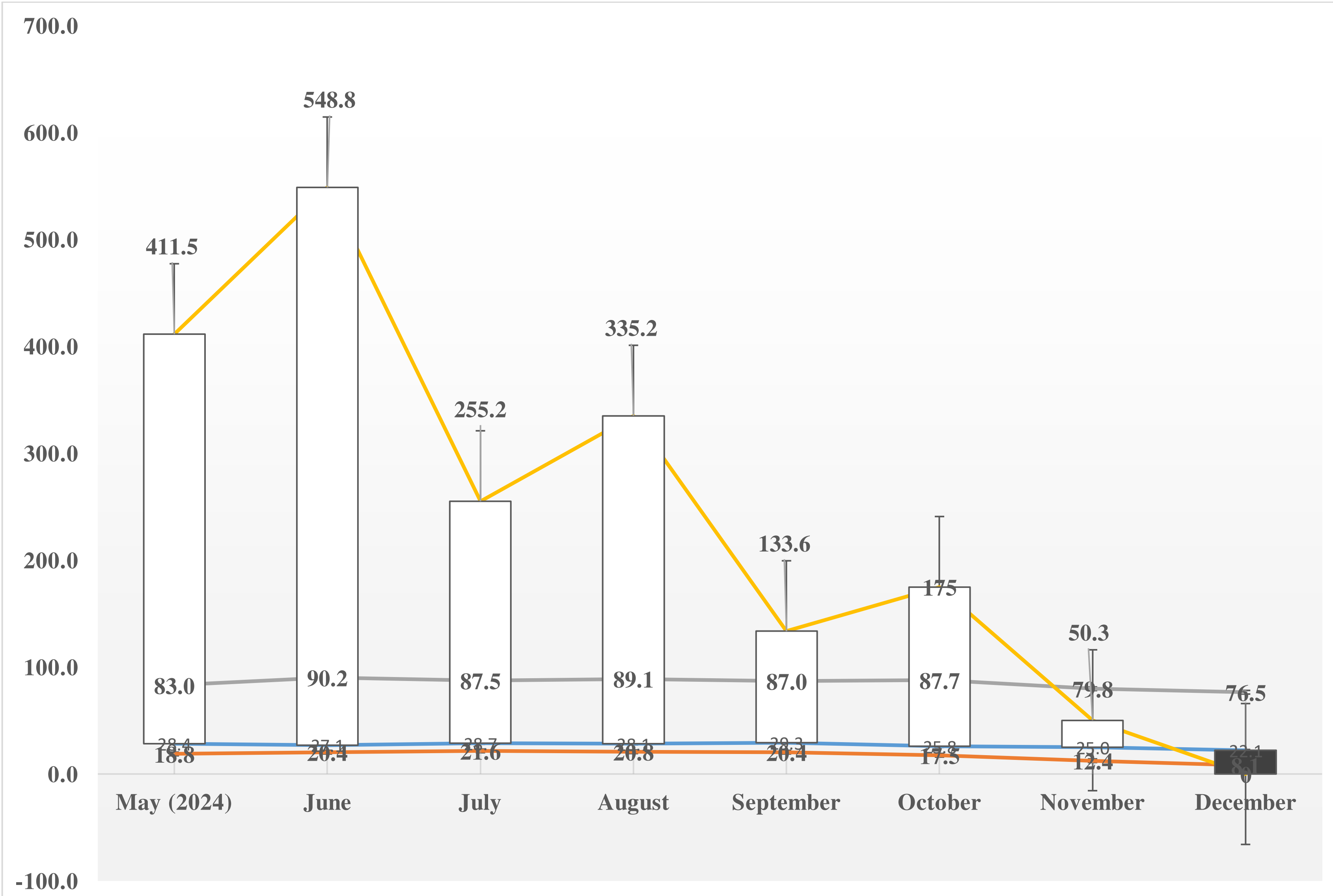


Fig 3.1(b): Meteorological data recorded during the cropping season May- December, 2024

3.1.3 Previous cropping history of the experimental field:

The configuration of the plots used for the experiment was a mid-hill bench terrace. The experimental plots were used for experimentation on maize + toria cropping system and the details of cropping history of the experimental field for last three years experimentation were given as below:

Table 3.2 Previous cropping history of the experimental field

Year	**Crops grown**		
	Pre-kharif	***Kharif***	***Rabi***
2020-2021	-	Maize	Rapeseed
2021-2022	-	Maize	Toria
2022-2023	Fallow	Fallow	Fallow

3.1.4 Soil condition

The soil of the experimental plot was categorized as sandy loam and well drained. Soil samples were collected before sowing and after harvest of crop from each plot and were air dried, ground, and sieved through 2 mm diameter sieve and were used for estimation of available N, P, K, and organic carbon.

The soil was acidic in nature with high organic carbon content. The details of physio-chemical status of the soil at the experimental site before sowing and after harvest of crop is presented in Table 3.3.

Table 3.3 Initial soil status of experimental field

Soil parameters	Method followed	2023		2024	
		Content/ Value	Interference	Content/ Value	Interference
Soil pH	Digital pH meter (Jackson,1973)	3.96	Strongly acidic	4.34	Strongly acidic
Organic carbon (%)	Titrimetric determination (Walkley and Black method,1934)	1.63	High	1.66	High
Available N ($kg\ ha^{-1}$)	Alkaline potassium permanganate method (Subbiah and Asija, 1956)	128.58	Low	127.39	Low
Available P ($kg\ ha^{-1}$)	Bray's I method (Bray and Kurtz, 1945)	6.72	Low	7.49	Low
Available K ($kg\ ha^{-1}$)	Neutral normal ammonium acetate method (Jakson,1973)	187.26	Medium	188.88	Medium

3.2. Experimental materials

3.2.1 Crops and varieties

The general descriptions of the crop varieties used in the present experiment are given below:

Finger millet (VL-Mandua 352)

VL-Mandua 352 is an early-maturing finger millet (ragi) variety, developed by ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), that can be grown in most finger millet-growing states except Tamil Nadu and Maharashtra. It is known for being drought and pest resilient, and is well-suited for organic farming in challenging climates like the hilly regions of Meghalaya.

3.2.2 Chemical fertilizers

Nitrogen as Urea, Phosphorus as Single Super Phosphate and Potash as Muriate of Potash were utilized in the present experiment.

3.2.3 Plant protection chemicals

The crop finger millet being drought and pest resilient, very minimal pest and diseases was recorded during the crop period. Therefore, only neem oil were used for prevention and control insects in the crop.

3.3 Experimental details

3.3.1 Experimental design

The experiment was laid in Factorial Randomized Block Design (FRBD) with three replications. The experiment primarily consists of two factors; Sowing dates and nutrient management. The first factor is divided into three sowing dates, and the second factor into four different nutrient management strategies. The treatments will be replicated three times. The layout of the experiment is given in Fig 3.2.

3.3.2 Details of the experimental techniques

Experimental Design	: Factorial Randomized Block Design (FRBD)
Crop	: Finger millet
Variety	: VL - Mandua 352
Spacing	: 30 cm × 10 cm
Plot size	: 5 m × 3 m
Net plot size	: 15 m^2
Gross plot size	: 540 m^2
Total number of treatments	: 3 × 4=12
No. of replications	: 3
Total number of experiments plots	: 12 × 3=36

3.3.3 Treatment details

The experiment primarily consists of two factors; Sowing dates and nutrient management. The first factor is divided into three sowing dates, and the second factor into four different nutrient management strategies. The treatments were replicated three times.

A) Sowing dates (D)

D_1 - 1st June

D_2 - 15th June

D_3 - 1st July

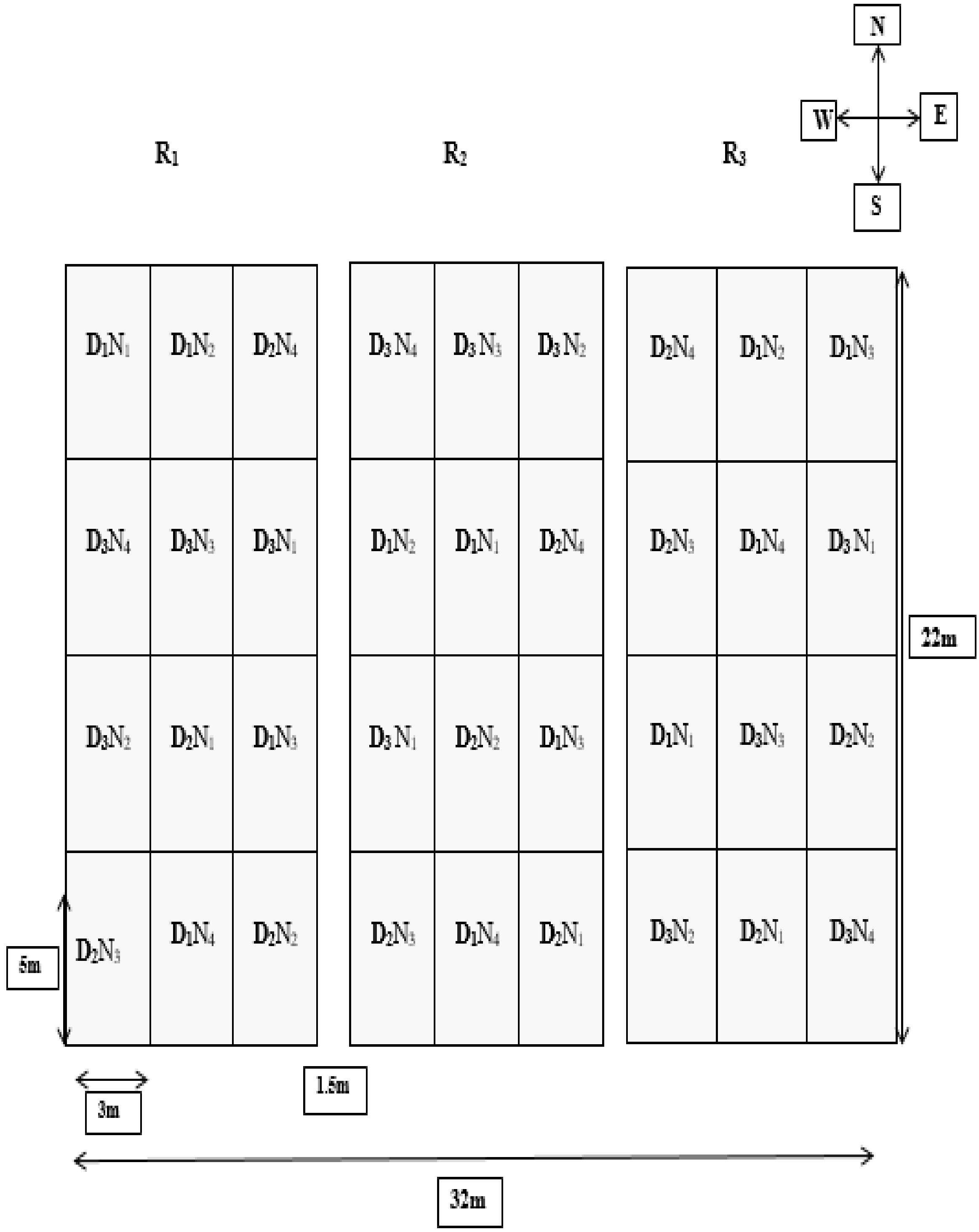
B) Nutrient management (N)

N_1 - Control (No fertilizer)

N_2 - RDF – N, P_2O_5 and K_2O: 40-30-20 kg ha^{-1}

N_3 - 100% Organic through FYM on N equivalent basis (10 t ha^{-1})

N_4 - 50% Inorganic + 50% Organic through FYM



Net plot area = 15 m^2
Gross area = 540 m^2

Fig. 3.2: Field layout of the experiment in Factorial Randomized Block Design (RBD)

3.3.4 Cultivation details

The agronomic practices carried out during the course of experiment are given below. The calendar of agronomic management practices followed during the investigation period are presented in Appendix-A

3.3.4.1 Field preparation

The field experiment was carried out at the research farm (agronomy field) of the ICAR Research Complex for NEH Region, Umiam, Meghalaya. The field was thoroughly ploughed with power tiller in the last week of April followed by harrowing in the last week of May and levelled properly. All the stubbles and debris were removed and the layout were prepared accordingly.

3.3.4.2 Application of manure

The recommended dose of 10 t ha^{-1} FYM was taken and calculated for the plots that need to be apply as per the treatments.

3.3.4.3 Application of fertilizers

Finger millet was fertilized as per the treatments before sowing. Basal dose of N, P and K fertilizer applied at the time of sowing. Half of the nitrogen was applied as top dressing at 25th days after sowing. The urea (46% N), single super phosphate (16% P_2O_5) and murate of potash (60% K_2O) were used as fertilizer sources in the form of NPK briquettes.

3.3.4.4 Seed treatment

Seed was treated with thiram @ 3 g kg^{-1} of seeds, before sowing in order to protect the crop against seed and soil borne diseases.

3.3.4.5 Seed rate

Healthy and clean seeds were selected as per their recommended seed rate. The seed rate of 4 kg ha^{-1} were followed respectively.

3.3.4.6 Planting geometry

The crop was sown in line with a spacing of 30 cm row to row and 10 cm plant to plant were followed.

3.3.4.7 Sowing of seeds

The crop were sown in 3 different sowing date, i.e., 1^{st} June, 15 July and 1^{st} August. Seeds were sown in the open furrows in lines.

3.3.4.8 Intercultural operations

Weeding was done twice, first weeding was done at 25 DAS and also thinning and gap filling were carried to maintain the optimum plant population in the field. Similarly, second weeding was done at 50 DAS.

3.3.4.9 Harvesting

The crop was harvested manually when 90 percent of the grains in a panicle were matures to avoid shedding of grains in three different times for three different sowing dates with the help of a sickle and bundled separately for each plot. The harvested crop was sun dried, threshed and winnowed manually. The grains were packed separately for each plot and marked according to the plot number.

3.3.4.10 Threshing

The earheads were sun dried for easy threshing. Earheads were beaten with the help of stick and thus grains were separated. The threshed product was winnowed and cleaned immediately and then the grain and straw weights were recorded.

3.4 Experimental observation

I. Crop observation

1. Growth attributes

For recording the growth attributes, five plants were selected randomly selected from each plot and tagged. The readings were recorded at different crop growth stages.

1.1 Plant height (cm)

Five number of plants were randomly selected for taking the height of plants from the middle rows in the plots. The measurements were recorded at 25, 50, 75 DAS and at harvest. The height of the plants was measured by the use of linear scale from the ground level to the terminal apex. The mean height from the selected plants were taken as the score for each plot. At harvest the height was recorded from the soil surface up to the base of earhead.

1.2 Plant population (m^{-2})

Plant population of the crop were recorded at 25 and 50 DAS from three randomly selected areas in all the treatments per square meter. The results thus obtained were recorded as plants per m^{-2}.

1.3 Germination (%)

Germination % were recorded at 25 and 50 DAS by calculating the plant populations.

1.4 Number of effective tillers m^{-2} at flowering

Total number of tillers $plant^{-1}$ and m^{-2} were periodically counted and recorded from the five selected plant. An average number tillers $plant^{-1}$ was then computed from the periodical data by dividing the number of shoots, excluding the main shoot by the number of main shoots recorded at flowering. Also, number of tillers m^{-2} were recorded.

1.5 Fresh weight of plant (g $plant^{-1}$) at 25, 50 DAS and at harvest

Single plant was randomly selected from each net plot for the fresh weight studies at the time of every observation. The plant was uprooted and its roots were removed. The aerial plant parts were chopped and we measure the weight in a digital weight machine.

1.6 Dry weight of plant (g $plant^{-1}$) at 25, 50 DAS and at harvest

Single plant was randomly selected from each net plot for dry matter studies at the time of every observation. The plant was uprooted and its roots were removed. The aerial plant parts were chopped and put in a brown paper bag. Then it was dried in thermo statistically controlled oven at 60 0C till the sample was dried till constant weight was recorded.

1.7 Crop growth rate (g m^{-2} day^{-1})

It is the rate of growth in an interval of time. It is defined as rate of dry matter production per unit ground area per unit time (Watson and Dallwitz, 1992). CGR is expressed as g m^{-2} day^{-1} and calculated using the formula.

$$CGR = \frac{W1\text{-}W2}{(t_2 - t_1)\ S}$$

Where, CGR= Crop growth rate, W_1 and W_2 = dry matter accumulation plant in g at time t_1 and t_2 respectively. S is land area (m^2) over which dry matter was recorded.

1.8 Relative growth rate (g g^{-1} day^{-1})

It is the rate of increase of plant material per unit weight per unit time. The unit of RGR is g g^{-1} day^{-1}.

$$RGR = \frac{\ln W2 - \ln W1}{(t2 - t1)}$$

Where, Log_eW_1 and Log_eW_2 are natural log of initial and final dry matter of plant at initial and final time interval.

1.9 Net Assimilation rate (g $m^{-1}day^{-1}$)

NAR is the rate of increase in dry weight per unit leaf area per unit time. It was estimated by using the formula given by Gregory (1926)

$$NAR= \frac{(W2 - W1)(\ln W2 - W1)}{(t2 - t1)\ (L2 - L1)}$$

Where, W_1 and W_2 are plant dry weight at time t_1 and t_2 respectively L_1 and L_2 are leaf area at time t_1 and t_2 respectively.

1.10 Leaf Area Index (LAI)

Leaf area of functional leaves carefully removed from each plant and grouped into three classes as per the size and leaf area was measured by “Automatic Leaf Area Meter”. Leaf area index of the five (%) tagged plants were recorded at 25, 50 DAS and at harvest. The LAI was worked out using the formula (Watson, 1952)

$$\text{LAI} = \frac{\text{Total leaf area (cm}^2\text{)}}{\text{Ground area (cm}^2\text{)}}$$

2. Yield attributes

2.1 Number of panicles (m^{-2})

Randomly 5 tagged plants were selected and the number of panicles on each tagged panicles were counted and mean was taken from each plot.

2.2 Number of fingers ear^{-1}

For recording mean number of fingers $earhead^{-1}$, fingers from all the five observations plants were added up and it was divided by total number of earheads from the five plants·

2.3 Number of grains $finger^{-1}$

For recording mean number of grains $fingers^{-1}$, grains from all the five fingers observations plants were added up.

2.4 Number of grains $earhead^{-1}$

For recording mean number of grains $earhead^{-1}$, fingers from all the five observations plants were added up and it was divided by total number of earheads from the five plants.

2.5 Length of finger (cm)

To record average length of finger, length of all fingers from the five observation hills was measured and it was divided by the total number of earheads.

2.6 Test weight (g)

A representative sample of grain was taken from each treatment after threshing and drying. Then thousand grains were counted carefully and then its weight was recorded.

3. Yield

3.1 Grain yield plant^{-1} (g)

After threshing and cleaning of the produce, grains from the five tagged plant were sun dried and their final air dry weight treatment-1 was recorded.

3.2 Grain yield (kg ha^{-1})

After threshing and cleaning of the produce, grains from each treatment plot were sun dried and their final air dry weight treatment-1 was recorded and converted on hectare basis.

3.3 Straw yield (kg ha^{-1})

The yield of straw net plot^{-1} was weighed after drying and expressed on hectare basis. The produce after harvesting were left in the field for sun drying. The straw yield of each plot was obtained in kg plot^{-1} by subtracting the seed yield of respective plot from the weight of these bundles and then converted into kg ha^{-1} by multiply with conversion factor. The straw of the plant *i.e.* leaves and grain covers of the crop were weighed after threshing in each plot.

3.4 Harvest index (%)

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

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (grain yield)}}{\text{Biological yield (grain+straw yield)}} \times 100$$

II Quality parameters

1. Crude protein content (%)

Crude protein content (%) of seed was determined by using the Kjeldahl method (N%) as described by Peach and Tracey, (1956) with a conversion factor of 6.25.

2. Carbohydrate content (%)

Total carbohydrates were extracted according to Smith (1964)

3. Crude fiber content (%)

Crude fiber in finger millet is determined using a standard gravimetric method involving digestion with acid and alkali, followed by drying, ignition, and calculation based on weight loss.

4. Calcium content (%)

Grain calcium content was determined by dry ashing method. Total calcium was determined by versenate (EDTA).

III Nutrient content and uptake by the plant

1. N, P, K content in grain and straw (%)

Nitrogen content in samples was estimated by modified Microkjeldahl method (Piper, 1966) after digesting the plant sample with H_2SO_4 and H_2O_2. For phosphorous and potassium contents, plant samples were digested with tri-acid mixture (9:4:1 of HNO_3:H_2SO_4:$HClO_4$) (Piper, 1966).

2. N, P, K uptake by grain and straw (kg ha^{-1})

The nutrient uptake (kg/ha) was calculated by using their nitrogen, phosphorus and potassium concentration (%) values and yield of crop plant on hectare basis. Nutrient uptake was calculated as:

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

IV Soil analysis

1. Soil pH

The pH of the soil in 1:2.5 soil water suspensions was determined by digital pH meter (Jackson, 1973).

2. Organic carbon (%)

The organic carbon content of the soil was determined by rapid titration method (Walkley and Black, 1934) and the results were expressed in percentage.

3. Available Nitrogen (kg ha^{-1})

The available nitrogen in the soil was determined by alkaline permanganate method as given by Subbaiah and Asija (1956) with the help of Kelpus nitrogen analyser and the results were expressed in kg ha^{-1}.

4. Available Phosphorus (kg ha^{-1})

The available phosphorus content was determined by extracting with 0.03N NH_4F + 0.025 N HCl (Bray and Kurtz, 1945) and the phosphorus content was estimated colorimetrically using ascorbic acid method.

5. Available Potassium (kg ha^{-1})

The available potassium content was determined in neutral normal ammonium acetate extract using flame photometer (Jackson, 1973).

V Economic analysis

The cost of cultivation, gross return, net returns, return per rupee investment and benefit cost ratio of different treatments were worked out on the basis of prevailing market prices.

1. Cost of cultivation (₹ ha^{-1})

Cost of cultivation was calculated on the basis of existing local charges for different inputs used in the experimental plot.

2. Gross return (₹ ha^{-1})

Economic yield was calculated by subtracting the total cost of cultivation from the gross return.

3. Net return (₹ ha^{-1})

The net return was calculated by subtracting the total cost of cultivation from the gross return.

Net return = Gross return – Cost of cultivation

4. Benefit cost ratio (BCR)

Benefit cost ratio was calculated by using the formula:

$$\text{B-C Ratio} = \frac{\text{Net returns}}{\text{Cost of cultivation}} \text{ X } 100$$

VI Statistical analysis

All the experimental data were subjected to statistical analysis by adopting appropriate method of Analysis of Variance as described by Gomez and Gomez (1984). Wherever, the F values were found significant at 5 percent levels of probability, the critical difference (CD) values were computed for making comparison among the treatment mean.

Plate 1: General view of the experimental field

	
Plate 2: Primary ploughing of the experimental field	**Plate 3: Preparation of the field**
	
Plate 4: Row making	**Plate 5: Field Lay-out**

Plate 6: Fertilizers measurement

Plate 7: 1st Sowing date, 1st June 2023

Plate 8: 1st Sowing date, 1st June 2024

Plate 9: 2nd Sowing date, 15th June 2023

Plate 10: 2nd Sowing date, 15th June 2024

Plate 11: 3rd Sowing date (1th July 2023)

Plate 12: 3rd Sowing date (1th July 2024)

Plate 13: Germination

Plate 14: Crop at 10 DAS

Plate 15: Crop at Vegetative stage

Plate 16: Weeding and thinning

Plate 17: Crop at 50% flowering	Plate 18: Crop at 50% flowering

Plate 19: Crop at 50% flowering	Plate 20: Crop at reproductive stage

Plate 21: Field data collections

Plate 22: Field data collections

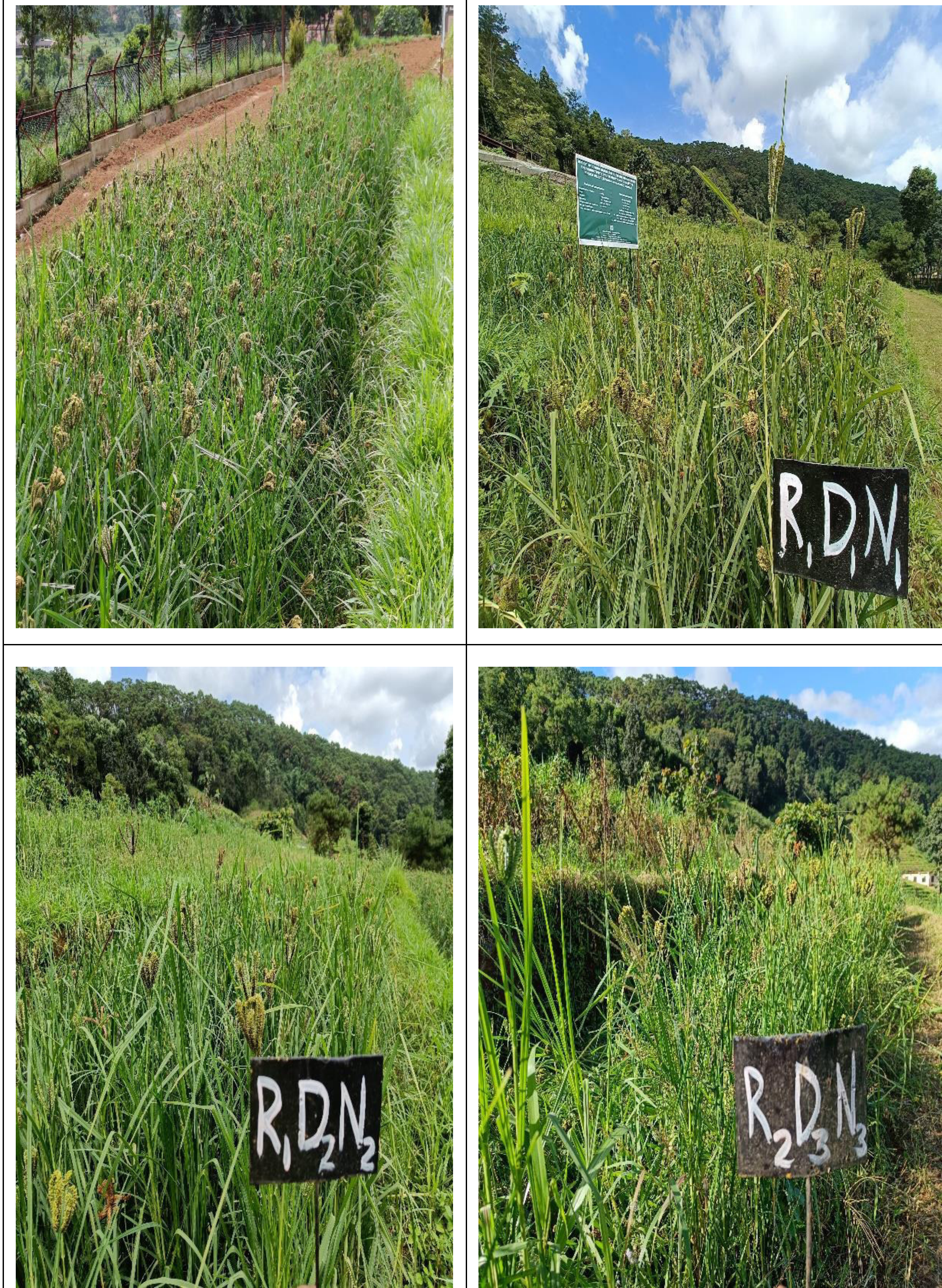


Plate 23: Crop at Maturity

Plate 24: Harvesting Time

Plate 25: Sun Drying

Plate 26: Threshing

Plate 27: Yield per plot

Plate 28: Yield of different Treatments

	
Plate 29: Determination of protein	**Plate 30: Determination of carbohydrate**
	
Plate 31: Determination of calcium	

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The results obtained during the course of time of present investigation on "Effect of sowing dates and nutrient management on productivity, profitability and quality of finger millet [*Eleusine coracana* (L.) Gaertn.]" was conducted in the research farm (agronomy field) of the ICAR Research Complex for NEH Region, Umiam, Meghalaya during two consecutive *kharif* seasons of 2023 and 2024. The experiment was laid in Factorial Randomized Block Design (FRBD) with three replications. The experiment primarily consists of two factors; sowing dates and nutrient management. The first factor is divided into three sowing dates, and the second factor into four different nutrient management strategies. The data recorded during the course of the experiment were statistically and the results obtained are being interpreted and further illustrated in this chapter.

4.1.1 Growth attributes

Growth parameters of finger millet were recorded at various phenological stages.

4.1.1.1 Plant height (cm)

The data on plant height (cm) of finger millet as influenced by sowing dates and nutrient management was recorded at 25, 50, 75 DAS and at harvest, and are given in in Table 4.1.(a-i), 4.1(a-ii) and Table 4.1.(b-i) and 4.1(b-ii). The data presented show that plant height of finger millet was significantly affected by sowing dates, nutrient management practices, and their interaction effects during both years (2023 and 2024) as well as in the pooled analysis.

Effect of Sowing Dates (D)

At 25 days after sowing (DAS), a clear variation in plant height was observed among the different sowing dates in both years of the study. In 2023, crops sown on 15th June (D_2) exhibited the tallest plants (25.44 cm), followed by 1st July (D_3) (23.65 cm), while the 1st June sowing (D_1) resulted in the shortest plants (20.85

cm). The same pattern was recorded in 2024, where the 15th June sowing (D_2) again produced the maximum plant height (20.08 cm), and the 1st June sowing (D_1) recorded the minimum (19.23 cm). The pooled mean further confirmed this trend, with D_2 (15th June) attaining the highest average plant height (22.76 cm), followed by D_3 (21.47 cm) and D_1 (20.04 cm).

At 50 DAS, the trend was reversed. In 2023, the tallest plants (74.96 cm) were obtained from D_1 (1st June), followed by D_2 (15th June) (69.41 cm), whereas the shortest plants (64.84 cm) were recorded under D_3 (1st July). In 2024, however, the 1st July (D_3) sowing produced the tallest plants (68.30 cm), followed by D_1 (1st June) (67.70 cm), with only a marginal difference among the treatments. The pooled mean revealed that D_1 (1st June) produced the maximum plant height (71.33 cm), followed by D_2 (70.27 cm), while D_3 (1st July) showed the lowest (66.56 cm).

At 75 DAS, the tallest plants were observed under D_3 (1st July) in both years. In 2023, D_3 (1st July) recorded a height of 99.75 cm, which was statistically similar to D_1 (1st June) (98.81 cm), whereas D_2 (15th June) produced the lowest height (96.79 cm). In 2024, the same trend persisted, with D_3 (1st July) showing the maximum height (101.48 cm), followed by D_1 (99.41 cm) and D_2 (96.48 cm). The pooled mean confirmed the superiority of D_3 (1st July) (100.62 cm), followed by D_1 (99.10 cm) and D_2 (96.64 cm).

At harvest, significant differences in plant height were also recorded among the sowing dates. In 2023, the tallest plants (142.66 cm) were produced under D_2 (15th June), which was comparable with D_3 (1st July) (139.96 cm), while the shortest plants (138.72 cm) were observed in D_1 (1st June). A similar pattern was seen in 2024, where D_2 (138.60 cm) and D_3 (136.86 cm) showed superior plant height over D_1 (137.97 cm). The pooled data revealed that D_2 (15th June) produced the tallest plants (140.63 cm), followed by D_3 (138.40 cm) and D_1 (138.32 cm). These findings suggest that mid-June sowing provided more favorable conditions such as adequate soil moisture, optimal temperature, and suitable light duration during the vegetative phase,contributing to better plant growth. The results also indicated that slightly delayed sowing (mid-June to early July) enhanced vegetative development due to improved rainfall distribution and favorable thermal conditions.

Effect of Nutrient Management (N)

At 25 DAS, plant height varied significantly among nutrient management practices. In 2023, the tallest plants (26.12 cm) were observed in N_4 (50% inorganic + 50% organic), followed by N_2 (RDF: 40:30:20 kg $N:P_2O_5:K_2O$ kg ha^{-1}) (23.84 cm), while the shortest (21.35 cm) occurred in the control (N_1). A similar trend was evident in 2024, where N_4 again recorded the highest plant height (24.84 cm) and N_1 the lowest (18.59 cm). The pooled data confirmed that N_4 (23.48 cm) produced significantly taller plants than other treatments, followed by N_2 (21.27 cm) and N_3 (20.98 cm), whereas N_1 (19.97 cm) had the lowest.

At 50 DAS, in 2023, the maximum plant height (73.93 cm) was recorded under N_2 (RDF), followed closely by N_4 (70.22 cm), while the lowest height (65.58 cm) was found in N_1 (control). In 2024, the highest plant height (70.22 cm) was again recorded under N_2 (RDF), with the minimum (65.60 cm) in N_1. The pooled results revealed that N_2 (72.08 cm) and N_4 (70.35 cm) were statistically at par and significantly superior to other treatments, indicating that both recommended and integrated nutrient management practices enhanced vegetative growth.

At 75 DAS, the tallest plants were observed in N_2 (RDF) in both years—101.90 cm in 2023 and 106.09 cm in 2024 followed by N_4 (50% inorganic + 50% organic) with 94.89 cm and 104.11 cm, respectively. The pooled data also indicated the superiority of N_2 (104.05 cm) followed by N_4 (99.54 cm), while N_1 (control) recorded the lowest height (93.09 cm).

At harvest, nutrient management significantly influenced plant height during both years. In 2023, the maximum height (143.82 cm) was recorded under N_4 (50% inorganic + 50% organic), followed by N_3 (100% organic) (142.38 cm) and N_2 (138.83 cm), while the minimum height (137.06 cm) occurred in N_1 (control). In 2024, N_4 again produced the tallest plants (142.34 cm), followed by N_3 (139.13 cm) and N_2 (138.52 cm), with the shortest under N_1 (130.13 cm). The pooled mean confirmed that N_4 (143.51 cm) achieved the highest plant height, followed by N_3 (140.68 cm) and N_2 (138.70 cm), whereas N_1 (133.59 cm) was the lowest. These results demonstrate the effectiveness of integrated nutrient management (N_4) in promoting plant height through a combination of quick nutrient release from inorganic sources and sustained supply from organic matter, leading to improved soil health and nutrient availability.

Interaction effect (D × N)

The interaction between sowing dates and nutrient management showed significant influence on plant height during both years. At 25 DAS, in 2023, the highest plant height (26.25 cm) was recorded under D_2N_4 (15th June + 50% inorganic + 50% organic), followed by D_1N_4 (1st June + 50% inorganic + 50% organic) (25.89 cm). In 2024, the maximum height (22.51 cm) was found in D_2N_3 (15th June + 100% organic), while the minimum (18.24 cm) occurred in D_1N_2 (1st June + RDF). The pooled mean revealed that D_2N_4 (23.79 cm) achieved the highest plant height, followed closely by D_1N_4 (23.26 cm).

At 50 DAS, in 2023, the tallest plants (78.73 cm) were observed in D_2N_2 (15th June + RDF), followed by D_1N_4 (75.08 cm), while D_3N_1 (1st July + control) showed the lowest (58.54 cm). The 2024 results showed a similar pattern, with D_2N_2 (67.61 cm) being the highest and D_3N_1 (66.09 cm) the lowest. The pooled data confirmed that D_2N_2 (73.17 cm) and D_1N_4 (72.83 cm) were statistically superior, highlighting the beneficial effect of mid-June sowing combined with either recommended or integrated nutrient management.

At 75 DAS (pooled), the tallest plants (107.04 cm) were recorded under D_1N_2 (1st June + RDF), closely followed by D_3N_2 (1st July + RDF) (105.78 cm), while the shortest (92.00 cm) occurred in D_1N_1 (1st June + control).

At harvest (pooled), the interaction effect remained significant. In 2023, the tallest plants (146.98 cm) were recorded under D_3N_4 (1st July + 50% inorganic +

50% organic), followed by D_2N_4 (143.91 cm) and D_1N_4 (140.57 cm), whereas the shortest (132.40 cm) occurred in D_1N_1 (control). In 2024, a similar trend continued, with D_3N_4 (143.57 cm) producing the tallest plants, followed by D_1N_4 (144.83 cm) and D_2N_4 (141.24 cm), and the lowest (129.61 cm) again under D_1N_1. The pooled mean confirmed that D_3N_4 (145.28 cm) resulted in the highest plant height, followed by D_1N_4 (142.70 cm) and D_2N_4 (142.58 cm), while D_1N_1 (131.00 cm) recorded the minimum. This indicates that 1st July sowing combined with integrated nutrient management (N_4) resulted in superior vegetative growth, possibly due to favorable weather conditions and a steady nutrient supply from both organic and inorganic sources.

The overall findings indicated that both sowing date and nutrient management, individually as well as in combination, had a significant effect on plant height of finger millet. The taller plants observed under mid-June (D_2) and early July (D_3) sowings could be attributed to favorable temperature, moisture availability, and optimal photoperiod during the vegetative phase, which enhanced tillering and internode elongation. Early sowing (D_1 – 1st June), in contrast, likely encountered higher temperature and occasional moisture stress during early growth, leading to comparatively reduced height. Nutrient management also played a crucial role, with integrated nutrient management (N_4) producing the tallest plants. This may be attributed to the synergistic effect of quick nutrient availability from inorganic fertilizers combined with gradual nutrient release and improved soil structure from organic matter. Organic amendments enhance microbial activity and nutrient uptake efficiency, leading to sustained vegetative growth. These results are consistent with the findings of Reddy *et al.* (2021), Srinivas *et al.* (2023) and Phom *et al.* (2024), who reported improved plant growth and biomass accumulation in finger millet under combined organic and inorganic nutrient regimes. The significant interaction effect (D × N) further confirms that late sowing (1st July) in combination with integrated nutrient management (N_4) provided the most favourable conditions for vegetative growth, resulting in taller plants. The combined influence of optimal climatic conditions and balanced nutrient availability ensured continuous growth and better plant vigour throughout the crop cycle.

Table 4.1(a-i): Plant height (cm) of finger millet under different sowing dates and nutrient management system at 25 and 50 DAS

Treatments	Plant height (cm)					
	25 DAS			50 DAS		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1^{st} June	20.85	19.23	20.05	74.96	67.70	71.33
D_2: 15^{th} June	25.44	20.09	22.77	69.41	71.15	70.27
D_3: 1^{st} July	23.65	19.29	21.47	64.84	68.31	66.56
SEm±	0.32	0.25	0.15	0.25	0.34	0.20
CD (P=0.05)	0.96	0.73	0.46	0.72	1.01	0.58
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)						
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	23.84	18.70	21.27	73.92	70.23	72.07
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	21.95	20.01	20.98	69.20	69.86	69.53
N_4: 50% Inorganic + 50% Organic through FYM	26.12	20.84	23.48	70.21	70.50	70.35
SEm±	0.374	0.28	0.17	0.28	0.39	0.23
CD (P=0.05)	1.09	0.83	0.528	0.84	1.16	0.67

Table 4.1(a-ii): Interaction effect on plant height (cm) of finger millet under different sowing dates and nutrient management system at 25 and 50 DAS

Interaction (D×N)	Plant height (cm)					
	25 DAS			50 DAS		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	17.82	19.25	18.54	71.91	63.84	67.88
T_2: D_1N_2	21.01	18.28	19.65	78.74	67.61	73.17
T_3: D_1N_3	18.68	18.80	18.74	74.08	68.81	71.45
T_4: D_1N_4	25.89	20.61	23.26	75.08	70.57	72.83
T_5: D_2N_1	24.54	18.28	21.40	66.30	66.87	66.58
T_6: D_2N_2	27.24	18.24	22.74	71.68	70.91	71.30
T_7: D_2N_3	23.76	22.51	23.14	68.60	74.92	71.77
T_8: D_2N_4	26.25	21.32	23.79	71.04	71.87	71.46
T_9: D_3N_1	21.69	18.25	19.97	58.55	66.09	62.33
T_{10}: D_3N_2	23.29	19.61	21.44	71.35	72.17	71.76
T_{11}: D_3N_3	23.41	18.73	21.07	64.93	65.88	65.41
T_{12}: D_3N_4	26.23	20.61	23.42	64.53	69.06	66.80
SEm±	0.65	0.49	0.31	0.50	0.69	0.40
CD (P=0.05)	1.90	1.45	0.91	1.45	2.02	1.17

Table 4.1(b-i): Plant height (cm) of finger millet under different sowing dates and nutrient manageme system at 75 DAS and at harvest

Treatments	**Plant height (cm)**					
	75 DAS			**Harvest**		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	98.81	99.41	99.10	138.73	137.93	138.32
D_2: 15th June	96.79	96.48	96.64	142.67	138.61	140.63
D_3: 1st July	99.75	101.49	100.63	139.97	136.86	138.40
SEm±	0.64	0.40	0.31	0.40	0.44	0.31
CD (P=0.05)	1.89	1.19	0.90	1.18	1.30	0.90
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	99.01	87.16	93.09	137.06	130.13	133.60
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	101.91	106.10	104.01	138.88	138.52	138.70
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	98.01	99.12	98.56	142.04	139.31	140.68
N_4: 50% Inorganic + 50% Organic throu FYM	94.89	104.11	99.50	143.82	143.21	143.51
SEm±	0.74	0.47	0.36	0.47	0.51	0.36
CD (P=0.05)	2.19	1.37	1.05	1.36	1.51	1.05

Table 4.1(b-ii): Interaction effect on plant height (cm) of finger millet under different sowing dates and nutrient manageme system at 75 DAS and at harvest

Interaction (D×N)	Plant height (cm)					
	75 DAS			Harvest		
	2023	2024	Pooled	2023	2024	Pooled
T1: D_1N_1	95.38	88.62	92.01	132.40	129.61	131.01
T2: D_1N_2	101.47	112.61	107.04	142.94	139.31	141.12
T3: D_1N_3	97.96	96.43	97.20	138.98	137.98	138.48
T4: D_1N_4	100.45	99.94	100.20	140.57	144.83	142.70
T5: D_2N_1	98.33	80.25	89.28	142.20	135.20	138.70
T6: D_2N_2	99.66	98.70	99.17	139.68	139.98	139.84
T7: D_2N_3	97.46	89.65	93.56	144.87	137.98	141.43
T8: D_2N_4	91.70	117.32	104.50	143.91	141.24	142.58
T9: D_3N_1	103.30	92.61	97.95	136.57	125.58	131.08
T10: D_3N_2	104.58	106.98	105.78	134.02	136.28	135.15
T11: D_3N_3	98.62	111.28	104.94	142.28	141.98	142.12
T12: D_3N_4	92.53	95.07	93.80	146.98	143.57	145.28
SEm±	1.29	0.81	0.62	0.81	0.89	0.62
CD (P=0.05)	3.77	2.36	1.80	2.36	2.60	1.82

4.1.1.2 Plant population (m^{-2})

Plant population data on finger millet were recorded at 25 and 50 DAS as influenced by sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.2(a) and 4.2(b).

Results revealed that plant population at 25 days after sowing (DAS) was significantly affected by both sowing dates and nutrient management practices during the two experimental years (2023 and 2024) as well as in the pooled mean.

Among the different sowing dates, the crop established on 1st July (D_3) consistently recorded the highest plant population, registering 30.66 m^{-2}, 29.00 m^{-2}, and 29.83 m^{-2} in 2023, 2024, and pooled data, respectively. This treatment, however, was statistically comparable with 1st June sowing (D_1) in both years. The lowest plant count was observed under the 15th June sowing (D_2), which recorded 29.83 m^{-2}, 27.17 m^{-2}, and 28.50 m^{-2} in 2023, 2024, and pooled data, respectively. The variation in plant population across sowing dates may be explained by the environmental conditions prevailing at the time of seedling establishment. Early July sowing likely benefited from adequate soil moisture, moderate temperatures, and favorable humidity, which collectively enhanced seed germination and initial crop establishment.

With respect to nutrient management, the treatment comprising 50% inorganic + 50% organic through FYM (N_4) registered the highest plant population (31.66, 29.33, and 30.50 m^{-2} in 2023, 2024, and pooled mean, respectively), followed by 100% organic through FYM (N_3). The lowest population was obtained under the control (N_1) treatment (29.66, 28.77, and 27.50 m^{-2} for 2023, 2024, and pooled mean, respectively). The improvement under integrated nutrient management can be attributed to the balanced and continuous nutrient availability from both organic and inorganic sources, which enhanced soil structure, microbial activity, and overall seedling vigor, resulting in better plant stand establishment.

A significant interaction effect (D × N) was also observed. The combination of D_3N_4 (1st July sowing + 50% inorganic + 50% organic) resulted in the highest plant population (31.33, 31.33, and 31.50 m^{-2} at 25 DAS during 2023, 2024, and pooled mean, respectively), whereas the lowest population (28.00, 22.66, and 25.33 m^{-2}) was recorded under D_1N_1 (1st June + control). The superior performance of D_3N_4 highlights the positive interaction between favorable sowing time and balanced nutrient application.

At 50 DAS, a similar trend in plant population was observed as at 25 DAS. Among the sowing dates, 1st July sowing (D_3) again recorded a higher population (27.75, 27.58, and 28.67 m^{-2} during 2023, 2024, and pooled data, respectively), followed by 15th June sowing (D_2). The lowest values were noted under 1st June sowing (D_1) (24.75, 27.16, and 27.17 m^{-2} in respective years). The consistent superiority of July sowing suggests that favourable rainfall distribution and soil moisture during early vegetative growth stages encouraged higher plant survival and improved tiller establishment.

Under different nutrient management regimes, N_4 (50% inorganic + 50% organic) again produced the highest plant population (30.44, 29.33, and 29.38 m^{-2} during 2023, 2024, and pooled mean), closely followed by N_3 (100% organic). The control (N_1) treatment recorded the lowest population (23.66, 26.22, and 25.00 m^{-2}). The consistent superiority of integrated nutrient management treatments underscores the beneficial role of combining quick-releasing chemical nutrients with slow-releasing organic manures, resulting in improved soil fertility, sustained nutrient supply, and better root and shoot development.

The interaction effect (D × N) at 50 DAS remained statistically significant. The D_3N_4 combination (1st July + 50% inorganic + 50% organic) produced the highest population (30.33, 29.67, and 30.00 m^{-2} during 2023, 2024, and pooled mean, respectively), while the lowest (27.33, 21.67, and 24.50 m^{-2}) was again associated with D_1N_1 (1st June + control). The superior plant population under D_3N_4 can be attributed to the synergistic influence of favorable climatic conditions during early July and the balanced nutrient environment provided by integrated nutrient management, both contributing to improved germination, vigorous seedling growth, and reduced mortality.

The significant effect of sowing dates on plant population across both years suggests that environmental variables such as temperature, rainfall, and humidity during the early growth phase play a critical role in germination and crop establishment. Early July sowing provided a favorable microclimate, ensuring adequate soil moisture and moderate temperatures, which enhanced seedling emergence and survival. These observations align with the findings of Bharathi *et al.* (2021) and Reddy *et al.* (2022), who reported that delayed sowing during early July led to improved establishment and higher plant density in finger millet under rainfed conditions.

Nutrient management practices exerted a pronounced influence on plant population as well. The superiority of the integrated nutrient treatment (N_4) may be attributed to the combined and complementary effects of inorganic fertilizers for immediate nutrient supply and organic manures for sustained release and improved soil physical properties. Enhanced microbial activity and soil aeration under integrated nutrient management further contributed to better germination and seedling vigor. Similar findings were also documented by Kumar *et al.* (2022) and Devi (2021) and Phom *et al.* (2024) who observed improved seedling establishment and uniform crop stand in millets under integrated nutrient management regimes.

Table 4.2(a): Plant population (m^{-2}) of finger millet under different sowing dates and nutrient management system at 25 and 50 DAS

Treatments	Plant Population (m^{-2})					
	25 DAS			50 DAS		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	30.50	25.50	28.00	29.58	24.75	27.17
D_2: 15th June	29.83	27.17	28.50	29.17	26.58	27.88
D_3: 1st July	30.67	29.00	29.83	29.58	27.75	28.67
SEm±	0.28	0.31	0.22	0.31	0.27	0.22
CD (*P=0.05*)	NS	0.90	0.63	NS	0.78	0.66
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	29.67	0.90	27.00	28.78	23.67	26.22
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	29.89	27.44	28.67	29.33	26.56	27.94
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	30.11	27.78	28.94	29.22	26.89	28.06
N_4: 50% Inorganic + 50% Organic through FYM	31.67	29.33	30.50	30.44	28.33	29.39
SEm±	0.33	0.35	0.25	0.36	0.31	0.26
CD (P=0.05)	0.96	1.03	0.72	1.04	0.91	0.75

Table 4.2(b): Interaction effect on plant population (m^{-2}) of finger millet under different sowing dates and nutrient management system at 25 and 50 DAS

Interaction (D×N)	Plant Population (m^{-2})					
	25 DAS			25 DAS		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	28.00	22.67	25.33	27.33	21.67	24.50
T_2: D_1N_2	30.33	26.00	28.17	29.33	25.33	27.33
T_3: D_1N_3	31.33	26.67	29.00	30.67	26.00	28.33
T_4: D_1N_4	32.33	26.67	29.50	31.00	26.00	28.50
T_5: D_2N_1	30.00	23.00	26.50	29.33	23.00	26.17
T_6: D_2N_2	29.33	28.00	28.67	29.00	27.00	28.00
T_7: D_2N_3	29.00	27.67	28.33	28.33	27.00	27.67
T_8: D_2N_4	31.00	30.00	30.50	30.00	29.33	29.67
T_9: D_3N_1	31.00	27.33	29.17	29.67	26.33	28.00
T_{10}: D_3N_2	30.00	28.33	29.17	29.67	27.33	28.50
T_{11}: D_3N_3	30.00	29.00	29.50	28.67	27.67	28.17
T_{12}: D_3N_4	31.67	31.33	31.50	30.33	29.67	30.00
SEm±	0.57	0.61	0.43	0.62	0.54	0.44
CD (P=0.05)	1.66	1.79	1.27	1.80	1.57	1.30

4.1.1.3 Germination percentage (%)

Germination percentage of finger millet were recorded at 25 and 50 DAS as influenced by sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.3(a) and 4.3(b)..

Results revealed that germination percentage at 25 and 50 days after sowing (DAS) was markedly influenced by both sowing dates and nutrient management practices during the years 2023 and 2024, as well as in the pooled mean.

Germination at 25 DAS

Among the sowing dates, 1st July (D_3) exhibited the maximum germination percentage with values of 91.00% in 2023, 87.00% in 2024, and a pooled mean of 89.00%, followed by 15th June (D_2) with corresponding values of 89.50%, 81.50%, and 85.50%. The lowest germination was recorded under 1st June sowing (D_1) with 91.58%, 76.50%, and 84.05% during 2023, 2024, and pooled mean, respectively.

Although D_1 showed slightly higher germination during the first year, the overall pooled data suggested that D_3 (1st July) was more consistent and stable across both years. This consistency might be due to more favorable soil moisture and temperature conditions prevailing during early July, which promoted uniform seed germination and better seedling establishment.

With respect to nutrient management, treatment N_4 (50% Inorganic + 50% Organic through FYM) recorded the highest germination percentage (95.11%, 88.00%, and 91.56% during 2023, 2024, and pooled mean, respectively), followed by N_3 (100% Organic through FYM). The lowest germination was noted in the control (N_1) treatment, with values of 88.00%, 73.00%, and 80.50%, respectively. The superiority of N_4 could be attributed to the synergistic effect of inorganic and organic nutrient sources, where organic matter improved soil structure, moisture retention, and microbial activity, while inorganic fertilizers ensured the timely availability of nutrients essential for vigorous seedling emergence.

The interaction between sowing dates and nutrient management (D × N) also showed a significant influence on germination percentage. The combination D_3N_4 (1st July + 50% Inorganic + 50% Organic) recorded the maximum germination (95.00%, 94.00%, and 94.50% in 2023, 2024, and pooled mean, respectively). In contrast, the minimum germination percentage (84.00%, 68.00%, and 76.00%) was observed in D_1N_1 (1st June + Control), indicating that early sowing without nutrient supplementation resulted in poor seedling establishment due to unfavorable soil moisture and limited nutrient availability.

Germination at 50 DAS

At 50 DAS, germination percentage followed a similar trend to that observed at 25 DAS. The 1st July sowing (D_3) maintained the highest germination rates with 88.75%, 83.17%, and 85.95% during 2023, 2024, and pooled mean, respectively, followed by 15th June (D_2) which recorded 87.50%, 79.75%, and 83.63%. The lowest germination was again recorded in 1st June (D_1) with 88.75%, 74.50%, and 81.63%, suggesting that early sowing was less favorable due to suboptimal rainfall distribution and soil moisture stress, which likely affected seedling survival and vigor.

Regarding nutrient management, N_4 (50% Inorganic + 50% Organic through FYM) continued to perform best, showing germination percentages of 91.33%, 85.00%, and 88.17% during 2023, 2024, and in the pooled mean, respectively. This was followed by N_3 (100% Organic) and N_2 (Recommended Dose of Fertilizer), while N_1 (Control) exhibited the lowest values (86.33%, 71.00%, and 78.67%). The consistent superiority of N_4 can be linked to enhanced nutrient availability and soil aeration, which supported better root growth and seedling survival over time.

The interaction effect (D × N) was also significant at 50 DAS. The combination D_3N_4 (1st July + 50% Inorganic + 50% Organic) recorded the highest germination percentages (91.00%, 89.00%, and 90.00% pooled mean), followed closely by D_2N_4 (15th June + 50% Inorganic + 50% Organic) with 90.00%, 88.00%, and 89.00%. The lowest germination (82.00%, 65.00%, and 73.50%) was observed in D_1N_1 (1st June + Control), confirming that the absence of fertilization combined with early sowing under less favorable environmental conditions reduced seedling establishment and survival.

The observed variation in germination percentage due to sowing dates can primarily be attributed to differences in environmental factors such as temperature, rainfall distribution, and soil moisture availability during the germination phase.

Sowing on 1st July (D_3) provided optimal microclimatic conditions that supported rapid and uniform germination, whereas early sowing (1st June) likely experienced moisture fluctuations and uneven rainfall, resulting in poor emergence. Similar findings were reported by Sharma (2022) and Reddy *et al*. (2022), who observed that delayed sowing towards early July improved germination and early seedling vigor in finger millet under favorable climatic conditions.

Nutrient management exerted a significant influence on germination and seedling establishment. The integrated nutrient management treatment (N_4) showed superior performance, likely due to a balanced nutrient supply and enhanced soil health. The combination of organic and inorganic nutrient sources ensures both immediate and sustained nutrient availability, fostering better physiological activity in the seeds.

These results are in agreement with Devi (2021) and Kumar *et al*. (2022), who emphasized that integrated nutrient management enhances soil microbial activity, nutrient uptake, and overall crop vigor during the early growth stages.

Table 4.3(a): Germination % of finger millet under different sowing dates and nutrient management system at 25 and 50 DAS

Treatments	Germination %					
	25 DAS			50 DAS		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1:1st June	91.58	76.50	84.05	88.75	74.50	81.63
D_2: 15th June	89.50	81.50	85.50	87.50	79.75	83.63
D_3: 1st July	91.00	87.00	89.00	88.75	83.17	85.95
SEm±	0.84	0.92	0.63	0.92	0.81	0.66
CD (P=0.05)	NS	2.69	1.84	NS	2.38	1.92
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	88.00	73.00	80.50	86.33	71.00	78.67
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	89.33	82.33	85.83	88.00	79.56	83.78
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	90.33	83.33	86.83	87.67	81.00	84.33
N_4: 50% Inorganic + 50% Organic through FYM	95.11	88.00	91.56	91.33	85.00	88.17
SEm±	0.96	1.06	0.72	1.07	0.94	0.76
CD (P=0.05)	2.82	3.10	2.11	3.12	2.75	2.21

Table 4.3(b): Interaction effect on germination % of finger millet under different sowing dates and nutrient management system at 25 and 50 DAS

Interaction (D×N)	Germination %					
	25 DAS			50 DAS		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	84.00	68.00	76.00	82.00	65.00	73.50
T_2: D_1N_2	91.00	78.00	84.50	88.00	76.00	82.00
T_3: D_1N_3	94.00	80.00	87.00	92.00	79.00	85.50
T_4: D_1N_4	97.33	80.00	88.67	93.00	78.00	85.50
T_5: D_2N_1	90.00	69.00	79.50	88.00	69.00	78.50
T_6: D_2N_2	88.00	84.00	86.00	87.00	81.00	84.00
T_7: D_2N_3	87.00	83.00	85.00	85.00	81.00	83.00
T_8: D_2N_4	93.00	90.00	91.50	90.00	88.00	89.00
T_9: D_3N_1	90.00	82.00	86.00	89.00	79.00	84.00
T_{10}: D_3N_2	89.00	85.00	87.00	89.00	81.67	85.33
T_{11}: D_3N_3	90.00	87.00	88.50	86.00	83.00	84.50
T_{12}: D_3N_4	95.00	94.00	94.50	91.00	89.00	90.00
SEm±	1.67	1.83	1.25	1.84	1.62	1.31
CD (P=0.05)	4.90	5.37	3.66	5.41	4.75	3.84

4.1.1.4 Number of effective tillers per plant and per square meter

The data related to number of effective tillers were recorded at flowering stage of of finger millet as influenced by different sowing dates and nutrient management system are depicted in Table 4.4(a) and 4.4(b)..

The data revealed that the number of effective tillers per plant and per square meter was significantly influenced by different sowing dates and nutrient management during both 2023 and 2024, as well as in the pooled analysis.

Effect of Sowing Dates

In 2023, the maximum number of effective tillers per plant (2.63) and per square meter (69.500) was obtained from the 1st July sowing (D_3), followed by 15th June (D_2) which recorded 2.43 tillers per plant and 68.91 tillers m^{-2}. The minimum tiller number was observed in 1st June sowing (D_1), which produced 2.26 tillers per plant and 66.41 tillers m^{-2}.

A similar pattern was observed during 2024, where D_3 (1st July) again produced the highest number of effective tillers (2.80 per plant and 67.16 tillers m^{-2}), while the lowest values (2.27 per plant and 65.16 tillers m^{-2}) were recorded under D_1 (1st June).

The pooled data also confirmed the consistent superiority of 1st July sowing (D_3), which resulted in 2.71 effective tillers per plant and 68.33 tillers m^{-2}, followed by 15th June (D_2) with 2.42 tillers per plant and 67.29 tillers m^{-2}. The lowest pooled mean was again associated with D_1 (1st June), recording 2.26 tillers per plant and 66.79 tillers m^{-2}.

The observed increase in tiller number with delayed sowing up to 1st July could be attributed to more favorable soil moisture and moderate temperature conditions during the early vegetative phase, which encouraged the initiation and survival of tillers. Thus, timely sowing in early July appears to create an optimum environment for vegetative growth and tiller development in finger millet.

Effect of Nutrient Management

Nutrient management practices exerted a significant influence on the number of effective tillers per plant and per square meter across both years and in the pooled analysis.

In 2023, the maximum number of effective tillers per plant (3.04) and per square meter (75.00) was recorded under N_4 (50% inorganic + 50% organic through FYM), which was statistically superior to all other treatments. This was followed by N_3 (100% organic through FYM) with 2.33 tillers per plant and 70.66 tillers m^{-2}. The control treatment (N_1) recorded the lowest number of effective tillers (2.13 per plant and 61.22 tillers m^{-2}).

During 2024, a similar trend was observed, where N_4 (50% inorganic + 50% organic) again produced the maximum number of effective tillers (2.91 per plant and 75.00 tillers m^{-2}), while the control (N_1) showed the minimum (2.29 per plant and 54.00 tillers m^{-2}).

The pooled analysis further supported this trend, with N_4 maintaining its superiority by recording 2.978 tillers per plant and 73.50 tillers m^{-2}, followed by N_3 (2.44 tillers per plant and 70.22 tillers m^{-2}). The lowest pooled mean was obtained under N_1 (control), which registered 2.218 tillers per plant and 57.61 tillers m^{-2}.

The enhancement in tiller production under the integrated nutrient management treatment (N_4) can be attributed to the synergistic effect of organic and inorganic nutrient sources. The organic component (FYM) likely improved soil structure, moisture retention, and microbial activity, while the inorganic fertilizer supplied readily available nutrients to support early tiller initiation and subsequent development. This balanced nutrient supply would have fostered enhanced plant vigor and tillering ability in finger millet.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D × N) was non-significant for the number of effective tillers per plant during 2023, but it became significant in 2024 and in the pooled mean.

Among the interaction combinations, T_{12} (D_3N_4: 1st July + 50% inorganic + 50% organic) recorded the highest number of effective tillers both per plant (3.08) and per square meter (74.33) in the pooled data, followed closely by T_4 (D_1N_4) and T_8 (D_2N_4). The lowest number of tillers per plant (1.70) and per square meter (56.16) were recorded in T_1 (D_1N_1: 1st June + Control). These results clearly indicate that the combination of optimum sowing time (1st July) with integrated nutrient management (N_4) produced the most favorable conditions for tiller formation and development in finger millet, leading to vigorous and uniform plant growth.

The observed increase in the number of effective tillers under the 1st July sowing (D_3) can be attributed to the favorable microclimatic conditions prevailing during the vegetative phase, particularly adequate soil moisture and moderate temperatures, which are conducive to tiller initiation and survival. Conversely, early sowing (1st June) likely encountered higher temperatures and insufficient soil moisture, resulting in reduced tiller establishment. Likewise, the pronounced improvement in tiller production under integrated nutrient management (N_4) corroborates the findings of Sharma (2022), Phom *et al.* (2024) and Srikanya *et al.* (2020), who reported that the combined use of organic and inorganic fertilizers enhances soil fertility, microbial activity, and nutrient availability, thereby improving vegetative growth and tillering in finger millet.

Table 4.4(a): Number of effective tillers at flowering under different sowing dates and nutrient management system at 25 and 50 DAS

Treatments	Number of effective tillers plant^{-1}			Number of effective tillers m^{-2}		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	2.27	2.28	2.27	68.42	65.17	66.80
D_2: 15th June	2.44	2.40	2.42	68.92	65.67	67.30
D_3: 1st July	2.64	2.81	2.71	69.50	67.17	68.33
SEm±	0.07	0.07	0.06	0.67	0.45	0.41
CD (P=0.05)	0.19	0.20	0.17	NS	1.32	1.20
Nutrient management (N)						
	2023	2024	**Pooled**	2023	2024	**Pooled**
N_1: Control (No fertilizer)	2.14	2.30	2.22	61.22	54.00	57.61
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	2.28	2.21	2.24	68.89	68.22	68.56
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	2.33	2.55	2.45	70.67	69.78	70.22
N_4: 50% Inorganic + 50% Organic through FYM	3.04	2.92	2.98	75.00	72.00	73.50
SEm±	0.08	0.08	0.06	0.77	0.52	0.47
CD (P=0.05)	0.23	0.24	0.18	2.25	1.53	1.39

Table 4.4(b): Interaction effect on number of effective tillers at flowering under different sowing dates and nutrient management system at 25 and 50 DAS

Interaction (D×N)	Number of effective tillers plant^{-1}			Number of effective tillers m^{-2}		
	2023	2024	Pooled	2023	2024	Pooled
T$_1$: D_1N_1	1.63	1.78	1.71	58.33	54.00	56.17
T$_2$: D_1N_2	2.07	2.06	2.06	68.67	67.33	68.00
T$_3$: D_1N_3	2.30	2.28	2.30	71.67	69.67	70.67
T$_4$: D_1N_4	3.06	2.97	3.02	75.00	69.67	72.33
T$_5$: D_2N_1	2.30	2.42	2.36	62.33	53.00	57.67
T$_6$: D_2N_2	2.23	1.83	2.03	69.00	66.33	67.67
T$_7$: D_2N_3	2.22	2.70	2.47	69.67	70.33	70.00
T$_8$: D_2N_4	2.99	2.68	2.83	74.67	73.00	73.83
T$_9$: D_3N_1	2.48	2.70	2.60	63.00	55.00	59.00
T$_{10}$: D_3N_2	2.53	2.73	2.63	69.00	71.00	70.00
T$_{11}$: D_3N_3	2.47	2.67	2.56	70.67	69.33	70.00
T$_{12}$: D_3N_4	3.07	3.10	3.08	75.33	73.33	74.33
SEm±	0.13	0.14	0.11	1.33	0.90	0.82
CD (P=0.05)	NS	0.41	0.33	NS	2.65	NS

4.1.1.5 Fresh weight (g)

Fresh weight data were recorded at 25, 50, 75 DAS and at harvest as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.5(a-i), 4.5(a-ii) and 4.5(b-i) and 4.5(b-ii).

Fresh Weight at 25 DAS

The data presented revealed that the fresh weight of finger millet plants at 25 DAS was significantly affected by both sowing dates and nutrient management during the two years of experimentation (2023 and 2024) as well as in the pooled mean.

Among the sowing dates, 1st July sowing (D_3) produced the highest fresh weight of 1.54 g plant^{-1} in 2023, 1.49 g plant^{-1} in 2024, and a pooled mean of 1.52 g plant^{-1}. This was followed by 15th June sowing (D_2) with respective values of 1.22 g, 1.20 g, and 1.21 g plant^{-1}. The lowest fresh weight was recorded in 1st June sowing (D_1) (1.24 g, 1.14 g, and 1.21 g plant^{-1} during 2023, 2024, and pooled mean, respectively). The results clearly indicate that delayed sowing up to 1st July favored higher fresh biomass accumulation, which could be attributed to favorable soil moisture and temperature conditions during the early vegetative stage that enhanced leaf development and overall plant growth. Regarding nutrient management, the treatment N_4 (50% Inorganic + 50% Organic through FYM) recorded the highest fresh weight at 25 DAS (1.48 g, 1.44 g, and 1.46 g plant^{-1} during 2023, 2024, and pooled mean, respectively), followed by N_3 (100% Organic through FYM) (1.34 g, 1.24 g, and 1.32 g plant^{-1}). The lowest fresh weight was observed under control (N_1) with respective values of 1.26 g, 1.24 g, and 1.25 g plant^{-1}. The superiority of N_4 can be attributed to the synergistic advantage of integrating organic and inorganic nutrient sources, resulting in balanced nutrient supply, improved soil physical properties, and enhanced water retention—factors conducive to vigorous early plant growth.

The interaction effect (D × N) on fresh weight at 25 DAS was found to be non-significant; however, numerically, the D_3N_4 combination (1st July + 50% Inorganic + 50% Organic) exhibited the highest pooled value (1.72 g plant^{-1}), followed by D_3N_3 (1.46 g plant^{-1}). The lowest value (1.00 g plant^{-1}) was obtained in D_1N_2 (1st June + RDF).

Fresh Weight at 50 DAS

At 50 DAS, significant variations were observed among sowing dates, while nutrient management and their interaction (D × N) also displayed noticeable numerical differences. Among sowing dates, D_3 (1st July) again produced the highest fresh weight, with 26.98 g plant^{-1} in 2023, 22.93 g plant^{-1} in 2024, and a pooled mean of 24.96 g plant^{-1}, followed by D_2 (15th June), which recorded a pooled mean of 22.09 g plant^{-1}. The lowest fresh weight was recorded in D_1 (1st June) (19.78 g, 19.28 g, and 19.53 g plant^{-1} during 2023, 2024, and pooled mean). The improved growth observed under 1st July sowing may be due to better rainfall distribution, moderate temperature, and enhanced nutrient uptake during the vegetative phase, resulting in greater accumulation of fresh biomass. In terms of nutrient management, the maximum fresh weight was obtained in N_4 (50% Inorganic + 50% Organic), recording 25.13 g, 21.67 g, and 23.40 g plant^{-1} in 2023, 2024, and pooled data, respectively. It was followed by N_3 (100% Organic through FYM), which produced 23.44 g, 21.46 g, and 22.45 g plant^{-1}, while the lowest value was again observed in Control (N_1) with 22.06 g, 20.19 g, and 21.12 g plant^{-1}. The improvement in plant fresh weight under integrated nutrient management can be attributed to sustained nutrient release, enhanced microbial activity, and improved soil aeration, all of which contribute to better physiological performance and vegetative development.

The interaction (D×N) also showed noticeable differences. The combination D_3N_4 (1st July + 50% Inorganic + 50% Organic) recorded the maximum fresh weight (30.13 g in 2023, 22.08 g in 2024, and 26.11 g plant^{-1} in pooled data), whereas the minimum (18.93 g) was recorded under D_1N_1 (1st June + Control). The superior performance of D_3N_4 can be ascribed to the confluence of favorable sowing conditions and balanced nutrient supply, which enhanced the photosynthetic rate, nutrient uptake, and biomass accumulation.

Fresh Weight at 75 DAS

The data presented in table 5 show that the fresh weight at 75 DAS was significantly influenced by sowing dates during 2023, while the effect was statistically non-significant in 2024. Among the sowing dates, the 1st July sowing (D_3) recorded the highest fresh weight of 109.20 g in 2023, 110.23 g in 2024, and a pooled mean of 109.71 g, followed by 1st June (D_1). The lowest value was obtained under 15th June (D_2) during both years.

At harvest, a similar pattern persisted, with 1st July sowing (D_3) producing the maximum fresh weight (126.54 g in 2023, 126.77 g in 2024, and pooled mean of 126.62 g). This was followed by 15th June (D_2), which recorded 124.37 g and 125.92 g in 2023 and 2024, respectively. The lowest values were observed in 1st June sowing (D_1) (126.26 g in 2023 and 125.87 g pooled). The superior performance under D_3 could be linked to favorable climatic conditions, particularly optimal temperature and soil moisture, which promoted efficient nutrient utilization and higher biomass production during the vegetative and reproductive stages.

Effect of Nutrient Management (N)

Fresh weight was also significantly affected by different nutrient management practices. The treatment N_4 (50% Inorganic + 50% Organic through FYM) recorded the maximum fresh weight of 105.67 g at 75 DAS and 129.98 g at harvest (pooled data), followed by RDF (N_2) and N_3 (100% Organic through FYM), which were statistically comparable. The lowest fresh weight was observed under Control (N_1) with 104.58 g at 75 DAS and 119.16 g at harvest (pooled data). The significant improvement under integrated nutrient management (N_4) can be attributed to balanced nutrient supply, enhanced soil microbial activity, and better root development, resulting in improved photosynthetic efficiency and greater biomass accumulation.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D × N) was non-significant, but numerical variations indicated clear trends. The combination D_3N_4 (T_{12}: 1st July + 50% Inorganic + 50% Organic) produced the highest fresh weight (114.57 g at 75 DAS and 130.35 g at harvest, pooled data), followed by D_3N_2 (T_{10}) and D_3N_3 (T_{11}). The lowest values were recorded under D_2N_3 (T_7) at 75 DAS (98.556 g pooled) and D_1N_1 (T_1) at harvest (116.003 g pooled). Although statistically non-significant, these numerical differences demonstrate that the integration of organic and inorganic nutrient sources under late sowing (1st July) consistently enhanced the vegetative growth and biomass accumulation of finger millet.

The results clearly demonstrate that both sowing date and nutrient management exerted a pronounced influence on the fresh weight of finger millet plants at different growth stages. The superiority of the 1st July sowing could be attributed to favorable environmental factors, including adequate soil moisture, moderate temperatures, and well-distributed rainfall, which promoted vigorous early growth and sustained biomass production. These observations are in agreement with the findings of Reddy and Vengadessan (2022) and Bharathi *et al.* (2021), who reported enhanced vegetative growth and higher biomass yield in finger millet sown during early July under rainfed conditions. Similarly, the positive response to integrated nutrient management (N_4) supports the findings of Shinggu *et al.* (2019), Srikanya *et al.* (2020) and Devi (2021), who emphasized that combining organic manures with chemical fertilizers improves soil fertility, nutrient uptake, and microbial activity, thereby promoting greater accumulation of fresh and dry matter. The enhanced plant vigor observed under N_4 can also be attributed to improved soil structure and better water-holding capacity provided by FYM.

Table 4.5(a-i): Fresh weight under different sowing dates and nutrient management system at 25 and 50 DAS

Treatments	Fresh Weight (g)					
	25 DAS			50 DAS		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	1.25	1.15	1.21	19.79	19.28	19.53
D_2: 15th June	1.23	1.20	1.21	22.87	21.32	22.09
D_3: 1st July	1.54	1.49	1.53	26.98	22.93	24.97
SEm±	0.06	0.07	0.06	0.87	0.73	0.42
CD (P=0.05)	0.17	0.18	0.17	2.55	2.14	1.22
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	1.27	1.25	1.25	22.06	20.19	21.13
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	1.25	1.20	1.22	22.22	21.38	21.80
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	1.35	1.25	1.33	23.45	21.47	22.46
N_4: 50% Inorganic + 50% Organic through FYM	1.49	1.45	1.46	25.13	21.68	23.41
SEm±	0.07	0.08	0.07	1.00	0.84	0.48
CD (P=0.05)	NS	NS	NS	NS	NS	1.40

Table 4.5(a-ii): Interaction effect on fresh weight

Interaction (D×N)	Fresh Weight (g)					
	25 DAS			50 DAS		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	1.13	1.18	1.15	19.08	18.79	18.93
T_2: D_1N_2	0.99	1.03	1.01	19.59	19.93	19.76
T_3: D_1N_3	1.24	1.10	1.27	20.63	19.67	20.15
T_4: D_1N_4	1.61	1.27	1.44	19.85	18.74	19.29
T_5: D_2N_1	1.14	1.19	1.16	19.87	18.39	19.13
T_6: D_2N_2	1.22	1.22	1.22	22.43	21.42	21.93
T_7: D_2N_3	1.26	1.23	1.25	23.79	21.24	22.52
T_8: D_2N_4	1.26	1.20	1.23	25.41	24.21	24.81
T_9: D_3N_1	1.53	1.38	1.45	27.24	23.39	25.32
T_{10}: D_3N_2	1.54	1.35	1.45	24.66	22.79	23.73
T_{11}: D_3N_3	1.54	1.40	1.47	25.92	23.48	24.70
T_{12}: D_3N_4	1.58	1.87	1.73	30.13	22.09	26.12
SEm±	0.12	0.14	0.12	1.74	1.46	0.83
CD (P=0.05)	NS	NS	NS	NS	NS	2.43

Table 4.5(b-i): Fresh weight under different sowing dates and nutrient management system at 75 DAS and at Harvest

Treatments	Fresh Weight (g)					
	75 DAS			Harvest		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	106.55	108.90	107.73	126.27	208.83	125.88
D_2: 15th June	98.86	106.15	102.51	124.38	209.22	125.13
D_3: 1st July	109.21	110.24	109.71	126.54	126.70	126.63
SEm±	1.90	2.75	1.75	1.68	1.77	1.63
CD (P=0.05)	5.56	NS	5.13	4.93	NS	4.78
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	105.54	107.64	106.58	117.89	231.54	119.17
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	107.01	109.49	108.25	127.15	126.91	127.02
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	103.48	108.68	106.07	126.84	127.84	127.34
N_4: 50% Inorganic + 50% Organic through FYM	103.45	107.89	105.67	131.03	240.05	129.98
SEm±	2.19	3.17	2.02	1.94	2.05	1.88
CD (P=0.05)	NS	NS	NS	5.70	220.27	5.52

Table 4.5(b-ii): Interaction effect on fresh weight under different sowing dates and nutrient management system at 75 DAS and at Harvest

Interaction (D×N)	Fresh Weight (g)					
	75 DAS			Harvest		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	106.08	111.17	108.63	116.31	115.69	116.00
T_2: D_1N_2	106.51	104.15	105.33	126.76	124.83	125.80
T_3: D_1N_3	108.62	114.61	111.62	129.68	130.21	129.94
T_4: D_1N_4	104.99	105.67	105.33	132.31	464.57	131.75
T_5: D_2N_1	101.35	104.95	103.15	116.02	454.65	118.66
T_6: D_2N_2	101.74	107.95	104.85	125.39	128.94	127.17
T_7: D_2N_3	94.35	102.78	98.56	126.75	127.01	126.88
T_8: D_2N_4	97.99	108.91	103.46	129.35	126.31	127.84
T_9: D_3N_1	109.18	106.80	108.00	121.35	124.28	122.81
T_{10}: D_3N_2	112.78	116.38	114.57	129.31	126.94	128.12
T_{11}: D_3N_3	107.47	108.64	108.05	124.09	126.32	125.20
T_{12}: D_3N_4	107.38	109.10	108.24	131.42	129.28	130.35
SEm±	3.80	5.50	3.50	3.37	3.55	3.26
CD (P=0.05)	NS	NS	NS	NS	NS	NS

4.1.1.6 Dry weight (g)

Dry weight data were recorded at 25, 50, 75 DAS and at harvest as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.6(a-i), 4.6(a-ii) and 4.6(b-i) and 4.6(b-ii).

Effect of Sowing Dates (D)

The data presented indicate that the dry matter accumulation of finger millet was influenced by sowing time during both years of the experiment (2023 and 2024).

At 25 DAS, the dry weight ranged from 0.23 to 0.24 g plant^{-1} across sowing dates. In 2023, the crop sown on 15th June (D_2) produced the highest dry weight *(*0.26 g plant^{-1}*),* which was closely followed by 1st July (D_3) *(*0.25 g plant^{-1}*),* whereas 1st June (D_1) recorded the lowest value *(*0.24 g plant^{-1}*).*

A similar pattern was noted in 2024, with D_2 again registering the highest dry weight *(*0.22 g plant^{-1}*),* followed by D_3 *(*0.21 g plant^{-1}*).* The pooled analysis also confirmed that D_2 (15th June) achieved the maximum dry weight *(*0.24 g plant^{-1}*).*

At 50 DAS, sowing time showed a marked effect on dry matter accumulation, being significant in 2024 but not in 2023. The 15th June sowing (D_2) recorded the greatest dry weight *(*24.93 g in 2023*,* 24.00 g in 2024*,* and a pooled mean of 24.47 g plant^{-1}*),* followed by 1st July (D_3) *(*21.99 g pooled*).* The minimum dry weight was observed in 1st June (D_1) *(*22.39 g pooled*).*

The consistent advantage of mid-June sowing suggests that this period provided a balanced combination of soil moisture, temperature, and radiation conducive to higher biomass accumulation during the vegetative stage.

At 75 DAS, the dry matter accumulation of finger millet was significantly influenced by both sowing time and nutrient management across both years and in pooled data. Among sowing dates, 1st July (D_3) exhibited the highest dry weight

(58.69 g in 2023, 55.22 g in 2024, pooled 59.67 g plant^{-1}), followed by 15th June (D_2) (58.439 g pooled). The lowest was noted under 1st June (D_1) (52.40 g pooled). The enhanced dry matter accumulation in later sowings can be ascribed to better synchronization of vegetative growth with favorable rainfall and temperature regimes.

At harvest, the dry matter accumulation was significantly affected by sowing dates, nutrient management, and their interaction. Among sowing times, 15th June (D_2) registered the maximum dry weight (70.06 g in 2023, 70.05 g in 2024, pooled 70.06 g plant^{-1}), followed closely by 1st July (D_3) (69.64 g pooled). The minimum dry weight was obtained from 1st June (D_1) (63.49 g pooled).

The higher dry matter accumulation under D_2 might be due to favorable climatic conditions during vegetative and reproductive phases, which enhanced photosynthesis and assimilate translocation.

Effect of Nutrient Management (N)

Nutrient management significantly influenced dry matter production at both growth stages.

At 25 DAS, the application of 50% inorganic + 50% organic through FYM (N_4) resulted in the highest dry weight (0.28 g in 2023, 0.22 g in 2024, pooled mean 0.25 *g* plant^{-1}), followed by RDF (N_2) (0.23 g pooled). The lowest dry weight was recorded in the control (N_1) (0.22 g pooled).

At 50 DAS, although statistical differences were not significant, treatments receiving nutrients consistently outperformed the control. The 100% organic (N_3) treatment produced the highest pooled dry weight (23.80 g plant^{-1}), followed by N_4 (23.29 g plant^{-1}). The control (N_1) showed the lowest mean (21.87 g plant^{-1}), indicating the importance of nutrient supply for biomass accumulation.

At 75 DAS, Regarding nutrient management, the N_4 treatment (50% inorganic + 50% organic through FYM) recorded the maximum dry weight (59.19 g in 2023, 54.28 g in 2024, pooled 60.37 g), followed by N_3 (100% organic) (56.48 g pooled). The lowest dry weight was obtained in N_1 (control) (53.74 g pooled). Although the D×N interaction was non-significant, numerically the treatment D_3N_4 (T_{12}) produced the highest pooled dry weight (61.94 g $plant^{-1}$).

At Harvest, among nutrient management practices, N_4 (50% inorganic + 50% organic) again performed best (69.84 g in 2023, 67.85 g in 2024, pooled 68.85 g $plant^{-1}$), followed by N_3 (100% organic) (69.74 g pooled). The lowest dry matter was recorded under the control treatment (65.20 g pooled), demonstrating the role of integrated nutrient supply in promoting plant vigor and yield potential.

Interaction Effect (D × N)

Although the interaction between sowing dates and nutrient management was statistically non-significant, clear numerical differences were observed.

At 25 DAS, the combination D_1N_4 (T_4) recorded the highest dry weight (0.31 g in 2023), followed by D_2N_2 (T_6) (0.22 g in 2024; 0.24 g pooled). The lowest value was observed under D_2N_3 (T_7) (0.19 g pooled).

At 50 DAS, the maximum pooled dry weight (25.28 g $plant^{-1}$) was obtained from D_2N_4 (T_8), followed by D_2N_2 (T_6) (25.11 g). The lowest value was recorded in D_3N_1 (T_9) (20.81 g). The consistent superiority of D_2N_4 across stages suggests that the combination of optimum sowing time (15th June) with balanced nutrient supply (50% inorganic + 50% organic) provided favorable conditions for biomass accumulation.

The interaction effect (D×N) was statistically significant at harvest. The combination D_2N_1 (T_5) and D_2N_4 (T_8) showed maximum dry weights during 2024 (71.31 g and 70.90 g, respectively), while in pooled data, D_2N_1 (T_5) achieved the highest value (71.96 g), which was comparable with D_2N_4 (T_8) (71.42 g) and D_3N_4 (T_{12}) (70.31 g).

These results indicate that moderate sowing time (15th June) coupled with balanced nutrient supply significantly enhanced total biomass production.

The observed differences in dry matter accumulation among sowing times can be linked to the variations in environmental conditions prevalent during crop growth. Crops sown on 15th June and 1st July benefited from moderate temperature, sufficient soil moisture, and well-distributed rainfall, which favored efficient photosynthesis and vegetative growth, resulting in higher dry weight.

Similar findings were reported by Reddy *et al*. (2021) and Shinggu *et al.* (2019), Srikanya *et al.* (2020), who documented enhanced biomass accumulation in finger millet with mid-June sowing under rainfed situations.

The superior performance of integrated nutrient management (N_4) reflects the combined benefits of organic and inorganic nutrient sources. Organic manure improves soil physical properties, microbial activity, and nutrient retention, while inorganic fertilizers ensure immediate nutrient supply during critical growth phases. This synergy enhances nutrient-use efficiency and root development, contributing to greater dry matter accumulation. Comparable observations were made by Patil *et al.* (2020), Rao and Nagamani (2022), Manish *et al.* (2021) and Devi (2021) in finger millet and similar cereal crops.

Table 4.6(a-i): Dry weight under different sowing dates and nutrient management system at 25 and 50 DAS

Treatments	Dry Weight (g)					
	25 DAS			50 DAS		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1^{st} June	0.24	0.22	0.23	22.81	21.99	22.40
D_2: 15^{th} June	0.26	0.22	0.25	24.94	24.00	24.47
D_3: 1^{st} July	0.26	0.21	0.24	22.74	21.24	21.99
SEm±	0.02	0.02	0.02	0.72	0.75	0.53
CD (P=0.05)	NS	NS	0.06	NS	2.20	1.56
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	0.24	0.22	0.23	21.25	22.50	21.87
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	0.26	0.22	0.23	23.43	22.28	22.85
N_3: **100%** Organic through FYM on N equivalent basis (10 t ha^{-1})	0.24	0.23	0.24	24.63	22.98	23.81
N_4: 50% Inorganic + 50% Organic through FYM	0.29	0.22	0.25	24.67	21.91	23.29
SEm±	0.03	0.02	0.02	0.83	0.87	0.62
CD (P=0.05)	NS	NS	0.06	NS	NS	NS

Table 4.5(a-ii): Interaction effect on dry weight under different sowing dates and nutrient management system at 25 and 50 DAS

Interaction (D×N)	Dry Weight (g)					
	25 DAS			50 DAS		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	0.19	0.23	0.21	20.37	23.39	21.89
T_2: D_1N_2	0.29	0.26	0.28	22.85	20.98	21.91
T_3: D_1N_3	0.21	0.22	0.21	24.73	23.57	24.16
T_4: D_1N_4	0.31	0.19	0.26	23.29	20.00	21.65
T_5: D_2N_1	0.29	0.22	0.26	21.94	23.90	22.93
T_6: D_2N_2	0.26	0.23	0.24	25.78	24.46	25.11
T_7: D_2N_3	0.21	0.18	0.20	25.76	23.38	24.58
T_8: D_2N_4	0.27	0.26	0.26	26.26	24.30	25.29
T_9: D_3N_1	0.23	0.20	0.22	21.43	20.20	20.82
T_{10}: D_3N_2	0.22	0.18	0.21	21.65	21.39	21.52
T_{11}: D_3N_3	0.29	0.27	0.28	23.39	21.99	22.69
T_{12}: D_3N_4	0.27	0.22	0.24	24.47	21.42	22.95
SEm±	0.04	0.04	0.04	1.44	1.50	1.07
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 4.6(b-i): Dry weight under different sowing dates and nutrient management system at 50 DAS and at Harvest

Treatments	Dry Weight (g)					
	75 DAS			Harvest		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1^{st} June	51.04	49.26	52.41	65.28	61.73	63.50
D_2: 15^{th} June	57.68	52.05	58.44	70.06	70.06	70.06
D_3: 1^{st} July	58.70	55.23	59.68	70.34	68.96	69.64
SEm±	1.31	1.59	1.00	1.28	1.17	1.10
CD (P=0.05)	3.84	4.65	2.92	3.74	3.44	3.23
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	54.02	49.56	53.74	66.32	64.09	65.21
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	55.28	51.76	56.73	67.65	66.61	67.12
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	54.71	53.09	56.48	70.41	69.08	69.74
N_4: 50% Inorganic + 50% Organic through FYM	59.20	54.29	60.38	69.84	67.86	68.85
SEm±	1.52	1.83	1.15	1.47	1.35	1.27
CD (P=0.05)	NS	NS	3.37	NS	NS	3.74

Table 4.6(b-ii): Interaction effect on dry weight under different sowing dates and nutrient management system at 50 DAS and at Harvest

Interaction (D×N)	Dry Weight (g)					
	75 DAS			Harvest		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	48.03	44.92	46.87	57.68	54.28	55.97
T_2: D_1N_2	51.10	45.11	52.32	65.57	61.54	63.55
T_3: D_1N_3	51.14	52.74	54.33	71.24	68.05	69.65
T_4: D_1N_4	53.90	54.24	56.10	66.61	63.01	64.82
T_5: D_2N_1	55.62	49.44	56.24	72.61	71.31	71.97
T_6: D_2N_2	57.54	54.42	57.84	66.35	68.68	67.51
T_7: D_2N_3	55.45	48.98	56.59	69.35	69.32	69.34
T_8: D_2N_4	62.10	55.33	63.11	71.94	70.91	71.43
T_9: D_3N_1	58.42	54.31	58.14	68.68	66.68	67.68
T_{10}: D_3N_2	57.21	55.75	60.05	71.02	69.61	70.32
T_{11}: D_3N_3	57.54	57.54	58.55	70.65	69.87	70.26
T_{12}: D_3N_4	61.60	53.29	61.94	70.98	69.65	70.31
SEm±	2.62	3.17	1.99	2.55	2.35	2.20
CD (P=0.05)	NS	NS	NS	NS	NS	6.46

4.1.1.7 Leaf Area Index (LAI)

Leaf area index data were recorded at 25, 50, 75 DAS and at harvest as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.7(a-i), 4.7(a-ii), 4.7(b-i) and 4.7(b-ii).

The data presented in reveal that the leaf area index (LAI) of finger millet at 25 DAS was significantly influenced by different sowing dates during both experimental years (2023 and 2024). However, the effects of nutrient management and their interaction (D×N) were statistically non-significant.

At 25 DAS, among the sowing dates, 1st June (D_1) recorded the highest LAI with values of 0.18 *in 2023,* 0.18 in 2024, and a pooled mean of 0.18. This was followed by 15th June (D_2) with a pooled LAI of 0.17, whereas the minimum LAI was observed under 1st July (D_3) (0.11 pooled mean). The decline in LAI with delayed sowing could be attributed to a shorter vegetative phase and suboptimal environmental conditions, which might have restricted leaf initiation and expansion during the early growth period.

Under nutrient management practices, the differences in LAI were non-significant at this stage, although a numerical advantage was noted in N_3 (100% organic through FYM), which recorded 0.16 in 2023, 0.17 in 2024, and a pooled value of 0.17, followed by N_4 (50% inorganic + 50% organic through FYM) (0.15 pooled). The lowest LAI was registered under N_1 (control) (0.14 pooled). The slight improvement in LAI under nutrient-applied treatments can be ascribed to better nutrient availability supporting early vegetative growth and leaf expansion.

Although the interaction effect (D×N) was statistically non-significant, numerically, the combination D_1N_3 (T_3) recorded the highest LAI (0.20 in 2024; 0.19 pooled), whereas the lowest was noted under D_3N_2 (T_{10}) (0.08 pooled).

At 50 DAS, LAI was significantly influenced by both sowing dates and nutrient management, while their interaction effect remained non-significant. Among sowing dates, 1st June (D_1) exhibited the highest LAI values (0.71 *in* 2023, 0.72 in 2024, and 0.71 pooled), followed by 1st July (D_3) (pooled 0.56). The lowest LAI was recorded in 15th June (D_2) (pooled 0.55). The higher LAI in early-sown crops can be attributed to a prolonged vegetative growth period and favourable climatic conditions that encouraged greater leaf expansion and photosynthetic efficiency.

With respect to nutrient management, the treatment N_4 (50% inorganic + 50% organic through FYM) recorded the maximum LAI (0.65 in 2023, 0.651 in 2024, pooled 0.65), followed by N_3 (100% organic through FYM) (0.60 pooled). The minimum LAI was observed under N_1 (control) (0.56 pooled). This result underscores the importance of integrated nutrient management in enhancing canopy size and photosynthetic surface area through improved soil health and sustained nutrient availability.

Although the D×N interaction was statistically non-significant, numerically higher LAI values were recorded in the combination D_1N_4 (T_4) (0.81 pooled), followed by D_1N_3 (T_3) (0.75 pooled). The lowest value was noted under D_3N_3 (T_{11}) (0.49 pooled). This suggests that early sowing combined with integrated nutrient management promotes rapid leaf development and a denser canopy structure.

At 75 DAS, the influence of both sowing dates and nutrient management on LAI was marginal and statistically non-significant, though noticeable numerical variations were observed across treatments. Among the sowing dates, the highest LAI was recorded under 1st June (D_1) with values of 1.406 in 2023, 1.31 in 2024, and a pooled mean of 1.35, followed closely by 15th June (D_2) (1.29 pooled). The lowest LAI was observed in 1st July (D_3) (1.29 pooled). The gradual decline in LAI with delayed sowing might be attributed to reduced vegetative duration and comparatively less favourable temperature and moisture conditions during canopy expansion.

Among nutrient treatments, N_4 (50% inorganic + 50% organic through FYM) produced the maximum LAI (1.47 in 2023, 1.32 in 2024, pooled 1.40), followed by N_2 (RDF: 40:30:20 kg N, P_2O_5, K_2O ha^{-1}) (1.33 pooled). The minimum

LAI was noted in N_1 (control) (1.24 pooled). The increased LAI with nutrient application could be due to improved soil fertility and nutrient availability, which facilitated leaf initiation and expansion, leading to better canopy development.

The interaction (D×N) effect was non-significant, though numerically, D_1N_4 (T_4) recorded the highest pooled LAI (1.46), followed by D_1N_2 (T_2) (1.44 pooled), whereas the lowest was observed in D_1N_1 (T_1) (1.20 pooled). These results suggest that early sowing combined with balanced and integrated nutrient management contributes to superior leaf area development and canopy establishment.

At harvest, LAI followed a similar pattern as at 75 DAS, with non-significant differences among treatments but consistent numerical variations. Among the sowing dates, the maximum LAI was observed in 1st June (D_1) (1.49 in 2023, 1.63 in 2024, and 1.56 pooled), followed by 1st July (D_3) (1.44 pooled). The minimum LAI was recorded in 15th June (D_2) (1.43 pooled). The higher LAI under early sowing may be ascribed to an extended vegetative phase, enhanced leaf expansion, and delayed senescence due to more favourable environmental conditions.

Under nutrient management practices, N_4 (50% inorganic + 50% organic through FYM) again registered the highest LAI (1.52 in 2023, 1.72 in 2024, pooled 1.62), followed by N_2 (RDF) (1.52 pooled). The lowest LAI was obtained in N_1 (control) (1.35 pooled). The observed improvement in LAI under integrated nutrient management might result from the combined benefits of organic matter in improving soil physical conditions and the continuous release of nutrients that sustain crop growth until harvest.

The interaction (D×N) remained statistically non-significant, although numerically, D_1N_4 (T_4) recorded the highest pooled LAI (1.79), followed by D_1N_2 (T_2) (1.65 pooled). The minimum LAI was noted in D_3N_1 (T_9) (1.31 pooled). This emphasizes that early sowing coupled with integrated nutrient management enhances canopy growth and sustains photosynthetic area until maturity.

The consistent superiority of early sowing (1st June) in maintaining higher LAI throughout the growth period suggests that favourable climatic conditions such as optimal temperature, radiation, and moisture availability during the early stages promoted vigorous vegetative development. Delayed sowing (1st July) reduced the effective growing period, resulting in lower LAI due to limited time for leaf expansion and canopy formation.

Nutrient management also played a crucial role in influencing LAI. Treatments receiving combined organic and inorganic nutrient sources (N_4) or recommended fertilizer doses (N_2) consistently recorded higher LAI than the control. The improved canopy growth under these treatments may be attributed to enhanced nutrient uptake, better soil aeration, and increased microbial activity. The organic component (FYM) likely contributed to improved soil structure and sustained nutrient supply throughout crop growth.

These observations align with the findings of Hebbal *et al*. (2017), Patil *et al*. (2020), Manish *et al.* (2021) and Bharathi *et al.* (2021), who also reported enhanced LAI and photosynthetic efficiency in finger millet and other cereals under integrated nutrient management systems. Although the interaction effects (D×N) were statistically non-significant, the numerical advantage of D_1N_4 highlights the positive impact of combining early sowing with balanced nutrient inputs for maximizing leaf area and canopy efficiency.

Table 4.7(a-i): LAI under different sowing dates and nutrient management system at 25 and 50 DAS

Treatments	LAI					
	25 DAS			50 DAS		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1^{st} June	0.18	0.19	0.18	0.72	0.72	0.71
D_2: 15^{th} June	0.17	0.18	0.18	0.55	0.56	0.56
D_3: 1^{st} July	0.11	0.13	0.12	0.54	0.59	0.57
SEm±	0.01	0.01	0.01	0.02	0.02	0.02
CD (P=0.05)	0.03	0.03	0.03	0.06	0.06	0.05
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	0.13	0.16	0.15	0.55	0.57	0.56
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	0.16	0.16	0.16	0.61	0.64	0.63
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	0.17	0.18	0.18	0.60	0.61	0.60
N_4: 50% Inorganic + 50% Organic through FYM	0.16	0.16	0.16	0.65	0.65	0.65
SEm±	0.01	0.01	0.01	0.02	0.02	0.02
CD (P=0.05)	NS	NS	NS	0.07	NS	0.05

Table 4.7(a-ii): Interaction effect on LAI under different sowing dates and nutrient management system at 25 and 50 DAS

Interaction (D×N)	LAI					
	25 DAS			50 DAS		
	2023	2024	Pooled	2023	2024	Pooled
T$_1$: D_1N_1	0.15	0.19	0.17	0.57	0.53	0.55
T$_2$: D_1N_2	0.19	0.17	0.18	0.75	0.76	0.76
T$_3$: D_1N_3	0.18	0.20	0.19	0.77	0.74	0.75
T$_4$: D_1N_4	0.20	0.18	0.19	0.78	0.84	0.81
T$_5$: D_2N_1	0.16	0.16	0.16	0.50	0.53	0.51
T$_6$: D_2N_2	0.19	0.20	0.20	0.53	0.56	0.55
T$_7$: D_2N_3	0.19	0.18	0.18	0.55	0.58	0.57
T$_8$: D_2N_4	0.16	0.16	0.16	0.61	0.55	0.58
T$_9$: D_3N_1	0.10	0.13	0.11	0.59	0.64	0.62
T$_{10}$: D_3N_2	0.09	0.10	0.08	0.55	0.61	0.57
T$_{11}$: D_3N_3	0.13	0.15	0.14	0.48	0.52	0.50
T$_{12}$: D_3N_4	0.11	0.12	0.12	0.57	0.56	0.56
SEm±	0.01	0.02	0.02	0.04	0.04	0.03
CD (P=0.05)	NS	NS	NS	0.12	0.11	0.09

Table 4.7(b-i): LAI under different sowing dates and nutrient management system at 50 DAS and at Harvest

<table>
<tr><th rowspan="2">Treatments</th><th colspan="6">LAI</th></tr>
<tr><th colspan="3">75 DAS</th><th colspan="3">Harvest</th></tr>
<tr><td colspan="7">Sowing dates (D)</td></tr>
<tr><td></td><td>2023</td><td>2024</td><td>Pooled</td><td>2023</td><td>2024</td><td>Pooled</td></tr>
<tr><td>D_1:1st June</td><td>1.41</td><td>1.31</td><td>1.35</td><td>1.49</td><td>1.64</td><td>1.57</td></tr>
<tr><td>D_2: 15th June</td><td>1.31</td><td>1.29</td><td>1.30</td><td>1.39</td><td>1.48</td><td>1.43</td></tr>
<tr><td>D_3: 1st July</td><td>1.31</td><td>1.29</td><td>1.30</td><td>1.38</td><td>1.52</td><td>1.45</td></tr>
<tr><td>SEm±</td><td>0.06</td><td>0.03</td><td>0.03</td><td>0.05</td><td>0.06</td><td>0.04</td></tr>
<tr><td>CD (P=0.05)</td><td>NS</td><td>NS</td><td>NS</td><td>NS</td><td>NS</td><td>NS</td></tr>
<tr><td colspan="7">Nutrient management (N)</td></tr>
<tr><td></td><td>2023</td><td>2024</td><td>Pooled</td><td>2023</td><td>2024</td><td>Pooled</td></tr>
<tr><td>N_1: Control (No fertilizer)</td><td>1.21</td><td>1.28</td><td>1.24</td><td>1.31</td><td>1.40</td><td>1.36</td></tr>
<tr><td>N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}</td><td>1.38</td><td>1.29</td><td>1.34</td><td>1.48</td><td>1.57</td><td>1.53</td></tr>
<tr><td>N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})</td><td>1.30</td><td>1.29</td><td>1.29</td><td>1.36</td><td>1.50</td><td>1.43</td></tr>
<tr><td>N_4: 50% Inorganic + 50% Organic through FYM</td><td>1.48</td><td>1.32</td><td>1.40</td><td>1.53</td><td>1.72</td><td>1.62</td></tr>
<tr><td>SEm±</td><td>0.07</td><td>0.04</td><td>0.04</td><td>0.05</td><td>0.07</td><td>0.05</td></tr>
<tr><td>CD (P=0.05)</td><td>0.19</td><td>NS</td><td>NS</td><td>0.16</td><td>0.19</td><td>0.15</td></tr>
</table>

Table 4.7(b-ii): Interaction effect on LAI under different sowing dates and nutrient management system at 50 DAS and at Harvest

Interaction (D×N)	LAI					
	75 DAS			Harvest		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	1.14	1.26	1.21	1.33	1.33	1.33
T_2: D_1N_2	1.53	1.37	1.45	1.67	1.65	1.65
T_3: D_1N_3	1.37	1.24	1.31	1.39	1.57	1.48
T_4: D_1N_4	1.57	1.37	1.47	1.61	1.98	1.80
T_5: D_2N_1	1.29	1.27	1.28	1.38	1.46	1.41
T_6: D_2N_2	1.34	1.26	1.30	1.42	1.55	1.49
T_7: D_2N_3	1.27	1.29	1.28	1.32	1.40	1.37
T_8: D_2N_4	1.38	1.31	1.35	1.42	1.53	1.48
T_9: D_3N_1	1.19	1.32	1.26	1.23	1.41	1.32
T_{10}: D_3N_2	1.26	1.24	1.26	1.34	1.50	1.42
T_{11}: D_3N_3	1.26	1.33	1.29	1.38	1.53	1.45
T_{12}: D_3N_4	1.49	1.29	1.38	1.55	1.66	1.60
SEm±	0.11	0.06	0.07	0.09	0.11	0.08
CD (P=0.05)	NS	NS	NS	NS	NS	NS

4.1.1.8 CGR (g m^{-2} day^{-1})

Crop growth rate data were recorded at 25-50 and 50-75 DAS and at harvest as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.8(a) and 4.8(b).

Effect of Sowing Dates (D)

The results presented clearly demonstrate that sowing dates had a marked influence on the crop growth rate (CGR) of finger millet at both the 25–50 DAS and 50–75 DAS growth intervals during 2023 and 2024, as well as in the pooled analysis.

CGR during 25–50 DAS, in 2023, the crop sown on 15th June (D_2) recorded the highest CGR (3.28 g m^{-2} day^{-1}), closely followed by 1st June sowing (D_1) with 3.01 g m^{-2} day^{-1}. The lowest CGR (3.01 g m^{-2} day^{-1}) was observed in the late sowing on 1st July (D_3). A similar pattern was evident in 2024, where D_2 again registered the maximum CGR (3.10 g m^{-2} day^{-1}), while D_3 produced the lowest (2.75 g m^{-2} day^{-1}). The pooled mean data further confirmed the superiority of D_2 (3.19 g m^{-2} day^{-1}), followed by D_1 (2.98 g m^{-2} day^{-1}) and D_3 (2.88 g m^{-2} day^{-1}).

CGR during 50–75 DAS, during the later growth phase, CGR increased notably across all sowing dates. In 2023, the crop sown on 1st July (D_3) attained the highest CGR (4.73 g m^{-2} day^{-1}), followed by D_2 (4.27 g m^{-2} day^{-1}), while the minimum (4.03 g m^{-2} day^{-1}) was noted in D_1 (1st June). This trend was consistent in 2024, with D_3 again showing the highest CGR (4.52 g m^{-2} day^{-1}).

Pooled results also revealed that D_3 maintained superiority with 4.10 g m^{-2} day^{-1}, followed by D_2 (3.69 g m^{-2} day^{-1}) and D_1 (3.55 g m^{-2} day^{-1}). These observations suggest that mid-sown crops (15th June) exhibited more vigorous growth during the early vegetative stage (25–50 DAS), whereas late-sown crops (1st July) performed better during the later stages (50–75 DAS), possibly due to favorable temperature and soil moisture conditions prevailing at those times.

Effect of Nutrient Management (N)

Nutrient management strategies significantly affected CGR at both stages of crop growth.

CGR during 25–50 DAS, In 2023, the treatment receiving 100% organic nutrient supply through FYM (N_3) registered the highest CGR (3.24 g m^{-2} day^{-1}), followed closely by N_4 (50% inorganic + 50% organic) with 3.20 g m^{-2} day^{-1}, and N_2 (RDF) with 3.12 g m^{-2} day^{-1}. The control (N_1) recorded the lowest CGR (2.84 g m^{-2} day^{-1}). The same trend persisted in 2024, where N_3 again showed superiority (3.02 g m^{-2} day^{-1}) followed by N_2 and N_4, while N_1 remained the lowest (2.90 g m^{-2} day^{-1}). The pooled mean further confirmed that N_3 (3.13 g m^{-2} day^{-1}) performed best, followed by N_4 (3.051 g m^{-2} day^{-1}) and N_2 (3.03 g m^{-2} day^{-1}), with N_1 (2.87 g m^{-2} day^{-1}) being the least productive.

CGR during 50–75 DAS, At this stage, CGR values increased across all treatments. In 2023, the integrated nutrient treatment (N_4) recorded the maximum CGR (4.54 g m^{-2} day^{-1}), followed by N_3 (4.32 g m^{-2} day^{-1}), whereas the control (N_1) had the lowest (4.238 g m^{-2} day^{-1}). In 2024, N_4 once again produced the highest CGR (4.317 g m^{-2} day^{-1}), followed by N_3 (4.01 g m^{-2} day^{-1}). Pooled data showed that N_4 maintained its superiority with 3.95 g m^{-2} day^{-1}, followed by N_3 (3.88 g m^{-2} day^{-1}), and N_1 recorded the lowest (3.73 g m^{-2} day^{-1}). The enhanced growth rate observed in N_3 and N_4 treatments can be attributed to the synergistic effect of balanced nutrient availability from both organic and inorganic sources, which improved soil structure, nutrient uptake, and photosynthetic efficiency, leading to higher dry matter accumulation.

Interaction Effect (D × N)

The interaction effect between sowing dates and nutrient management (D × N) on CGR was statistically non-significant across both growth stages and study years, as well as in the pooled mean. However, numerical differences were evident.

During 25–50 DAS, the combination of D_2N_4 (T_8) produced the highest CGR (3.34 g m^{-2} day^{-1}), followed by D_2N_2 (T_6) and D_2N_3 (T_7), while the lowest value (2.69 g m^{-2} day^{-1}) was recorded under D_3N_1 (T_9). In the 50–75 DAS phase, the treatment combination D_3N_4 (T_{11}) exhibited the highest pooled CGR (4.43 g m^{-2} day^{-1}), followed by D_3N_1 (T_9) and D_2N_4 (T_8). The minimum CGR (2.93 g m^{-2} day^{-1}) was observed under D_1N_2 (T_2). These findings indicate that optimum sowing time (15th June or 1st July), when coupled with integrated nutrient management (N_4), favors enhanced crop growth through efficient nutrient utilization and favorable climatic synchronization.

The progressive increase in CGR during 50–75 DAS compared to 25–50 DAS reflects the rapid vegetative and early reproductive development of finger millet, marked by enhanced dry matter accumulation and higher photosynthetic activity. The mid-sown crop (15th June) performed best during the initial phase due to favorable climatic conditions that facilitated quick canopy formation and nutrient absorption. Conversely, the late-sown crop (1st July) showed superior performance in the later phase, likely due to better soil moisture conservation and extended vegetative growth. Integrated nutrient management (N_4) played a crucial role in sustaining higher CGR by ensuring a continuous nutrient supply from both organic and inorganic sources. The organic component improved soil health, microbial activity, and nutrient retention, while inorganic fertilizers provided immediate nutrient availability, resulting in improved plant vigor and growth rate.

These results are consistent with earlier findings of Shinggu *et al.* (2019), Srikanya *et al.* (2020) and Ramesh *et al.* (2022), who reported that the combined use of organic and inorganic nutrient sources enhances CGR and biomass accumulation in finger millet through improved soil fertility and balanced nutrient dynamics.

Table 4.8(a): CGR under different sowing dates and nutrient management system at 25-50 and 50-75 DAS

Treatments	CGR (g m^{-2} day^{-1})					
	25-50 DAS			50-75 DAS		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	3.02	2.97	2.98	4.04	3.64	3.56
D_2: 15th June	3.29	3.11	3.19	4.27	3.74	3.69
D_3: 1st July	3.02	2.76	2.89	4.74	4.52	4.11
SEm±	0.10	0.13	0.08	0.24	0.21	0.12
CD (P=0.05)	NS	NS	0.24	NS	0.63	0.36
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	2.84	2.90	2.88	4.24	3.61	3.74
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	3.13	2.93	3.03	4.29	3.93	3.57
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	3.25	3.03	3.13	4.32	4.01	3.89
N_4: 50% Inorganic + 50% Organic through FYM	3.21	2.90	3.05	4.54	4.32	3.96
SEm±	0.11	0.15	0.10	0.27	0.25	0.14
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 4.8(b): Interaction effect on CGR under different sowing dates and nutrient management system at 25-50 and 50-75 DAS

Interaction (D×N)	CGR (g m^{-2} day^{-1})					
	25-50 DAS			50-75 DAS		
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
T_1: D_1N_1	2.72	3.37	3.05	3.68	2.87	3.52
T_2: D_1N_2	3.00	2.76	2.88	3.87	3.22	2.93
T_3: D_1N_3	3.26	3.11	3.19	4.49	3.89	3.85
T_4: D_1N_4	3.06	2.64	2.85	4.08	4.57	3.92
T_5: D_2N_1	2.88	2.88	2.88	4.48	3.40	3.50
T_6: D_2N_2	3.39	3.22	3.31	4.25	4.00	3.89
T_7: D_2N_3	3.40	3.09	3.25	3.92	3.41	3.39
T_8: D_2N_4	3.47	3.22	3.35	4.45	4.14	4.01
T_9: D_3N_1	2.92	2.46	2.69	4.55	4.55	4.18
T_{10}: D_3N_2	2.98	2.82	2.90	4.74	4.58	3.88
T_{11}: D_3N_3	3.08	2.89	2.99	4.55	4.74	4.43
T_{12}: D_3N_4	3.09	2.84	2.97	5.10	4.25	3.93
SEm±	0.19	0.26	0.17	0.48	0.43	0.25
CD (P=0.05)	NS	NS	NS	NS	NS	NS

4.1.1.9 RGR (g g^{-1} day)

Regulative growth rate data were recorded at 25-50 and 50-75 DAS as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.9(a) and 4.9(b).

RGR during 25–50 DAS: The results presented indicate that the Relative Growth Rate (RGR) of finger millet between 25 and 50 DAS was not significantly affected by sowing dates, nutrient management, or their interaction in either experimental year or in the pooled mean analysis.

Effect of Sowing Dates (D)

During the 2023 season, RGR values remained almost uniform across the sowing dates, averaging around 0.05 g g^{-1} day^{-1}. In 2024, slight numerical differences were noted, ranging from 0.05 to 0.05 g g^{-1} day^{-1}, with the maximum value observed under the 15th June sowing (D_2). The pooled mean, however, indicated a marginally higher RGR in D_1 (1st June) at 0.09 g g^{-1} day^{-1}, followed by D_3 (1st July) and D_2 (15th June). Though statistically non-significant, these minor differences suggest that early sowing might have provided favorable thermal and moisture conditions for enhanced initial vegetative growth and photosynthetic activity.

Effect of Nutrient Management (N)

In 2023, the RGR among nutrient treatments ranged from 0.05 to 0.05 g g^{-1} day^{-1}, with the highest value recorded under N_3 (100% organic through FYM). A similar pattern was observed in 2024, where RGR values varied narrowly from 0.052 to 0.05 g g^{-1} day^{-1}. Pooled analysis revealed that N_4 (50% inorganic + 50% organic through FYM) produced the highest mean RGR (0.06 g g^{-1} day^{-1}), followed by N_3 (0.05 g g^{-1} day^{-1}), while the lowest value was associated with N_2 (RDF: 40:30:20 kg ha^{-1} of N, P_2O_5, K_2O). The superior RGR under integrated and organic nutrient regimes may be attributed to better nutrient synchronization, improved soil aeration, and enhanced root proliferation during the early vegetative phase.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management did not exhibit any significant influence on RGR at 25–50 DAS during either year or in the pooled data. Nevertheless, numerical variation indicated that D_1N_3 (T_3) and D_3N_4 (T_{12}) recorded the highest pooled RGR (both 0.06 g g^{-1} day^{-1}), whereas D_1N_2 (T_2) resulted in the lowest value (0.05 g g^{-1} day^{-1}). These observations imply that the combination of early sowing and organic or integrated nutrient supply slightly enhanced physiological efficiency and biomass accumulation during the early growth period.

Effect of Sowing Dates (D)

At the later growth phase (50–75 DAS), sowing dates had no significant effect on RGR during both years. In 2023, values ranged narrowly from 0.059 to 0.061 g g^{-1} day^{-1}, and in 2024 from 0.05 to 0.06 g g^{-1} day^{-1}. The pooled mean revealed the highest RGR (0.06 g g^{-1} day^{-1}) under D_3 (1st July), followed by D_1 (0.05 g g^{-1} day^{-1}). The slightly enhanced RGR in late sowing might be linked to favorable microclimatic conditions such as optimum temperature and humidity during the late vegetative period, which encouraged faster physiological and metabolic activity.

Effect of Nutrient Management (N)

Across nutrient treatments, RGR values during 50–75 DAS varied from 0.05 to 0.05 g g^{-1} day^{-1} in 2023 and 0.05 to 0.06 g g^{-1} day^{-1} in 2024. Pooled data revealed that N_4 (50% inorganic + 50% organic) achieved the highest RGR (0.06 g g^{-1} day^{-1}), followed by N_3 (0.05 g g^{-1} day^{-1}), while the lowest was observed in N_2 (RDF) at 0.05 g g^{-1} day^{-1}. The higher growth rate under N_4 and N_3 could be ascribed to the balanced and sustained nutrient release, improved soil moisture retention, and enhanced microbial activity that collectively supported steady biomass accumulation during mid-growth stages.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management was also found to be statistically non-significant for this stage. Nonetheless, numerical values demonstrated that the combination D_3N_3 (T_{11}) recorded the highest pooled RGR (0.06 g g^{-1} day^{-1}), followed by D_3N_4 (T_{12}) and D_1N_4 (T_4) (each 0.06 g g^{-1} day^{-1}). The lowest value (0.053 g g^{-1} day^{-1}) was again observed in D_1N_2 (T_2). This pattern suggests that delayed sowing, coupled with integrated nutrient management, fostered marginally better growth efficiency owing to synchronized nutrient availability and conducive environmental conditions during the later vegetative and early reproductive phases.

The Relative Growth Rate serves as a critical indicator of the plant's efficiency in producing new biomass relative to its existing dry matter, thereby reflecting overall vigor and metabolic potential. In the present study, the non-significant treatment differences imply that inherent genetic factors and environmental influences primarily governed finger millet growth, while the effects of management practices were relatively moderate. However, the consistent numerical advantage of integrated (N_4) and organic (N_3) nutrient sources highlights the importance of combined nutrient strategies in sustaining higher RGR values. The synergistic effect of organic matter and inorganic fertilizers likely improved soil health, microbial activity, and nutrient synchronization, resulting in better photosynthetic performance and biomass accumulation. These results are in agreement with the findings of Rao *et al.* (2022) and Narayan *et al.* (2018), who reported superior growth and nutrient uptake under integrated nutrient management systems. Similarly, sowing date variations exerted minimal but adaptive influence on RGR, confirming the crop's flexibility to perform across a range of sowing windows. Both early (1st June) and slightly delayed (1st July) sowings maintained comparable growth efficiency, corroborating the observations of Bharathi *et al.* (2021) and Shoman *et al.* (2018), who noted that finger millet can adjust its physiological processes under varying agro-climatic conditions without substantial compromise in growth rate.

Table 4.9(a): RGR under different sowing dates and nutrient management system at 25-50 and 50-75 DAS

Treatments	RGR (g g^{-1} day)					
	25-50 DAS			50-75 DAS		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1:1st June	0.06	0.05	0.10	0.06	0.06	0.05
D_2: 15th June	0.06	0.06	0.05	0.07	0.06	0.05
D_3: 1st July	0.06	0.05	0.05	0.06	0.06	0.07
SEm±	0.00	0.00	0.00	0.00	0.00	0.00
CD (P=0.05)	0.00	NS	NS	0.00	0.01	0.01
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	0.05	0.05	0.05	0.06	0.06	0.06
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	0.06	0.05	0.05	0.06	0.05	0.05
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	0.06	0.05	0.06	0.06	0.06	0.06
N_4: 50% Inorganic + 50% Organic through FYM	0.06	0.05	0.10	0.06	0.06	0.07
SEm±	0.11	0.00	0.00	0.00	0.00	0.00
CD (P=0.05)	0.00	NS	NS	NS	NS	NS

Table 4.9(b): Interaction effect on RGR under different sowing dates and nutrient management system at 25-50 and 50-75 DAS

Interaction (D×N)	RGR (g g^{-1} day)					
	25-50 DAS			50-75 DAS		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	0.05	0.05	0.05	0.06	0.06	0.06
T_2: D_1N_2	0.06	0.05	0.05	0.06	0.06	0.05
T_3: D_1N_3	0.06	0.06	0.05	0.06	0.05	0.05
T_4: D_1N_4	0.05	0.05	0.21	0.05	0.06	0.06
T_5: D_2N_1	0.05	0.05	0.05	0.06	0.06	0.06
T_6: D_2N_2	0.06	0.06	0.06	0.06	0.06	0.06
T_7: D_2N_3	0.06	0.06	0.05	0.06	0.06	0.05
T_8: D_2N_4	0.06	0.06	0.06	0.06	0.06	0.06
T_9: D_3N_1	0.05	0.05	0.06	0.07	0.06	0.06
T_{10}: D_3N_2	0.05	0.05	0.05	0.07	0.06	0.06
T_{11}: D_3N_3	0.05	0.05	0.06	0.06	0.06	0.07
T_{12}: D_3N_4	0.05	0.05	0.05	0.07	0.06	0.06
SEm±	0.00	0.00	0.00	0.00	0.00	0.00
CD (P=0.05)	0.01	NS	NS	NS	NS	NS

4.1.1.10 NAR (g m^{-2} day^{-1})

Net Assimilation Rate data were recorded at 25-50 and 50-75 DAS as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.10(a) and 4.10(b).

NAR during 25–50 DAS**:** The data presented indicate that the Net Assimilation Rate (NAR) of finger millet between 25 and 50 DAS was not significantly affected by sowing dates, nutrient management, or their interaction during both years (2023 and 2024) as well as in the pooled analysis.

Effect of Sowing Dates (D)

During the 2023 season, the NAR values remained uniform across all sowing dates, with each treatment recording 0.006 g m^{-2} day^{-1}. A similar pattern was evident in 2024, where NAR values varied slightly from 0.006 to 0.007 g m^{-2} day^{-1}. The pooled mean data revealed a marginally higher NAR for D_3 (1st July) at 0.007 g m^{-2} day^{-1}, compared with D_1 (1st June) and D_2 (15th June), which both recorded 0.006 g m^{-2} day^{-1}. Although these differences were statistically non-significant, the slightly higher NAR under late sowing (D_3) could be attributed to better canopy retention and higher relative humidity during the vegetative period, which reduced transpirational loss and sustained leaf photosynthetic efficiency.

Effect of Nutrient Management (N)

Nutrient management practices also did not exert a significant influence on NAR during this stage. Across both years, mean NAR values ranged between 0.006 and 0.007 g m^{-2} day^{-1}. Pooled data revealed that N_2 (RDF: 40:30:20 kg ha^{-1} of N, P_2O_5, K_2O) and N_4 (50% inorganic + 50% organic through FYM) each recorded the highest NAR of 0.007 g m^{-2} day^{-1}, whereas the lowest was observed in N_1 (control) at 0.006 g m^{-2} day^{-1}. The marginal improvement under N_2 and N_4 treatments might be associated with balanced nutrient supply promoting greater photosynthetic assimilation per unit leaf area and more efficient translocation of assimilates to the growing tissues.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D × N) remained statistically non-significant for NAR during this stage. Nevertheless, numerically higher pooled NAR values were observed in T_6 (D_2N_2) and T_{12} (D_3N_4) (each 0.007 g m^{-2} day^{-1}). These treatment combinations, which integrated timely sowing with balanced or integrated nutrient management, likely promoted optimal photosynthetic performance and early vegetative dry matter accumulation.

NAR during 50–75 DAS

Effect of Sowing Dates (D)

At the 50–75 DAS interval, the NAR values also exhibited no statistically significant variation among sowing dates. During 2023, NAR ranged from 0.007 to 0.009 g m^{-2} day^{-1}, while in 2024, it varied between 0.006 and 0.008 g m^{-2} day^{-1}. The pooled analysis showed the highest NAR (0.009 g m^{-2} day^{-1}) for D_1 (1st June), followed by D_2 (15th June) and D_3 (1st July). The relatively higher NAR in the early-sown crop (D_1) can be attributed to extended exposure to favorable solar radiation and optimal temperature, which enhanced photosynthetic efficiency and assimilation rate per unit leaf area during the active vegetative phase.

Effect of Nutrient Management (N)

Among nutrient management treatments, NAR values during 50–75 DAS ranged narrowly from 0.007 to 0.009 g m^{-2} day^{-1} across both years. The pooled data revealed that N_4 (50% inorganic + 50% organic through FYM) recorded the highest NAR (0.009 g m^{-2} day^{-1}), followed by N_2 (RDF) at 0.007 g m^{-2} day^{-1}, while N_1 (control) registered the lowest (0.007 g m^{-2} day^{-1}). The superior performance of N_4 can be ascribed to the synergistic effects of organic and inorganic nutrient sources that maintained nutrient availability, improved root health, and enhanced chlorophyll stability, thereby supporting higher assimilation efficiency during this stage.

Interaction Effect (D × N)

The D × N interaction was non-significant for NAR during 50–75 DAS. However, numerically, the highest pooled NAR (0.009 g m^{-2} day^{-1}) was noted in T_6 (D_2N_2) and T_{12} (D_3N_4), suggesting that a combination of either mid or late sowing with integrated or balanced nutrient management fostered superior carbon assimilation. These combinations likely improved photosynthetic efficiency and delayed senescence, contributing to sustained dry matter production during the mid-growth phase.

The Net Assimilation Rate (NAR) serves as an important physiological indicator, reflecting the plant's capacity to convert photosynthetically assimilated carbon into biomass per unit leaf area over time. The absence of significant treatment effects across both years indicates that inherent physiological mechanisms and environmental stability maintained consistent assimilation rates in finger millet, regardless of sowing time or nutrient treatment. Despite this, numerical trends consistently demonstrated that integrated (N_4) and balanced (N_2) nutrient management treatments performed marginally better than the control, emphasizing the importance of maintaining balanced nutrient availability. Such treatments likely enhanced chlorophyll concentration, nutrient uptake efficiency, and photosynthetic capacity, leading to marginally higher assimilation efficiency. These observations are consistent with the findings of Shoman *et al.* (2018), Manojgowda *et al.* (2021) and Patil *et al.* (2020), who also reported improved NAR under integrated nutrient management due to sustained nutrient release and improved leaf functional duration. Moreover, slightly higher NAR values under early sowing (1st June) suggest that the crop benefited from optimal climatic conditions particularly moderate temperatures and adequate solar radiation which favoured efficient carbon fixation and assimilation during the vegetative phase. Similar observations were recorded by Verma *et al.* (2019) and Bharathi *et al.* (2021), who highlighted that combining organic sources with recommended fertilizer doses enhances carbon assimilation, nutrient use efficiency, and biomass partitioning in finger millet.

Table 4.10(a): NAR under different sowing dates and nutrient management system at 25-50 and 50-75 DAS

Treatments	NAR (g m^{-2} day^{-1})					
	25-50 DAS			50-75 DAS		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1^{st} June	0.006	0.007	0.006	0.009	0.009	0.009
D_2: 15^{th} June	0.006	0.006	0.006	0.008	0.009	0.008
D_3: 1^{st} July	0.006	0.007	0.007	0.007	0.006	0.007
SEm±	0.000	0.000	0.000	0.000	0.000	0.000
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	0.006	0.006	0.006	0.008	0.007	0.007
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	0.006	0.006	0.007	0.007	0.008	0.007
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	0.006	0.007	0.006	0.008	0.009	0.008
N_4: 50% Inorganic + 50% Organic through FYM	0.007	0.007	0.006	0.000	0.008	0.009
SEm±	0.000	0.000	0.000	0.000	0.000	0.000
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 4.10(b): Interaction effect on NAR

Interaction (D×N)	NAR (g m^{-2} day^{-1})					
	25-50 DAS			50-75 DAS		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	0.007	0.006	0.007	0.009	0.007	0.008
T_2: D_1N_2	0.006	0.006	0.006	0.007	0.009	0.008
T_3: D_1N_3	0.006	0.007	0.006	0.001	0.000	0.000
T_4: D_1N_4	0.007	0.007	0.007	0.001	0.008	0.000
T_5: D_2N_1	0.006	0.005	0.006	0.006	0.008	0.007
T_6: D_2N_2	0.007	0.006	0.007	0.008	0.008	0.008
T_7: D_2N_3	0.006	0.007	0.007	0.007	0.002	0.009
T_8: D_2N_4	0.007	0.006	0.006	0.009	0.008	0.008
T_9: D_3N_1	0.006	0.007	0.007	0.009	0.006	0.007
T_{10}: D_3N_2	0.007	0.006	0.007	0.005	0.006	0.006
T_{11}: D_3N_3	0.006	0.007	0.006	0.005	0.005	0.005
T_{12}: D_3N_4	0.007	0.007	0.007	0.009	0.008	0.009
SEm±	0.000	0.000	0.000	0.000	0.000	0.000
CD (P=0.05)	NS	NS	NS	NS	NS	0.005

4.1.1.11 Days to 50% flowering

Days to 50% flowering data were recorded at 25-50 and 50-75 DAS as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.11(a) and 4.11(b).

The data presented illustrate the influence of different sowing dates and nutrient management practices on the days required to attain 50% flowering in finger millet during the years, along with their pooled mean.

Effect of Sowing Dates (D)

The variation in sowing dates exerted a significant influence on the number of days taken to reach 50% flowering during both experimental years as well as in the pooled analysis. In 2023, the crop sown on 15th June (D_2) exhibited the longest duration to 50% flowering (81.92 days), followed by 1st June (D_1) with 80.83 days, whereas the earliest flowering (79.25 days) was observed under 1st July (D_3) sowing.

A comparable pattern was recorded in 2024, where D_2 (15th June) again required the maximum number of days (78.17 days) to attain 50% flowering, while D_3 (1st July) recorded the minimum (77.92 days). The pooled mean also followed the same trend, indicating that D_2 (15th June) took the longest period (80.05 days) to reach flowering, in contrast to D_3 (1st July), which recorded the shortest duration (78.58 days). The results suggested that both early (1st June) and late (1st July) sowing tended to accelerate flowering, whereas mid-June sowing slightly delayed it.

This delay may be attributed to the favourable vegetative environment including optimal temperature and day length prevailing during the mid-June period, which encouraged vigorous vegetative growth before the onset of flowering.

Effect of Nutrient Management (N)

Nutrient management practices had a significant impact on the days to 50% flowering during both years and in the pooled mean. During 2023, the RDF treatment (N_2: 40:30:20 kg $N:P_2O_5:K_2O$ ha^{-1}) recorded the highest duration to flowering (82.78

days), closely followed by the control (N_1) with 82.22 days, while the shortest duration (77.67 days) was recorded under 100% organic nutrient application (N_3). Similarly, in 2024, N_2 (RDF) again took the maximum number of days (80.17), followed by N_4 (50% inorganic + 50% organic) with 80.33 days, whereas the minimum (75.89 days) was observed in N_3 (100% organic).

The pooled mean confirmed that RDF (N_2) delayed flowering (81.22 days), while N_3 (100% organic) promoted earlier flowering (76.78 days). The delay under RDF could be linked to rapid vegetative growth resulting from an immediate nutrient supply, whereas the earlier flowering under organic treatment may be due to gradual nutrient release and more balanced physiological growth patterns that led to earlier reproductive transition.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D × N) was statistically significant during both years and in the pooled analysis. In 2023, the longest period to 50% flowering (87.33 days) was recorded in T_5 (D_2N_1: 15th June × Control), followed by T_6 (D_2N_2: 15th June × RDF) with 84.33 days, whereas the shortest duration (74.67 days) was observed in T_3 (D_1N_3: 1st June × 100% Organic).

A similar trend continued in 2024, with T_4 (D_1N_4: 1st June × 50% inorganic + 50% organic) taking the maximum time to flower (84.33 days) and T_{11} (D_3N_3: 1st July × 100% organic) showing the minimum (74.33 days). In the pooled mean, T_4 (D_1N_4) recorded the maximum duration (84.83 days) to reach 50% flowering, while T_{11} (D_3N_3) exhibited the earliest flowering (76.17 days).

These results indicate that early sowing combined with integrated nutrient management (D_1N_4) tends to extend the vegetative phase, while late sowing coupled with full organic management (D_3N_3) promotes earlier transition to flowering, possibly due to environmental stress and reduced nutrient availability at later growth stages.

The significant variation in flowering time due to sowing dates and nutrient management underscores the influence of environmental and nutritional factors on the phenological behaviour of finger millet. Delayed flowering observed under 15th June sowing and nutrient-rich treatments (RDF and integrated management) can be attributed to enhanced vegetative vigour resulting from adequate nutrient supply and favourable climatic conditions, which prolonged the vegetative phase before flowering initiation.

Conversely, late sowing (1st July) accelerated flowering, likely due to reduced temperature, shorter day length, and mild moisture stress, which hastened reproductive development. These observations are in line with the findings of Kumar *et al.* (2021) and Aliveni *et al.* (2021), who reported that delayed sowing tends to shorten the period to 50% flowering, whereas balanced and integrated nutrient management prolongs the vegetative phase by sustaining crop vigour and delaying the onset of reproductive growth.

Overall, the results highlight that optimum sowing time (mid-June) in combination with balanced nutrient supply ensures better vegetative development, while organic nutrient regimes under late sowing may induce early flowering due to moderated growth and nutrient dynamics.

Table 4.11(a): Days to 50% flowering under different sowing dates and nutrient management system of finger millet

Treatments	Days to 50% flowering		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1st June	80.83	78.17	79.50
D_2: 15th June	81.92	78.17	80.05
D_3: 1st July	79.25	77.92	78.58
SEm±	0.62	0.57	0.48
CD (P=0.05)	1.83	1.67	1.41
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	82.22	76.44	79.33
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	82.78	79.67	81.22
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	77.67	75.89	76.78
N_4: 50% Inorganic + 50% Organic through FYM	80.00	80.33	80.17
SEm±	0.72	0.66	0.56
CD (P=0.05)	2.11	1.93	1.63

Table 4.11(b): Interaction effect on days to 50% flowering under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Days to 50% flowering		
	2023	2024	Pooled
T_1: D_1N_1	79.67	73.67	76.67
T_2: D_1N_2	83.67	78.67	81.17
T_3: D_1N_3	74.67	76.00	75.33
T_4: D_1N_4	85.33	84.33	84.83
T_5: D_2N_1	87.33	77.00	82.17
T_6: D_2N_2	84.33	81.00	82.67
T_7: D_2N_3	80.33	77.33	78.83
T_8: D_2N_4	75.67	77.33	76.50
T_9: D_3N_1	79.67	78.67	79.17
T_{10}: D_3N_2	80.33	79.33	79.83
T_{11}: D_3N_3	78.00	74.33	76.17
T_{12}: D_3N_4	79.00	79.33	79.17
SEm±	1.25	1.14	0.97
CD (P=0.05)	3.65	3.33	2.83

4.1.1.12 Days to maturity

Days to maturity data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.12(a) and 4.12(b).

The data presented illustrate the influence of different sowing dates and nutrient management practices on the days to maturity of finger millet during 2023 and 2024, along with the pooled mean across both years.

Effect of Sowing Dates (D)

The results revealed that sowing dates significantly influenced the duration to maturity in both years as well as in the pooled analysis.In 2023, the crop sown on 1st June (D_1) required the maximum number of days to maturity (121.33 days), followed by 15th June (D_2) with 117.41 days, while the shortest duration (110.66 days) was recorded under 1st July sowing (D_3). A similar trend was recorded in 2024, where D_1 (1st June) again exhibited the longest maturity period (119.67 days), while D_3 (1st July) matured the earliest (113.58 days).

The pooled data confirmed this consistent pattern, with D_1 (1st June) requiring 120.50 days to reach maturity, compared to D_3 (1st July) which took only 112.13 days. These findings suggest that early sowing extended the crop duration due to favourable climatic conditions and longer vegetative phases, whereas delayed sowing shortened the crop period, possibly due to higher temperatures and moisture stress during the latter part of the growing season. This indicates that environmental conditions prevailing during the crop growth stage play a critical role in determining maturity duration.

Effect of Nutrient Management (N)

The data also demonstrated that nutrient management practices influenced the time to maturity, although the magnitude of variation was relatively small. In 2023, treatments N_1 (Control) and N_2 (RDF: 40:30:20 kg $N:P_2O_5:K_2O$ ha^{-1}) recorded slightly longer maturity durations (116.66 days each), whereas N_3 (100% Organic through FYM) and N_4 (50% Inorganic + 50% Organic) had marginally shorter durations (116.11 and 116.44 days, respectively). In 2024, N_4 (50% Inorganic + 50% Organic) recorded the maximum days to maturity (118.56 days), followed by N_1 (117.55 days), while N_3 (116.77 days) matured the earliest.

On a pooled basis, N_4 (117.50 days) exhibited the longest crop duration, closely followed by N_1 (117.11 days), whereas N_3 (116.44 days) showed the shortest duration. This slight extension in maturity under integrated nutrient management (N_4) may be attributed to sustained nutrient availability throughout the crop cycle, which supports continuous vegetative growth and delays senescence. In contrast, the relatively shorter duration under 100% organic management (N_3) might be due to gradual nutrient depletion during later growth stages, leading to faster physiological maturity.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D × N) was found to be significant during both years and in the pooled mean. In 2023, the combination T_1 (D_1N_1: 1st June × Control) recorded the maximum number of days to maturity (123.33 days), followed by T_2 (D_1N_2: 1st June × RDF) with 122.67 days, whereas the minimum (108.67 days) was observed under T_{10} (D_3N_2: 1st July × RDF). A similar pattern was observed in 2024, where T_1 (D_1N_1) again recorded the longest duration (121.00 days), and T_{11} (D_3N_3: 1st July × 100% Organic) exhibited the shortest period (110.67 days).

When pooled across years, T_1 (D_1N_1) showed the highest mean duration to maturity (122.17 days), while T_{10} (D_3N_2) recorded the shortest (110.50 days). This pattern suggests that early sowing without fertilizer application (D_1N_1) prolonged the growth period due to slower nutrient uptake and extended vegetative growth, whereas delayed sowing with recommended fertilizer dose (D_3N_2) accelerated the physiological processes, leading to earlier maturity. Hence, nutrient availability and environmental conditions act synergistically to influence crop phenology.

The findings clearly demonstrate that days to maturity decreased significantly with delayed sowing, highlighting the influence of temperature and photoperiod on crop development. Late sowing exposed the crop to higher temperatures and shorter growing periods, which accelerated physiological maturity.

Conversely, early sowing (1st June) benefited from a longer growth window with favorable conditions during both vegetative and reproductive phases, resulting in an extended maturity duration. Nutrient management practices also played a role in determining crop duration. Treatments receiving balanced or integrated nutrient application (RDF or 50% inorganic + 50% organic) tended to prolong maturity slightly, possibly due to enhanced vegetative vigor and sustained nutrient supply. On the other hand, organic-only treatments led to earlier maturity, likely because of slower nutrient mineralization and faster physiological aging once nutrient availability declined.

The interaction results emphasize that sowing time and nutrient management are interdependent factors early sowing combined with limited nutrient input extended the growth duration, while late sowing with adequate fertilization accelerated crop maturity by optimizing nutrient uptake within a shorter growth window.

These observations are consistent with the findings of Manojgowda *et al.* (2021) and Khandelwal *et al.* (2017), who reported that delayed sowing shortens the crop duration in finger millet due to higher thermal accumulation and reduced growth period. Similarly, Reddy *et al.* (2021) noted that integrated nutrient management prolongs maturity by enhancing vegetative development and delaying leaf senescence.

Table 4.12(a): Days to maturity under different sowing dates and nutrient management system of finger millet

Treatments	Days to maturity		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1st June	121.33	119.67	120.50
D_2: 15th June	117.42	119.33	118.38
D_3: 1st July	110.67	113.58	112.13
SEm±	0.66	1.16	0.70
CD (P=0.05)	1.92	3.39	NS
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	116.67	117.56	117.11
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	116.67	117.22	116.94
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	116.11	116.78	116.44
N_4: 50% Inorganic + 50% Organic through FYM	116.44	118.56	117.50
SEm±	0.76	1.33	0.81
CD (P=0.05)	NS	NS	NS

Table 4.12(b): Interaction effect on days to maturity under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Days to maturity		
	2023	2024	Pooled
T_1: D_1N_1	123.33	121.00	122.17
T_2: D_1N_2	122.67	119.00	120.83
T_3: D_1N_3	119.33	120.00	119.67
T_4: D_1N_4	120.00	118.67	119.33
T_5: D_2N_1	116.67	118.33	117.50
T_6: D_2N_2	118.67	120.33	119.50
T_7: D_2N_3	118.33	119.67	119.00
T_8: D_2N_4	116.00	119.00	117.50
T_9: D_3N_1	110.00	113.33	111.67
T_{10}: D_3N_2	108.67	112.33	110.50
T_{11}: D_3N_3	110.67	110.67	110.67
T_{12}: D_3N_4	113.33	118.00	115.67
SEm±	1.31	2.31	1.41
CD (P=0.05)	3.85	NS	NS

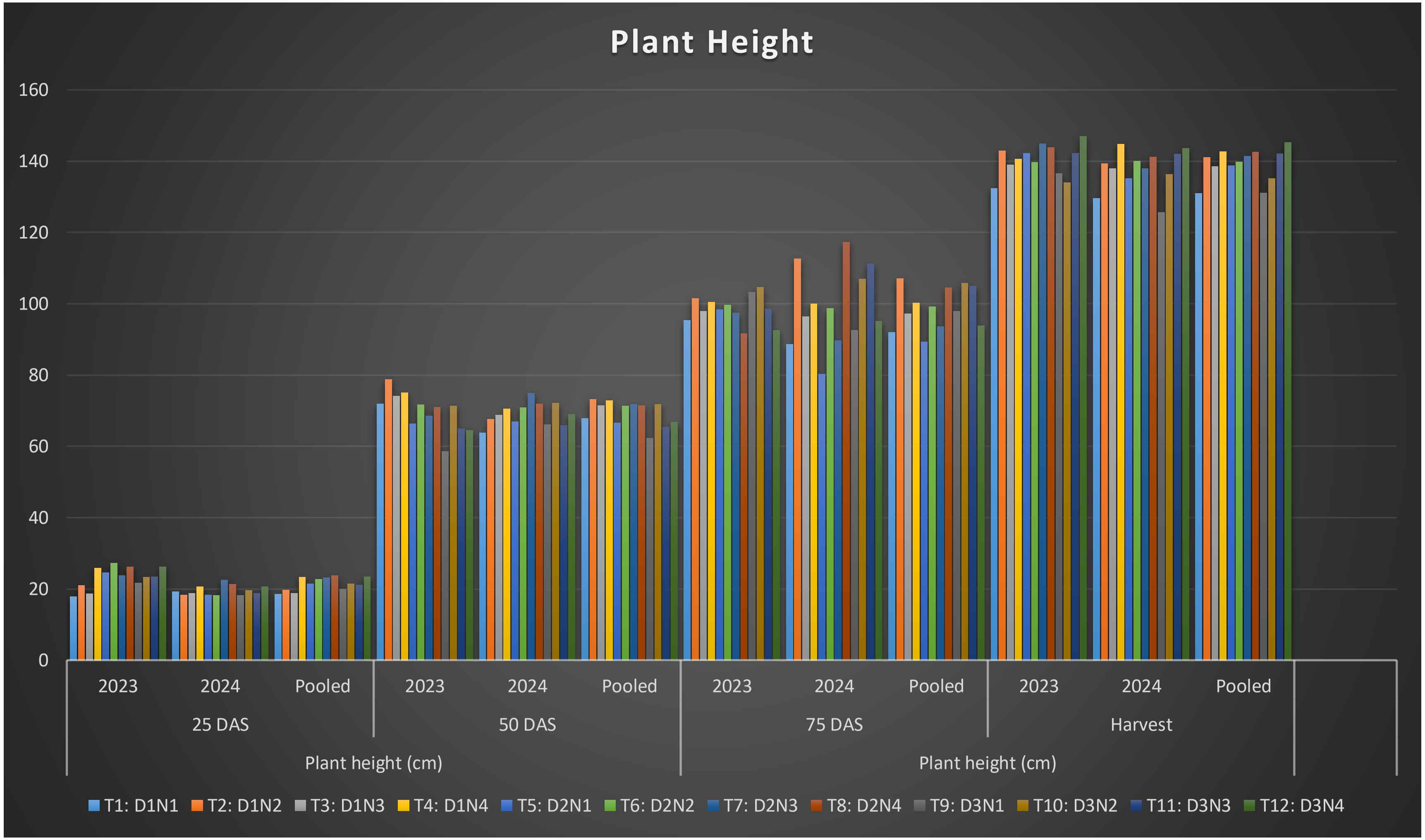


Fig. 4.1 Effect of different sowing dates and nutrient management on Plant Height (cm)

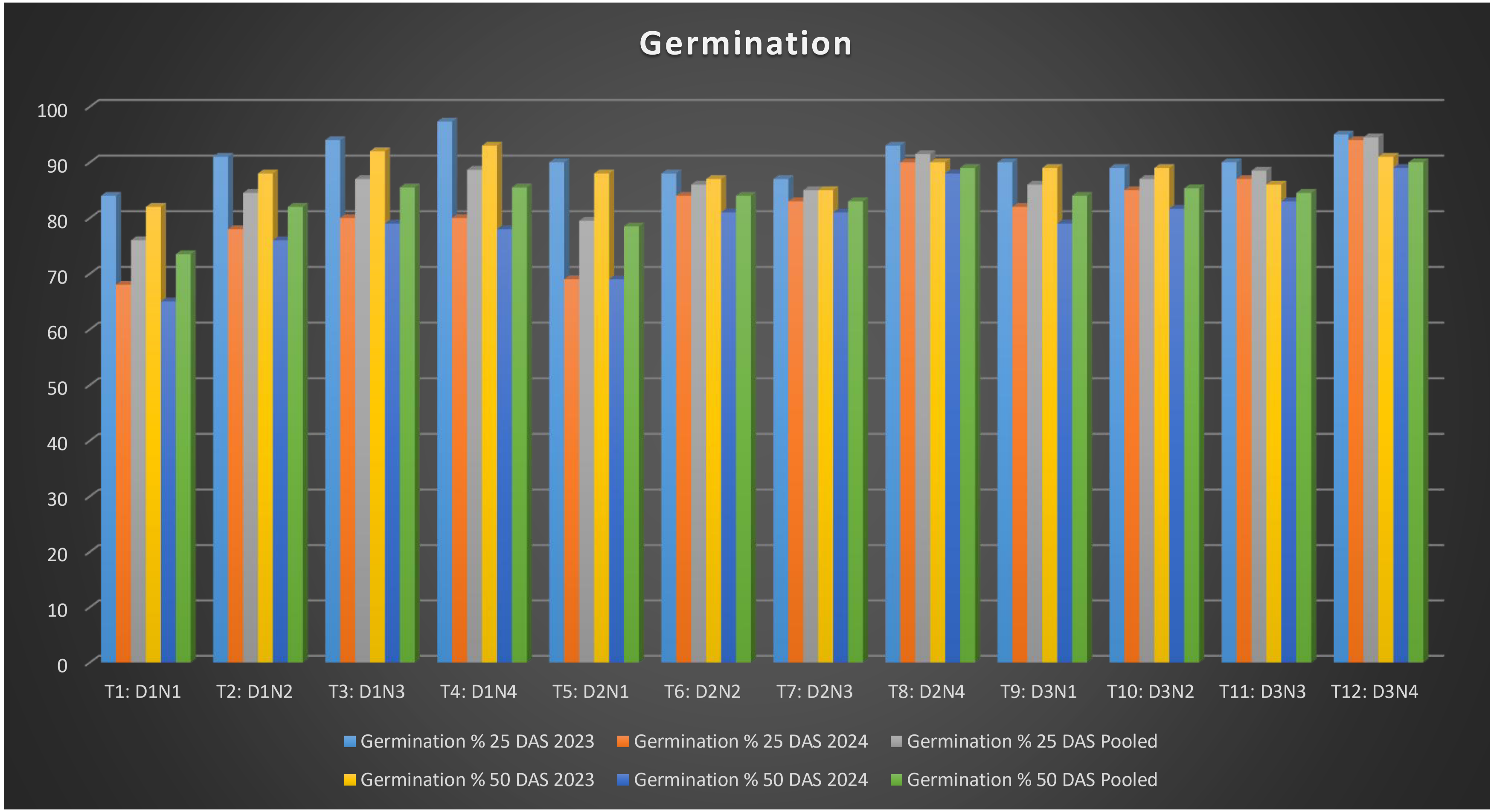


Fig. 4.2 Effect of different sowing dates and nutrient management on Germination (%)

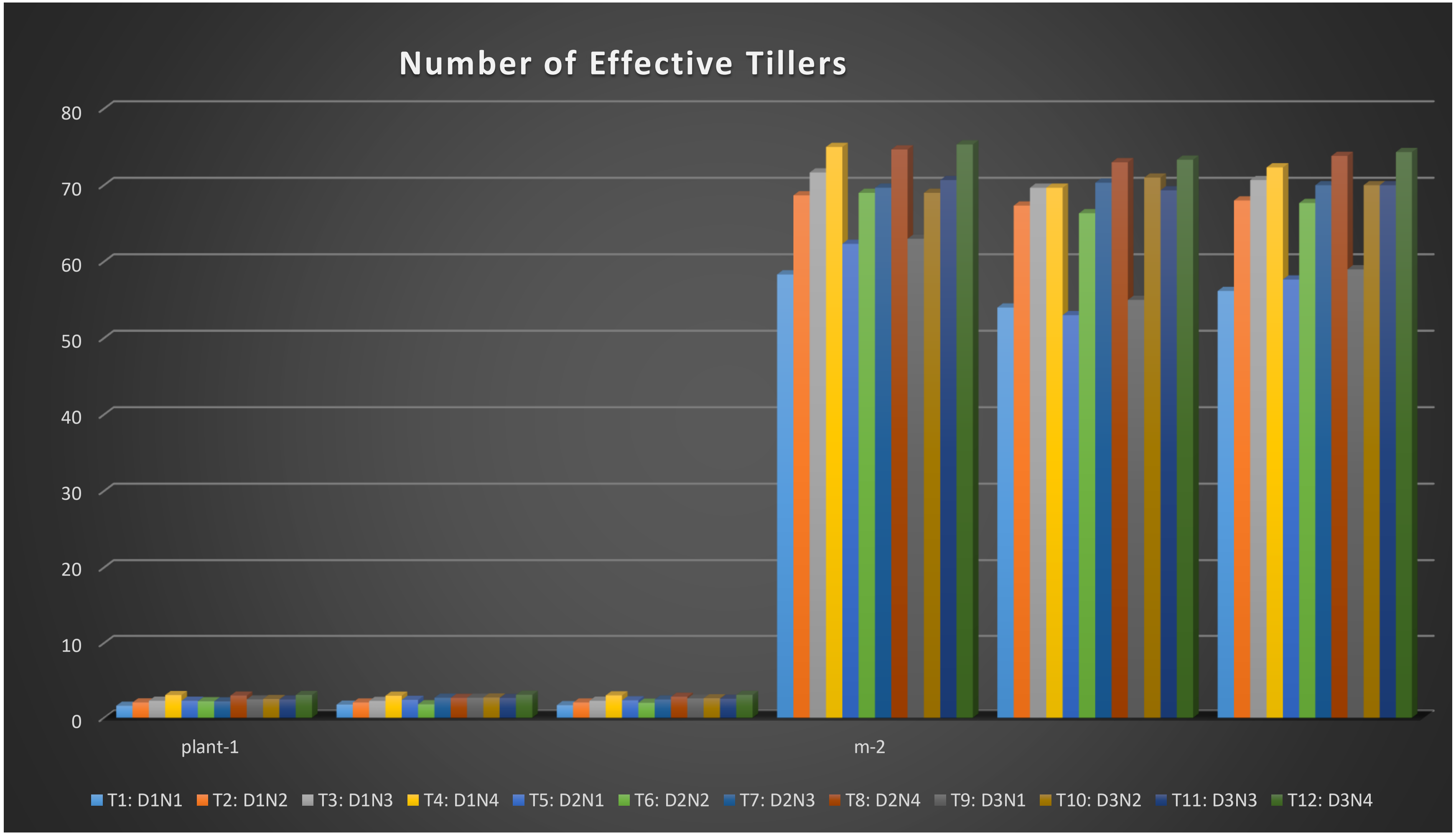


Fig. 4.3 Effect of different sowing dates and nutrient management on plant population (%)

4.1.2 Yield attributes and yield

4.1.2.1 Number of panicles (m^{-2})

Number of panicle data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.13(a) and 4.13(b).

Effect of Sowing Dates (D)

The data presented demonstrate that the number of panicles per square meter was significantly affected by the different sowing dates during both years of investigation as well as in the pooled mean. In the year 2023, the values ranged between 199.58 and 207.50 panicles m^{-2}. The maximum number of panicles (207.50 m^{-2}) was recorded when the crop was sown on 1st July (D_3), followed by 1st June (D_1) with 204.16 m^{-2}, whereas the lowest count (199.58 m^{-2}) was observed on 15th June (D_2). In 2024, a slightly varied trend was noted, with the highest number of panicles (197.33 m^{-2}) again associated with D_3 (1st July), followed by D_2 (15th June) having 187.66 m^{-2}, while the minimum (164.08 m^{-2}) occurred under D_1 (1st June).

The pooled mean results further emphasized that sowing on 1st July (D_3) resulted in the greatest number of panicles (202.41 m^{-2}), whereas the lowest (184.12 m^{-2}) was recorded under D_1 (1st June). These findings suggest that late sowing (1st July) provided favorable conditions for panicle development in finger millet. Such improvement could be attributed to congenial weather, adequate soil moisture, and an extended vegetative phase, which collectively enhanced tiller survival and facilitated greater conversion of tillers into productive panicles.

Effect of Nutrient Management (N)

Nutrient management practices exerted a significant influence on the number of panicles per square meter during both years as well as in pooled analysis. In 2023, the maximum number of panicles (252.22 m^{-2}) was obtained with N_4 (50% inorganic + 50% organic through FYM), followed by N_2 (RDF: 40:30:20 kg N, P_2O_5,

K_2O ha^{-1}) which recorded 215.33 m^{-2}. The lowest number (156.55 m^{-2}) occurred under the control treatment (N_1). A similar response was evident in 2024, where N_4 continued to outperform other treatments, producing 211.11 m^{-2}, followed by N_3 (100% organic through FYM) with 194.22 m^{-2}, and N_2 (192.55 m^{-2}). The minimum (134.222 m^{-2}) again appeared in the control plot.

The pooled mean clearly revealed the superiority of N_4, registering 231.66 m^{-2}, while the lowest (145.38 m^{-2}) was under N_1. The enhanced performance under the integrated nutrient treatment (N_4) could be attributed to a balanced and sustained nutrient supply from both organic and inorganic sources. This approach likely improved soil fertility, enhanced microbial activity, and maintained nutrient availability over the crop growth period, thereby promoting superior panicle initiation and development.

Interaction Effect (D × N)

The interaction effect between sowing dates and nutrient management (D × N) exhibited a significant influence on the number of panicles per square meter across both years and in the pooled mean. During 2023, the highest number of panicles (253.33 m^{-2}) was recorded under T_4 (D_1N_4: 1st June + 50% inorganic + 50% organic), closely followed by T_{12} (D_3N_4) with 253.00 m^{-2}, while the lowest (154.33 m^{-2}) occurred under T_1 (D_1N_1: 1st June + no fertilizer). In 2024, the combination T_{12} (D_3N_4: 1st July + 50% inorganic + 50% organic) again recorded the maximum panicles (247.33 m^{-2}), followed by T_8 (D_2N_4) with 205.00 m^{-2}. The minimum (122.66 m^{-2}) was obtained in T_1 (D_1N_1).

The pooled analysis reaffirmed this pattern, where T_{12} (D_3N_4) produced the highest number of panicles (250.16 m^{-2}), and the lowest (138.50 m^{-2}) was associated with T_1 (D_1N_1).

These findings confirm that sowing on 1st July in combination with integrated nutrient management (50% inorganic + 50% organic) created the most conducive conditions for panicle production. This interaction likely optimized nutrient synchronization and physiological processes during the reproductive stage, resulting in enhanced panicle formation and higher productivity.

The increase in the number of panicles under late sowing (1st July) may be attributed to more favourable climatic conditions, particularly adequate soil moisture and moderate temperature during the critical panicle initiation and flowering stages.

Conversely, early sowing (1st June) might have been subjected to higher temperature stress and quicker moisture depletion, thereby limiting effective tiller transformation into panicles. The superior performance of integrated nutrient management (N_4) aligns with earlier research findings by Sagar *et al.* (2020), Aliveni *et al.* (2021), Singh and Vermireddy (2022) and Gautam *et al*. (2025), which highlighted that a balanced combination of organic and inorganic nutrients ensures continuous nutrient availability and improves soil health. The organic fraction enhances microbial activity and soil structure, whereas the inorganic portion ensures immediate nutrient supply, together leading to improved photosynthetic efficiency and assimilate partitioning towards reproductive organs such as panicles.

The interaction effect (D × N) further demonstrates that optimizing both sowing date and nutrient strategy is essential for achieving superior productivity in finger millet. The D_3N_4 combination provided ideal conditions for nutrient uptake, vigorous tillering, and efficient panicle development, ultimately contributing to enhanced yield potential.

Table 4.13(a): Number of panicles m^{-2} under different sowing dates and nutrient management system of finger millet

Treatments	Number of panicles m^{-2}		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1st June	204.17	164.08	184.13
D_2: 15th June	199.58	187.67	193.63
D_3: 1st July	207.50	197.33	202.42
SEm±	6.16	6.20	4.76
CD (P=0.05)	NS	18.18	13.95
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	156.56	134.22	145.39
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	215.33	192.56	203.94
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	190.89	194.22	192.56
N_4: 50% Inorganic + 50% Organic through FYM	252.22	211.11	231.67
SEm±	7.11	7.16	5.49
CD (P=0.05)	20.86	20.99	16.12

Table 4.13(b): Interaction effect on number of panicles m^{-2} under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Number of panicles m^{-2}		
	2023	2024	Pooled
T_1: D_1N_1	154.33	122.67	138.50
T_2: D_1N_2	225.33	170.00	197.67
T_3: D_1N_3	183.67	182.67	183.17
T_4: D_1N_4	253.33	181.00	217.17
T_5: D_2N_1	156.67	122.33	139.50
T_6: D_2N_2	203.00	216.33	209.67
T_7: D_2N_3	188.33	207.00	197.67
T_8: D_2N_4	250.33	205.00	227.67
T_9: D_3N_1	158.67	157.67	158.17
T_{10}: D_3N_2	217.67	191.33	204.50
T_{11}: D_3N_3	200.67	193.00	196.83
T_{12}: D_3N_4	253.00	247.33	250.17
SEm±	12.32	12.40	9.52
CD (P=0.05)	NS	NS	NS

4.1.2.2 Number of fingers ear^{-1}

Number of finger ear^{-1} data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.14(a) and 4.14(b).

Effect of Sowing Dates (D)

The data summarized show that the number of fingers per ear was markedly affected by different sowing dates in both 2023 and 2024, as well as in the pooled mean.

In 2023, the number of fingers ear^{-1} varied from 6.77 to 7.00, with the highest value (7.00) obtained under D_3 (1st July). This was followed by D_2 (15th June) with 6.83, while the minimum (6.77) occurred in D_1 (1st June). A similar pattern was evident in 2024, where D_3 (1st July) again produced the maximum number of fingers (7.08 ear^{-1}), followed by D_2 (15th June) with 7.00, and the lowest (6.500) was recorded under D_1 (1st June).

The pooled data supported this trend, showing the highest average number of fingers (7.04 ear^{-1}) for D_3, followed by D_2 (6.91 ear^{-1}), while the lowest (6.63 ear^{-1}) was observed in D_1. Overall, these results suggest that delayed sowing (1st July) consistently promoted the formation of more fingers per ear. This enhancement could be attributed to favourable climatic conditions during the reproductive phase, including optimal temperature, sufficient soil moisture, and a balanced transition between vegetative and reproductive growth stages, which together encouraged better ear development and finger formation.

Effect of Nutrient Management (N)

The number of fingers ear^{-1} was also significantly influenced by nutrient management practices during both years of experimentation and in the pooled mean.

In 2023, the maximum number of fingers (8.25 ear^{-1}) was recorded under N_4 (50% inorganic + 50% organic through FYM), followed by N_2 (RDF: 40:30:20 kg N, P_2O_5, K_2O ha^{-1}) with 7.33, and N_3 (100% organic) with 6.55. The lowest value (5.33 ear^{-1}) was obtained in the control (N_1). In 2024, the same trend persisted, where N_4 achieved the highest number of fingers (7.44 ear^{-1}), followed by N_2 (7.22) and N_3 (7.22), whereas N_1 (control) recorded the lowest (5.55 ear^{-1}).

The pooled mean reinforced the superiority of N_4, which yielded 7.85 fingers ear^{-1}, followed by N_2 (7.27) and N_3 (6.88), while the minimum (5.444 ear^{-1}) occurred under N_1 (control). The remarkable performance of N_4 can be ascribed to the synergistic effect of organic and inorganic nutrient sources, which ensured both immediate and long-term nutrient availability. The integration improved soil fertility, microbial activity, and nutrient-use efficiency, leading to enhanced plant vigour, panicle development, and ultimately greater finger formation.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D × N) significantly affected the number of fingers per ear across both experimental years and in the pooled mean.

During 2023, the treatment T_{12} (D_3N_4: 1st July + 50% inorganic + 50% organic) recorded the highest number of fingers (8.33 ear^{-1}), followed by T_8 (D_2N_4) with 8.33 and T_4 (D_1N_4) with 8.100. The lowest number of fingers (5.33 ear^{-1}) was noted under T_1 (D_1N_1: 1st June + no fertilizer) and T_5 (D_2N_1). In 2024, a similar response was observed where T_{12} (D_3N_4) again produced the highest number of fingers (8.33 ear^{-1}), followed by T_{10} (D_3N_2) with 7.00 and T_6 (D_2N_2) with 8.00. The lowest (5.333 ear^{-1}) occurred under T_1 (D_1N_1) and T_5 (D_2N_1).

The pooled data further confirmed this trend, indicating that T_{12} (D_3N_4) was the best-performing combination, producing 8.333 fingers ear^{-1}, whereas the minimum (5.33 ear^{-1}) was recorded in T_1 (D_1N_1). These results demonstrate that sowing on 1st July along with integrated nutrient management (50% inorganic + 50%

organic) provided the most conducive conditions for ear development and finger formation. The combination ensured adequate nutrient synchronization with crop growth stages, resulting in better ear differentiation and efficient translocation of assimilates toward finger initiation and grain filling.

The results distinctly reveal that both sowing date and nutrient management play a pivotal role in determining the number of fingers per ear in finger millet. The superior performance of the 1st July sowing (D_3) can be attributed to the prevailing moderate temperature and adequate soil moisture during the reproductive phase, which favour panicle differentiation and finger formation.

Conversely, early sowing (1st June) may expose the crop to elevated temperatures and moisture stress, adversely impacting ear development. The consistent advantage of integrated nutrient management (N_4) can be credited to the combined contribution of organic manures and inorganic fertilizers. The organic component enhances soil structure, biological activity, and water-holding capacity, while the inorganic portion ensures an immediate nutrient supply. This integrated approach supports continuous nutrient availability, vigorous vegetative growth, and improved reproductive efficiency, leading to more fingers per ear.

These findings are in agreement with earlier studies by Mahapatra *et al.* (2020) and Gautam *et al.* (2025), who reported that integrated nutrient sources improve growth and yield attributes in finger millet by maintaining a balanced nutrient regime and stimulating root and shoot growth.

Table 4.14(a): Number of fingers ear^{-1} under different sowing dates and nutrient management system of finger millet

Treatments	Number of fingers ear^{-1}		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1^{st} June	6.78	6.50	6.64
D_2: 15^{th} June	6.83	7.00	6.92
D_3: 1^{st} July	7.00	7.08	7.05
SEm±	0.25	0.24	0.17
CD (P=0.05)	NS	NS	NS
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	5.33	5.56	5.44
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	7.33	7.22	7.28
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	6.56	7.22	6.89
N_4: 50% Inorganic + 50% Organic through FYM	8.26	7.44	7.85
SEm±	0.25	0.28	0.20
CD (P=0.05)	0.68	0.81	0.58

Table 4.14(b): Interaction effect on number of fingers ear^{-1} under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Number of fingers ear^{-1}		
	2023	2024	Pooled
T$_1$: D_1N_1	5.33	5.33	5.33
T$_2$: D_1N_2	7.67	6.67	7.17
T$_3$: D_1N_3	6.00	7.00	6.50
T$_4$: D_1N_4	8.10	7.00	7.55
T$_5$: D_2N_1	5.33	5.33	5.33
T$_6$: D_2N_2	7.00	8.00	7.50
T$_7$: D_2N_3	6.67	7.67	7.17
T$_8$: D_2N_4	8.33	7.00	7.67
T$_9$: D_3N_1	5.33	6.00	5.67
T$_{10}$: D_3N_2	7.33	7.00	7.17
T$_{11}$: D_3N_3	7.00	7.00	7.00
T$_{12}$: D_3N_4	8.33	8.33	8.33
SEm±	0.44	0.48	0.34
CD (P=0.05)	1.16	NS	NS

4.1.2.3 Number of grains finger^{-1}

Number of grains ear^{-1} data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.15(a) and 4.15(b).

Effect of Sowing Dates (D)

The data presented revealed that the number of grains per finger was significantly influenced by different sowing dates during both years of experimentation (2023 and 2024) as well as in the pooled mean.

During the year 2023, the sowing date D_2 (15th June) produced the maximum number of grains per finger (332.16), which was statistically on par with D_3 (1st July) recording 331.41 grains per finger. The lowest value (327.08) was obtained under D_1 (1st June). In 2024, a similar pattern was observed, with D_3 (1st July) producing the highest number of grains per finger (334.33), closely followed by D_2 (15th June) (332.75), while the minimum (331.00) was recorded in D_1 (1st June).

The pooled analysis indicated that D_3 (1st July) resulted in the maximum number of grains per finger (332.87), followed by D_2 (15th June) (332.45), whereas the minimum number (329.04) was associated with D_1 (1st June). These results suggest that delayed sowing up to 1st July was more favourable for enhancing grain formation per finger. This could be attributed to the more congenial environmental conditions such as moderate temperature, adequate soil moisture, and favourable humidity during the critical reproductive phase, which supported efficient pollination and grain setting.

Effect of Nutrient Management (N)

Nutrient management exerted a significant influence on the number of grains per finger in both years as well as in the pooled mean.

In 2023, the highest number of grains per finger (346.77) was recorded under N_4 (50% inorganic + 50% organic through FYM), followed by N_3 (100% organic through FYM) (341.33) and N_2 (RDF: 40:30:20 kg N: P_2O_5: K_2O ha^{-1}) (332.00). The lowest value (300.77) was observed in the control treatment (N_1). A similar trend was noted in 2024, where N_4 recorded the highest number of grains per finger (346.66), followed by N_3 (341.33) and N_2 (336.44), while the control (N_1) produced the least (306.33).

The pooled data confirmed that N_4 (50% inorganic + 50% organic) resulted in the maximum number of grains per finger (346.72), followed by N_3 (341.333) and N_2 (334.22), whereas N_1 registered the lowest (303.55). This clearly demonstrates that the integrated nutrient application (N_4) was most beneficial in enhancing grain formation per finger. The possible reason may be the synchronized and sustained release of nutrients, which improved soil fertility and microbial activity, enhanced nutrient uptake, and promoted effective translocation of assimilates to the developing grains.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D×N) also exhibited a significant effect on the number of grains per finger during both years and in the pooled mean.

In 2023, the highest value (348.00) was recorded under the treatment T_8 (D_2N_4: 15th June × 50% inorganic + 50% organic), which was statistically at par with T_4 (D_1N_4) (346.00) and T_{12} (D_3N_4) (346.33). The lowest number of grains per finger (297.33) was obtained under T_1 (D_1N_1: 1st June × Control). During 2024, the maximum grains per finger (348.333) were observed in T_4 (D_1N_4), followed by T_8 (D_2N_4) (345.66), while T_1 (D_1N_1) again recorded the minimum (301.66).

In the pooled mean, T_4 (D_1N_4) recorded the highest number of grains per finger (347.16), followed by T_8 (D_2N_4) (346.83) and T_{12} (D_3N_4) (346.16). The lowest (299.50) was noted under T_1 (D_1N_1). These results clearly indicate that the integration of 50% inorganic and 50% organic nutrient sources across different sowing dates consistently enhanced the number of grains per finger. The combination of mid (15th June) and late (1st July) sowing with integrated nutrient management proved most effective in improving reproductive performance.

The significant influence of both sowing dates and nutrient management on the number of grains per finger may be attributed to their combined effect on the physiological and reproductive processes of finger millet.

The late sowing (1st July) appeared to create more favourable conditions for grain filling, with optimal temperature, relative humidity, and soil moisture ensuring better fertilization, pollination efficiency, and grain setting. Furthermore, the superior performance of integrated nutrient management (N_4) treatments could be due to the balanced and gradual nutrient release from organic and inorganic sources, which supported steady growth and improved source-sink relationships. The inclusion of organic manures enhanced soil structure, water retention, and microbial activity, while inorganic fertilizers ensured immediate nutrient availability—together improving photosynthetic efficiency and assimilate translocation towards the developing grains.

The present findings are consistent with the observations of Reddy *et al.* (2020), Mahapatra *et al.* (2020) and Gautam *et al.* (2025), who also reported that integrated nutrient management practices significantly increased the number of grains per ear or finger in cereal crops. They attributed this improvement to enhanced nutrient availability, better root growth, and favourable physiological conditions, leading to improved reproductive efficiency and yield potential.

Table 4.15(a): Number of grains fingers^{-1} under different sowing dates and nutrient management system of finger millet

Treatments	**Number of grains finger^{-1}**		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1^{st} June	327.08	331.00	329.05
D_2: 15^{th} June	332.17	332.75	332.45
D_3: 1^{st} July	331.42	334.33	332.88
SEm±	0.36	0.54	0.39
CD (P=0.05)	1.06	1.60	1.15
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	300.78	306.33	303.56
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	332.00	336.44	334.22
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	341.33	341.33	341.33
N_4: 50% Inorganic + 50% Organic through FYM	346.78	346.67	346.72
SEm±	0.42	0.63	0.45
CD (P=0.05)	1.23	1.84	1.34

Table 4.15(b): Interaction effect on number of grains fingers^{-1} under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Number of grains finger^{-1}		
	2023	**2024**	**Pooled**
T$_1$: D_1N_1	297.33	301.67	299.50
T$_2$: D_1N_2	323.33	333.00	328.17
T$_3$: D_1N_3	341.67	341.00	341.33
T$_4$: D_1N_4	346.00	348.33	347.17
T$_5$: D_2N_1	300.00	306.00	303.00
T$_6$: D_2N_2	337.00	338.67	337.83
T$_7$: D_2N_3	343.67	340.67	342.17
T$_8$: D_2N_4	348.00	345.67	346.83
T$_9$: D_3N_1	305.00	311.33	308.17
T$_{10}$: D_3N_2	335.67	337.67	336.67
T$_{11}$: D_3N_3	338.67	342.33	340.50
T$_{12}$: D_3N_4	346.33	346.00	346.17
SEm±	0.73	1.09	0.79
CD (P=0.05)	2.13	3.18	2.30

4.1.2.4 Number of grains earhead^{-1}

Number of grains earhead^{-1} data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.16(a) and 4.16(b).

Effect of Sowing Dates (D)

The data presented revealed that sowing dates had a significant influence on the number of grains per earhead during both experimental years and in the pooled mean. In 2023, the 1st July sowing (D_3) recorded the highest number of grains per earhead (2332.00), followed by 15th June (D_2) with 2194.42 grains, whereas the 1st June sowing (D_1) resulted in the minimum number of grains (2112.93). A similar pattern was observed in 2024, where D_3 (1st July) again produced the maximum number of grains per earhead (2250.92), followed by D_2 (15th June), while the lowest value (2021.48) was noted in D_1 (1st June). The pooled mean of both years confirmed that delayed sowing (D_3) resulted in the highest number of grains per earhead (2242.96), followed by D_2 (15th June) (2264.09), while the lowest count (2029.78) was recorded under D_1 (1st June). These results clearly suggest that late sowing enhanced earhead grain formation, possibly due to the favourable temperature and adequate moisture availability during the reproductive and grain-filling stages. In contrast, early sowing might have exposed the crop to elevated temperatures during pollination and grain development, thereby reducing grain set and overall productivity.

Effect of Nutrient Management (N)

Nutrient management exhibited a highly significant impact on the number of grains per earhead in both years of the study as well as in the pooled mean. In 2023, the highest number of grains per earhead (2604.34) was observed under the treatment N_4 (50% inorganic + 50% organic through FYM), followed by N_2 (RDF: 40:30:20 kg N: P_2O_5: K_2O ha^{-1}) with 2448.34 grains and N_3 (100% organic through FYM) with 2192.77 grains. The lowest value (1607.00) was recorded under N_1 (Control). During

2024, a similar trend was evident, N_4 again produced the maximum number of grains per earhead (2369.89), whereas the minimum (1565.55) was obtained in the control (N_1). In the pooled data, the treatment N_4 (50% inorganic + 50% organic) maintained its superiority, recording 2373.27 grains per earhead, followed by N_2 (2296.29) and N_3 (2328.39), while the lowest value (1717.83) was recorded in N_1 (Control). The enhancement in the number of grains per earhead under integrated nutrient management (N_4) may be ascribed to better nutrient synchronization and sustained availability throughout the crop growth period. The combination of organic and inorganic sources likely improved soil fertility, microbial activity, and root growth, which collectively promoted better panicle development and grain filling. The comparatively lower grain number in the control plots can be attributed to nutrient limitations that adversely affected plant growth and reproductive efficiency.

Interaction Effect (D × N)

A significant interaction between sowing dates and nutrient management (D×N) was also observed during both years as well as in the pooled analysis. In 2023, the treatment T_{12} (D_3N_4: 1st July × 50% inorganic + 50% organic) recorded the maximum number of grains per earhead (2706.67), which was closely followed by T_4 (D_1N_4) (2694.37). The minimum number of grains (1177.67) was noted under T_1 (D_1N_1: 1st June × Control). Similarly, during 2024, T_{12} (D_3N_4) again exhibited the highest number of grains (2568.00), while T_1 (D_1N_1) produced the least (1179.00).

The pooled mean also confirmed that T_{12} (D_3N_4) was the most effective combination, recording the maximum number of grains per earhead (2552.83), followed by T_{11} (D_3N_3) (2487.00). The lowest grain number (1161.00) was obtained under T_1 (D_1N_1). These findings demonstrate that late sowing (1st July) in combination with integrated nutrient management (N_4) resulted in superior earhead grain production, whereas early sowing without fertilization (D_1N_1) led to poor grain formation. The interaction highlights the importance of synchronizing sowing time with appropriate nutrient management for maximizing the reproductive potential of finger millet.

The results were clearly establish that both sowing time and nutrient management play a crucial role in determining the number of grains per earhead in finger millet. The superiority of late sowing (1st July) can be attributed to favorable environmental conditions such as moderate temperature, sufficient soil moisture, and optimal humidity during the reproductive phase, which facilitated better pollination, fertilization, and spikelet development. These conditions likely improved grain retention and filling, resulting in enhanced grain numbers. The findings align with the observations of Kumar *et al*. (2021) who also reported that delayed sowing improved spikelet fertility and grain set in finger millet due to the synchronization of flowering with conducive climatic conditions. In terms of nutrient management, the superiority of N_4 (50% inorganic + 50% organic) and N_2 (RDF) treatments suggests that a balanced nutrient supply through integrated management ensures optimal plant growth and reproductive success. The combined use of organic and inorganic nutrients enhances soil health, microbial activity, and nutrient-use efficiency, leading to better assimilate translocation to developing grains.

The results corroborate the findings of Patel *et al*. (2022), Aliveni *et al.* (2021) and Reddy *et al*. (2021), who reported that integrated nutrient management significantly improved grain yield components in cereals by maintaining soil fertility and ensuring continuous nutrient availability. Furthermore, the significant interaction effect (D×N) emphasizes that nutrient management efficiency is highly dependent on the sowing period. The late sowing date coupled with balanced nutrient application (D_3N_4) provided the most conducive environment for reproductive development, resulting in the maximum number of grains per earhead. Hence, integrating delayed sowing with partial organic nutrient supplementation emerges as an effective strategy for optimizing grain production in finger millet.

Table 4.16(a): Number of grains earhead^{-1} under different sowing dates and nutrient management system of finger millet

Treatments	**Number of grain earhead^{-1}**		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1st June	2112.93	2021.48	2029.78
D_2: 15th June	2194.42	2222.67	2264.09
D_3: 1st July	2332.00	2250.92	2242.96
SEm±	34.70	39.32	23.32
CD (P=0.05)	101.77	115.35	121.08
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	1607.00	1565.55	1717.83
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	2448.34	2436.98	2296.29
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	2192.78	2287.67	2328.39
N_4: 50% Inorganic + 50% Organic through FYM	2604.34	2369.89	2373.27
SEm±	40.06	45.41	26.93
CD (P=0.05)	117.51	134.04	178.89

Table 4.16(b): Interaction effect on number of grains earhead^{-1} under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Number of grain earhead^{-1}		
	2023	2024	Pooled
T_1: D_1N_1	1177.67	1179.00	1161.00
T_2: D_1N_2	2227.03	2159.93	2280.52
T_3: D_1N_3	2352.67	2328.00	2286.82
T_4: D_1N_4	2694.37	2419.00	2390.83
T_5: D_2N_1	2159.67	2078.33	2274.00
T_6: D_2N_2	2533.00	2553.67	2394.83
T_7: D_2N_3	1673.00	2136.00	2211.33
T_8: D_2N_4	2412.00	2122.67	2176.17
T_9: D_3N_1	1483.67	1439.33	1718.50
T_{10}: D_3N_2	2585.00	2597.33	2213.50
T_{11}: D_3N_3	2552.67	2399.00	2487.00
T_{12}: D_3N_4	2706.67	2568.00	2552.83
SEm±	69.39	78.65	46.64
CD (P=0.05)	203.53	232.16	213.98

4.1.2.5 Length of finger (cm)

Length of finger data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.17(a) and 4.17(b).

Effect of Sowing Dates (D)

The data presented indicated that the length of finger in finger millet was not significantly affected by varying sowing dates during both experimental years (2023 and 2024) as well as in the pooled analysis.

In 2023, the finger length ranged from 7.21 cm under D_3 (1st July) to 7.38 cm under D_2 (15th June). Similarly, in 2024, the variation was between 7.17 cm (D_2) and 7.495 cm (D_3). The pooled mean revealed a comparable trend, where D_3 (1st July) exhibited the longest fingers (7.35 cm), followed closely by D_1 (1st June) (7.31 cm) and D_2 (15th June) (7.28 cm).

Although these differences were statistically non-significant, the data suggested a slight improvement in finger length with delayed sowing up to 1st July (D_3). This marginal increase could be attributed to better soil moisture availability and favourable climatic conditions during the panicle development phase, which likely supported finger elongation and grain formation.

Effect of Nutrient Management (N)

Nutrient management practices exerted a significant influence on the length of finger in both years of study as well as in the pooled mean.

In 2023, the N_4 treatment (50% inorganic + 50% organic through FYM) recorded the maximum finger length (8.24 cm), which was significantly superior to all other treatments. It was followed by N_2 (RDF: 40:30:20 kg N: P_2O_5: K_2O ha^{-1}) (7.702 cm) and N_3 (100% organic through FYM) (7.062 cm), whereas the shortest fingers (6.087 cm) were noted under N_1 (control). A similar pattern was recorded in

2024, where N_4 again produced the longest fingers (8.02 cm), followed by N_2 (7.95 cm) and N_3 (7.15 cm). The control (N_1) treatment resulted in the shortest finger length (6.301 cm). The pooled data corroborated these findings, showing that N_4 consistently maintained its superiority (8.13 cm), followed by N_2 (7.82 cm), while N_1 continued to record the lowest finger length (6.19 cm).

The overall improvement in finger length under integrated nutrient management (N_4) may be ascribed to the synergistic effect of organic and inorganic nutrient sources, which ensured a steady and balanced nutrient supply, improved soil microbial activity, and enhanced root growth and photosynthetic efficiency. This resulted in better translocation of assimilates to developing panicles, promoting longer finger formation.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D × N) was found to be significant in 2023, whereas in 2024 and in the pooled mean, the interaction remained non-significant.

During 2023, the treatment T_4 (D_1N_4: 1st June + 50% inorganic + 50% organic) produced the longest fingers (8.40 cm), which was statistically comparable with T_8 (D_2N_4: 15th June + 50% inorganic + 50% organic) (8.07 cm) and T_{12} (D_3N_4: 1st July + 50% inorganic + 50% organic) (8.25 cm). The shortest finger length (5.17 cm) was recorded under T_5 (D_2N_1: 15th June + Control).

In the pooled mean, a similar trend was evident where T_{12} (D_3N_4) recorded the maximum finger length (8.20 cm), followed by T_4 (D_1N_4) (8.18cm), while the minimum value (5.27 cm) was obtained from T_5 (D_2N_1). These results emphasize that integrating organic and inorganic nutrient sources irrespective of sowing time contributes substantially to improved finger development and overall panicle structure.

The enhanced availability of nutrients under N_4 treatments appeared to compensate for variations in sowing time, leading to consistently longer fingers.

The results from the two years of experimentation suggest that finger length is more responsive to nutrient availability than to sowing time, provided that environmental conditions such as temperature and moisture are conducive. The significant improvement in finger length under integrated nutrient management (N_4) can be attributed to enhanced soil fertility, improved microbial activity, and efficient nutrient release and uptake dynamics.

The combined application of FYM and inorganic fertilizers ensured both immediate nutrient supply and long-term soil enrichment, which together supported vigorous growth and panicle elongation. Although sowing dates did not cause significant variations, the marginally higher finger length observed under late sowing (1st July) indicates that favourable soil moisture and moderate temperatures during the reproductive stage promoted better panicle elongation and grain filling.

These findings are consistent with the observations of Mahapatra *et al.* (2020) and Gautam *et al.* (2025) who also reported that integrated nutrient management significantly enhanced yield attributes, including finger length and panicle weight, in finger millet. The study thus reaffirms the importance of balanced nutrient management combining organic and inorganic sources for optimizing yield-contributing traits in finger millet.

Table 4.17(a): Length of finger under different sowing dates and nutrient management system of finger millet

Treatments	Length of finger (cm)		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1st June	7.22	7.41	7.32
D_2: 15th June	7.38	7.18	7.28
D_3: 1st July	7.21	7.50	7.35
SEm±	0.23	0.23	0.21
CD (P=0.05)	NS	NS	NS
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	6.09	6.30	6.19
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	7.70	7.95	7.82
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	7.06	7.15	7.11
N_4: 50% Inorganic + 50% Organic through FYM	8.24	8.03	8.14
SEm±	0.27	0.26	0.25
CD (P=0.05)	0.78	0.76	0.72

Table 4.17(b): Interaction effect on length of finger under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Length of finger (cm)		
	2023	2024	Pooled
T_1: D_1N_1	6.58	6.73	6.66
T_2: D_1N_2	7.69	8.21	7.94
T_3: D_1N_3	6.21	6.73	6.47
T_4: D_1N_4	8.40	7.96	8.18
T_5: D_2N_1	5.17	5.37	5.27
T_6: D_2N_2	7.99	7.88	7.93
T_7: D_2N_3	8.32	7.48	7.90
T_8: D_2N_4	8.08	7.96	8.01
T_9: D_3N_1	6.51	6.80	6.66
T_{10}: D_3N_2	7.43	7.77	7.60
T_{11}: D_3N_3	6.66	7.25	6.95
T_{12}: D_3N_4	8.25	8.16	8.20
SEm±	0.47	0.45	0.43
CD (P=0.05)	1.37	NS	NS

4.1.2.6 Test weight (g)

Test weight data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.18(i) and 4.18(ii).

Effect of Sowing Dates (D)

The data presented indicate that the test weight of finger millet grains remained statistically unaffected by different sowing dates during both years of experimentation (2023 and 2024), as well as in the pooled mean.

During 2023, the test weight ranged between 3.30 g under D_3 (1st July) and 3.38 g under D_1 (1st June). Likewise, in 2024, it varied marginally from 3.32 g (D_2 and D_3) to 3.35 g (D_1). The pooled data followed a similar trend, wherein D_1 (1st June) registered the highest mean test weight (3.36 g), closely followed by D_2 (15th June) (3.35 g), whereas the lowest value (3.31 g) was recorded under D_3 (1st July).

Although the differences were not statistically significant, a gradual decline in test weight with delayed sowing was observed. This slight reduction might be attributed to a shortened grain-filling period and possible exposure to higher temperatures and lower soil moisture levels during the later stages of crop growth. Such environmental conditions could have limited the translocation and accumulation of assimilates into developing grains, thereby reducing their weight and density.

Effect of Nutrient Management (N)

Different nutrient management treatments exerted a non-significant but noticeable influence on the test weight of finger millet across both years and in the pooled mean.

In 2023, the N_3 treatment (100% organic through FYM) recorded the maximum test weight (3.58 g), followed by N_2 (RDF – 40:30:20 kg N: P_2O_5: K_2O ha^{-1}) with 3.34 g, while the lowest test weight (3.19 g) was observed under N_1

(control). A similar pattern was recorded during 2024, where N_3 (3.54 g) again produced the highest value, and N_1 (3.15 g) the lowest. The pooled mean further confirmed these findings, with N_3 (3.56 g) maintaining the highest test weight, followed by N_2 (3.34 g) and N_4 (50% inorganic + 50% organic through FYM) (3.30 g). The lowest test weight (3.17 g) was consistently associated with N_1 (control).

Although the variations were statistically non-significant, the slightly higher test weight observed under organic and integrated nutrient treatments could be attributed to the gradual release and steady supply of nutrients from FYM, which improved soil physical conditions and microbial activity, thereby supporting enhanced seed filling and grain density.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management was found to be non-significant in both years of the study as well as in the pooled analysis.

Nevertheless, numerical differences among the treatment combinations indicated that higher test weights were generally associated with organic nutrient sources. In 2023, the treatment T_3 (D_1N_3: 1st June + 100% organic) recorded the maximum test weight (3.65 g), followed closely by T_7 (D_2N_3: 15th June + 100% organic) with 3.66 g, while the lowest value (3.11 g) was obtained under T_9 (D_3N_1: 1st July + control).

A similar pattern persisted in the pooled mean, where T_3 (D_1N_3) produced the highest test weight (3.62 g), followed by T_7 (D_2N_3) (3.60 g), while the lowest value (3.19 g) occurred in T_1 (D_1N_1: 1st June + control).

Though the interaction was not statistically significant, these numerical trends suggest that timely sowing coupled with organic or integrated nutrient management contributes to marginally higher test weights by promoting better nutrient utilization efficiency and enhanced seed filling.

The findings reveal that the test weight, a crucial parameter reflecting grain boldness and density, was not significantly influenced either by sowing dates or nutrient management practices. However, the numerical superiority observed under organic and integrated nutrient management treatments suggests that farmyard manure (FYM) played a positive role in improving soil structure, moisture retention capacity, and nutrient availability, which in turn favoured more effective grain filling and assimilation of photosynthates during maturity.

The slightly higher test weight in the early sown crop (1st June) could be ascribed to favourable temperature and light conditions prevailing during the grain-filling phase, which facilitated enhanced photosynthetic activity and better partitioning of assimilates towards grain development.

These observations are in close agreement with the findings of Devi *et al.* (2021), Nwajei *et al.* (2022) and Reddy *et al*. (2020), who reported that the test weight of finger millet remained relatively unaffected by sowing date but exhibited marginal improvement under balanced and organic nutrient management. Similarly, Patil *et al*. (2022) noted that the application of organic manures led to an increase in seed weight by promoting favourable metabolic and enzymatic activities during grain development.

Thus, while the effect of sowing date on test weight was minimal, organic and integrated nutrient approaches demonstrated a slight but consistent enhancement in grain quality attributes, reinforcing their role in sustainable nutrient management for finger millet production.

Table 4.18(a): Test weight under different sowing dates and nutrient management system of finger millet

Treatments	Test weight (g)		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1^{st} June	3.39	3.35	3.37
D_2: 15^{th} June	3.37	3.32	3.36
D_3: 1^{st} July	3.31	3.32	3.31
SEm±	0.00	0.00	0.00
CD (P=0.05)	NS	NS	NS
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	3.19	3.15	3.18
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	3.34	3.35	3.35
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	3.59	3.54	3.56
N_4: 50% Inorganic + 50% Organic through FYM	3.30	3.31	3.31
SEm±	0.00	0.00	0.00
CD (P=0.05)	NS	NS	NS

Table 4.18(b): Interaction effect on test weight under different sowing dates and nutrient management system of finger millet

Interaction (DXN)	Test weight (g)		
	2023	2024	Pooled
T_1: D_1N_1	3.25	3.14	3.20
T_2: D_1N_2	3.32	3.34	3.34
T_3: D_1N_3	3.65	3.60	3.62
T_4: D_1N_4	3.30	3.33	3.32
T_5: D_2N_1	3.22	3.12	3.17
T_6: D_2N_2	3.34	3.36	3.34
T_7: D_2N_3	3.66	3.55	3.61
T_8: D_2N_4	3.30	3.29	3.29
T_9: D_3N_1	3.11	3.21	3.16
T_{10}: D_3N_2	3.37	3.34	3.36
T_{11}: D_3N_3	3.45	3.46	3.46
T_{12}: D_3N_4	3.29	3.30	3.30
SEm±	0.01	0.01	0.01
CD (P=0.05)	NS	NS	NS

4.1.3 Yield

4.1.3.1 Grain yield plant^{-1} (g)

Grain yield plant^{-1} data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.19(a) and 4.19(b).

Effect of Sowing Dates (D)

The data presented reveal that the grain yield per plant of finger millet was not significantly influenced by different sowing dates during both years of experimentation (2023 and 2024), as well as in the pooled mean.

Nevertheless, a consistent numerical trend was observed across years. During 2023, the maximum grain yield per plant (5.46 g) was obtained under D_3 (1st July), followed by D_2 (15th June) with 5.41 g, while the minimum (5.24 g) was recorded under D_1 (1st June). A similar pattern was evident in 2024, wherein D_3 (1st July) again recorded the highest yield (5.41 g), marginally higher than D_2 (5.26 g), with the lowest (4.84 g) observed in D_1 (1st June). The pooled data corroborated these findings, showing the highest grain yield per plant under D_3 (1st July) (5.43 g), followed by D_2 (5.33 g) and D_1 (5.04 g). Although statistically non-significant, the consistent superiority of late sowing (1st July) suggests that favourable climatic conditions, particularly optimum moisture, temperature, and humidity during the flowering and grain-filling phases, contributed to improved yield formation. Early sowing, on the other hand, might have exposed the crop to elevated temperatures and moisture stress, thereby slightly reducing yield potential.

Effect of Nutrient Management (N)

Nutrient management treatments exerted a significant influence on grain yield per plant during both years as well as in the pooled mean. In 2023, the maximum grain yield per plant (7.080 g) was obtained under N_4 (50% inorganic + 50% organic through FYM), followed by N_3 (100% organic through FYM) with 5.87 g and N_2 (RDF: 40:30:20 kg $N:P_2O_5:K_2O$ ha^{-1}) with 5.66 g, while the lowest yield

(3.02 g) was recorded under N_1 (control). A similar trend was evident during 2024, where N_4 again registered the highest yield (6.14 g), followed by N_3 (5.87 g) and N_2 (5.49 g), with N_1 (2.72 g) producing the least. The pooled mean further confirmed these trends, with N_4 producing the highest grain yield per plant (6.61 g), followed by N_3 (5.87 g) and N_2 (5.58 g), whereas the minimum (3.02 g) was obtained under N_1. The superiority of N_4 (integrated nutrient management) can be attributed to the complementary effects of organic and inorganic nutrient sources, which together enhance nutrient availability, soil structure, microbial activity, and nutrient use efficiency. The organic component (FYM) improves soil health and moisture retention, while inorganic fertilizers provide readily available nutrients during critical growth stages, ensuring balanced and sustained plant growth.

Interaction Effect (D × N)

The interaction effect between sowing dates and nutrient management was found to be non-significant during both years and in the pooled mean. However, numerical differences among the treatment combinations indicated clear trends. In 2023, the treatment combination T_{12} (D_3N_4: 1st July + 50% inorganic + 50% organic) recorded the highest grain yield per plant (7.16 g), followed closely by T_8 (D_2N_4: 15th June + 50% inorganic + 50% organic) (7.13 g). The lowest yield (3.06 g) was noted under T_1 (D_1N_1: 1st June + control). Similarly, in 2024, T_{12} (D_3N_4) again recorded the maximum yield (6.97 g), while T_1 (D_1N_1) produced the lowest (2.72 g). The pooled mean followed a similar pattern, with T_{12} (D_3N_4) producing the highest grain yield per plant (7.06 g), followed by T_8 (D_2N_4) (6.46 g) and T_{11} (D_3N_3) (5.764 g), while the lowest (2.86 g) was recorded under T_1 (D_1N_1).

These observations indicate that although the interaction was not statistically significant, the integration of organic and inorganic nutrient sources (N_4) in combination with optimal sowing dates (D_2 and D_3) consistently resulted in higher grain yield per plant. This trend underscores the synergistic effect of integrated nutrient management under favourable environmental conditions during the reproductive stage of finger millet.

The results clearly demonstrate that while sowing dates exerted a marginal influence on grain yield per plant, nutrient management practices played a decisive role in determining yield outcomes. The relatively higher grain yield observed under 1st July sowing (D_3) may be attributed to favourable agro-climatic conditions prevailing during the reproductive phase, particularly adequate soil moisture, moderate temperature, and relative humidity, which together favour grain filling and photosynthate translocation. Conversely, early sowing (1st June) likely subjected the crop to suboptimal conditions, such as higher temperatures and intermittent moisture stress, leading to a marginal reduction in yield.

Among the nutrient management treatments, integrated nutrient management (N_4) consistently outperformed other treatments. The synergistic combination of organic and inorganic fertilizers enhanced nutrient availability throughout the crop growth period. FYM contributed to improved soil physical properties, microbial activity, and nutrient retention, while the inorganic fraction ensured readily available nutrients for immediate plant uptake. Such balanced nutrient dynamics not only promoted vigorous vegetative growth but also ensured better reproductive development and grain formation.

The present findings corroborate the reports of Rao and Nagamani (2022), Devi *et al.* (2021), and Patil *et al.* (2020), who also observed that integrated nutrient management significantly enhanced yield attributes and overall productivity of finger millet compared to sole inorganic or control treatments. Furthermore, the relatively better performance of 100% organic treatment (N_3) over the recommended dose of fertilizer (N_2) highlights the sustainable benefits of organic nutrient sources in maintaining soil fertility and long-term productivity.

Table 4.19(a): Grain yield plant^{-1} under different sowing dates and nutrient management system of finger millet

Treatments	Grain yield plant^{-1} (g)		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1^{st} June	5.24	4.85	5.05
D_2: 15^{th} June	5.41	5.27	5.33
D_3: 1^{st} July	5.47	5.42	5.43
SEm±	0.18	0.18	0.14
CD (P=0.05)	NS	NS	NS
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	3.14	2.91	3.03
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	5.62	5.55	5.58
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	5.66	6.09	5.88
N_4: 50% Inorganic + 50% Organic through FYM	7.08	6.15	6.61
SEm±	0.20	0.21	0.16
CD (P=0.05)	0.60	0.61	NS

Table 4.19(b): Interaction effect on grain yield plant^{-1} under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Grain yield plant^{-1} (g)		
	2023	**2024**	**Pooled**
T_1: D_1N_1	3.01	2.73	2.87
T_2: D_1N_2	5.67	5.00	5.34
T_3: D_1N_3	5.37	5.99	5.68
T_4: D_1N_4	6.94	5.67	6.30
T_5: D_2N_1	3.22	2.70	2.97
T_6: D_2N_2	5.45	6.03	5.73
T_7: D_2N_3	5.84	6.52	6.18
T_8: D_2N_4	7.14	5.80	6.47
T_9: D_3N_1	3.19	3.30	3.24
T_{10}: D_3N_2	5.73	5.61	5.67
T_{11}: D_3N_3	5.77	5.76	5.76
T_{12}: D_3N_4	7.17	6.97	7.07
SEm±	0.35	0.37	0.27
CD (P=0.05)	NS	NS	NS

4.1.3.2 Grain yield (kg ha^{-1})

Grain yield data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.20(a) and 4.20(b).

Effect of Sowing Dates (D)

The data presented reveal that the grain yield of finger millet was significantly influenced by sowing dates across both experimental years (2023 and 2024), as well as in the pooled analysis. During the year 2023, sowing on 1st July (D_3) produced the highest grain yield (1620.65 kg ha^{-1}), which was followed by 15th June (D_2) with 1580.64 kg ha^{-1}, while the lowest yield (1570.25 kg ha^{-1}) was obtained under 1st June sowing (D_1).

A similar pattern was evident in 2024, where the 1st July sowing (D_3) once again recorded the maximum yield (1514.51 kg ha^{-1}), followed by 15th June (D_2) with 1427.05 kg ha^{-1}, and the minimum yield (1222.97 kg ha^{-1}) was observed under 1st June (D_1). When data from both years were pooled, the highest mean grain yield (1567.58 kg ha^{-1}) was associated with D_3 (1st July), while D_2 (15th June) and D_1 (1st June) recorded 1503.84 kg ha^{-1} and 1396.61 kg ha^{-1}, respectively. These results clearly establish that delayed sowing (1st July) was more advantageous for maximizing yield compared to early sowing dates. The superior performance under late sowing might be attributed to favourable environmental synchronization, particularly in terms of temperature, humidity, and soil moisture, during the vegetative and reproductive stages, which likely promoted better panicle initiation, grain filling, and overall productivity.

Effect of Nutrient Management (N)

The results further indicate that nutrient management practices exerted a highly significant influence on the grain yield of finger millet during both the experimental years and in the pooled data. In 2023, the treatment involving N_4 (50% inorganic + 50% organic through FYM) recorded the highest yield (2156.90 kg ha^{-1}), which was statistically superior to all other treatments. This was followed by N_2 (RDF: 40:30:20 kg ha^{-1} N, P_2O_5, K_2O) and N_3 (100% organic through FYM) with yields of 1649.62 kg ha^{-1} and 1649.18 kg ha^{-1}, respectively, while the lowest yield (906.41 kg ha^{-1}) was observed in N_1 (control).

A comparable trend was observed in 2024, where N_4 again achieved the maximum yield (1744.01 kg ha^{-1}), followed by N_3 (1637.67 kg ha^{-1}) and N_2 (1478.40 kg ha^{-1}). The control treatment (N_1) remained the lowest (692.63 kg ha^{-1}). The pooled mean across both years confirmed the consistent superiority of N_4, producing 1950.45 kg ha^{-1}, whereas N_3 and N_2 recorded 1643.40 kg ha^{-1} and 1564.01 kg ha^{-1}, respectively. The minimum pooled yield (799.52 kg ha^{-1}) was again recorded in N_1. The remarkable increase in yield under integrated nutrient management (N_4) may be attributed to balanced and sustained nutrient availability from both organic and inorganic sources. The combination of farmyard manure (FYM) and chemical fertilizers enhances soil fertility, microbial activity, and nutrient use efficiency, leading to improved photosynthetic performance, assimilate translocation, and grain development.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D × N) exhibited a significant effect on grain yield during both years and in the pooled analysis. In 2023, the treatment combination T_{12} (D_3N_4: 1st July + 50% inorganic + 50% organic through FYM) recorded the highest grain yield (2176.42 kg ha^{-1}), closely followed by T_8 (D_2N_4: 15th June + 50% inorganic + 50% organic) with 2142.54 kg ha^{-1}, while the lowest yield (819.29 kg ha^{-1}) was recorded under T_1 (D_1N_1: 1st June + control).

A similar trend was observed during 2024, wherein T_{12} (D_3N_4) maintained its superiority (2068.69 kg ha^{-1}), followed by T_8 (D_2N_4) with 1698.98 kg ha^{-1}, and the minimum yield (591.17 kg ha^{-1}) was again obtained in T_1 (D_1N_1). The pooled data also reaffirmed this pattern, with T_{12} (D_3N_4) yielding the highest (2122.56 kg ha^{-1}), followed by T_8 (D_2N_4) (1920.76 kg ha^{-1}), while T_1 (D_1N_1) remained the lowest

(705.23 kg ha^{-1}). These observations collectively demonstrate that the combination of late sowing (1st July) with integrated nutrient management (50% inorganic + 50% organic) was the most effective practice for achieving maximum productivity in finger millet.

The findings of this study underline that both time of sowing and nutrient management strategies play a crucial role in determining the grain yield of finger millet. The superior performance of the 1st July sowing (D_3) may be attributed to the optimum temperature, adequate soil moisture, and favourable humidity conditions prevailing during critical growth phases such as panicle emergence, flowering, and grain filling. These conditions likely promoted efficient photosynthate utilization and improved grain weight. Conversely, early sowing (1st June) may have exposed the crop to elevated temperature and moisture stress, adversely impacting pollination and kernel development. Regarding nutrient management, the integrated nutrient approach (N_4) consistently produced the highest yields across both years and pooled data. This approach ensures a complementary effect wherein inorganic fertilizers provide readily available nutrients for early growth, while FYM supplies slow-release nutrients, improves soil physical properties, and supports beneficial microbial populations. This combination not only enhances nutrient uptake and efficiency but also contributes to sustainable soil health and long-term productivity.

The present results corroborate the findings of Rao *et al.* (2022), Devi *et al.* (2021 and Gautam *et al.* (2025) who reported that integrating organic and inorganic nutrient sources substantially improved grain yield and soil nutrient status in finger millet. Similarly, Patil *et al.* (2020) also emphasized that the inclusion of FYM along with chemical fertilizers significantly enhanced yield attributes due to improved soil–plant nutrient dynamics and synergistic nutrient availability.

Table 4.20(a): Grain yield ha^{-1} under different sowing dates and nutrient management system of finger millet

Treatments	Grain yield ha^{-1} (kg)		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1st June	1570.26	1222.98	1396.62
D_2: 15th June	1580.65	1427.05	1503.85
D_3: 1st July	1620.65	1514.52	1567.59
SEm±	53.22	47.76	38.54
CD (P=0.05)	156.10	140.09	113.04
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	906.41	692.64	799.53
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	1649.63	1478.40	1564.02
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	1649.14	1637.67	1643.41
N_4: 50% Inorganic + 50% Organic through FYM	2156.90	1744.01	1950.45
SEm±	61.45	55.15	109.77
CD (P=0.05)	180.25	161.77	44.50

Table 4.20(b): Interaction effect on grain yield ha^{-1} under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Grain yield ha^{-1} (kg)		
	2023	**2024**	**Pooled**
T$_1$: D_1N_1	819.30	591.17	705.23
T$_2$: D_1N_2	1666.89	1272.34	1469.62
T$_3$: D_1N_3	1643.10	1564.03	1603.56
T$_4$: D_1N_4	2151.74	1464.36	1808.04
T$_5$: D_2N_1	948.87	618.66	783.76
T$_6$: D_2N_2	1580.67	1629.32	1604.99
T$_7$: D_2N_3	1650.50	1761.24	1705.87
T$_8$: D_2N_4	2142.55	1698.98	1920.76
T$_9$: D_3N_1	951.07	868.08	909.57
T$_{10}$: D_3N_2	1701.33	1533.55	1617.44
T$_{11}$: D_3N_3	1653.82	1587.74	1620.78
T$_{12}$: D_3N_4	2176.42	2068.70	2122.56
SEm±	106.44	95.53	77.08
CD (P=0.05)	312.18	280.19	226.09

4.1.3.3 Straw yield (kg ha^{-1})

Straw yield data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.21(a) and 4.21(b).

The data presented reveal that straw yield of finger millet was markedly affected by sowing dates, nutrient management practices, and their interactions during both experimental years (2023 and 2024) as well as in the pooled mean.

Effect of sowing dates

In the year 2023, sowing on 1st July (D_3) recorded the maximum straw yield of 4331.83 kg ha^{-1}, which was statistically comparable with the 15th June sowing (D_2) that produced 4349.67 kg ha^{-1}, while the minimum yield (4386.75 kg ha^{-1}) was obtained under 1st June sowing (D_1).

A similar pattern was observed in 2024, where the highest straw yield (4110.00 kg ha^{-1}) was associated with 1st July sowing (D_3), followed by 15th June (D_2) with 3923.17 kg ha^{-1}, and the lowest (3364.42 kg ha^{-1}) under 1st June (D_1).

The pooled analysis demonstrated that delayed sowing on 1st July (D_3) produced the highest mean straw yield (4220.92 kg ha^{-1}), significantly surpassing both 15th June (4136.42 kg ha^{-1}) and 1st June (3875.58 kg ha^{-1}) sowings. The comparatively reduced yield in early-sown crops may be attributed to exposure to higher temperatures and intermittent moisture stress during the initial vegetative phase, which might have curtailed tillering and biomass accumulation. Conversely, the later sowing favored optimum vegetative growth, enhanced tiller production, and higher dry matter accumulation, leading to greater straw yield.

Effect of Nutrient Management

Straw yield was also significantly influenced by nutrient management regimes during both the cropping years. In 2023, the integrated nutrient treatment N_4

(50% inorganic + 50% organic through FYM) resulted in the highest straw yield (5901.44 kg ha^{-1}), followed by N_3 (100% organic through FYM) with 4512.44 kg ha^{-1} and N_2 (RDF: 40:30:20 kg ha^{-1} of N, P_2O_5, and K_2O) with 4535.67 kg ha^{-1}. The lowest yield (2474.78 kg ha^{-1}) was recorded in the control (N_1) treatment.

A consistent trend was observed in 2024, where N_4 again produced the maximum straw yield (4709.89 kg ha^{-1}), while N_1 (control) recorded the lowest (1951.67 kg ha^{-1}).

Pooled data across the two years indicated that N_4 remained superior with an average straw yield of 5305.67 kg ha^{-1}, followed by N_3 (4483.28 kg ha^{-1}) and N_2 (4308.39 kg ha^{-1}), whereas the control (N_1) continued to produce the least (2213.22 kg ha^{-1}). The improvement in straw yield under integrated nutrient management (N_4) may be attributed to the combined effect of inorganic fertilizers providing readily available nutrients and organic manure improving soil physical properties, microbial activity, and nutrient retention. This synergistic interaction likely enhanced plant vigor, nutrient uptake, and overall biomass production.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management exhibited significant variation in both years of experimentation. During 2023, the combination D_1N_4 (1st June × 50% inorganic + 50% organic FYM) recorded the maximum straw yield (6055.33 kg ha^{-1}), closely followed by D_3N_4 (1st July × 50% inorganic + 50% organic FYM) with 5855.00 kg ha^{-1}. The minimum yield (2277.00 kg ha^{-1}) was obtained in D_1N_1 (1st June × control). In 2024, a similar response was noted, with the highest straw yield (5557.33 kg ha^{-1}) under D_3N_4, while D_1N_1 again produced the lowest (1774.00 kg ha^{-1}).

The pooled mean revealed that the combination D_3N_4 remained superior (5706.17 kg ha^{-1}), followed by D_2N_4 (5219.00 kg ha^{-1}), and the lowest (2025.50 kg ha^{-1}) was registered under D_1N_1. The enhanced performance of the D_3N_4 treatment may be due to favorable climatic conditions during later sowing that supported better vegetative growth, along with a balanced and sustained nutrient supply through integrated nutrient management. This synergism promoted efficient photosynthetic activity and accumulation of dry matter, leading to higher straw yield.

The findings clearly demonstrate that both sowing time and nutrient management significantly influence straw yield in finger millet. The superiority of later sowing (1st July) can be attributed to extended vegetative growth, better tiller formation, and increased leaf area index, all of which enhance light interception and photosynthate production. Early sowing, on the other hand, may expose the crop to higher temperature regimes, thereby reducing vegetative development and total biomass accumulation.

Regarding nutrient management, the integrated application of organic and inorganic sources (N_4) proved most effective in maximizing straw yield. This could be due to the complementary role of organic manures, such as FYM, in improving soil microbial population, nutrient-holding capacity, and structural stability, while inorganic fertilizers supply readily available nutrients essential for early crop establishment and sustained growth. Such a balanced approach ensures continuous nutrient availability throughout the crop growth period, resulting in enhanced biomass production.

These observations corroborate the reports of Devi *et al.* (2021), Patil *et al.* (2020) and Aliveni *et al.* (2021), who found that the integrated use of organic and inorganic nutrient sources significantly improved dry matter accumulation and overall biomass yield in millets.

Table 4.21(a): Straw yield ha^{-1} under different sowing dates and nutrient management system of finger millet

Treatments	Straw yield (kg ha^{-1})		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1st June	4386.75	3364.42	3875.58
D_2: 15th June	4349.67	3923.17	4136.42
D_3: 1st July	4331.83	4110.00	4220.92
SEm±	168.53	136.59	117.84
CD (P=0.05)	494.32	400.64	345.65
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	2474.78	1951.67	2213.22
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	4535.67	4081.11	4308.39
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	4512.44	4454.11	4483.28
N_4: 50% Inorganic + 50% Organic through FYM	5901.44	4709.89	5305.67
SEm±	194.60	157.72	136.07
CD (P=0.05)	570.79	462.61	399.11

Table 4.21(b): Interaction effect on straw yield ha^{-1} under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Straw yield (kg ha^{-1})		
	2023	2024	Pooled
T_1: D_1N_1	2277.00	1774.00	2025.50
T_2: D_1N_2	4597.00	3550.67	4073.83
T_3: D_1N_3	4617.67	4204.67	4411.17
T_4: D_1N_4	6055.33	3928.33	4991.83
T_5: D_2N_1	2715.33	1658.00	2186.67
T_6: D_2N_2	4377.33	4454.33	4415.83
T_7: D_2N_3	4512.00	4936.33	4724.17
T_8: D_2N_4	5794.00	4644.00	5219.00
T_9: D_3N_1	2432.00	2423.00	2427.50
T_{10}: D_3N_2	4632.67	4238.33	4435.50
T_{11}: D_3N_3	4407.67	4221.33	4314.50
T_{12}: D_3N_4	5855.00	5557.33	5706.17
SEm±	337.06	273.18	235.69
CD (P=0.05)	988.62	801.27	892.65

4.1.3.4 Harvest Index (%)

Harvest index data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.22(a) and 4.22(b).

The data summarized indicate that the harvest index (HI) of finger millet was marginally affected by sowing dates and nutrient management during both experimental years (2023 and 2024) as well as in the pooled mean. Although some differences were not statistically significant, distinct trends were evident across treatments.

Effect of sowing dates

In the year 2023, the crop sown on 1st July (D_3) recorded the highest harvest index (27.38%), followed by 15th June (D_2) with 26.58%, while the lowest (26.36%) was observed under 1st June sowing (D_1). A comparable trend continued in 2024, where D_3 again exhibited the maximum HI (26.841%), followed by D_2 (26.78%), and the minimum value (26.43%) was noted under D_1. The pooled mean further confirmed the superiority of 1st July sowing (D_3), which recorded a slightly higher harvest index (27.11%) compared to 15th June (D_2) (26.68%) and 1st June (D_1) (26.40%). The marginal advantage of delayed sowing may be attributed to favorable weather during the reproductive stage, which likely promoted efficient grain filling and improved the ratio of grain to total biomass production.

Effect of Nutrient Management

Nutrient management practices also exerted a subtle but measurable influence on the harvest index during both years and in the combined analysis. In 2023, the maximum HI (26.89%) was obtained in the control (N_1), closely followed by N_3 (100% organic through FYM) (26.76%) and N_2 (RDF: 40:30:20 kg ha^{-1} of N, P_2O_5, K_2O) (26.63%). The minimum HI (26.82%) was recorded under N_4 (50% inorganic + 50% organic through FYM), although the variation among treatments was relatively minor.

In 2024, the scenario slightly changed, with the highest HI (27.02%) observed under N_4, followed by N_3 (26.94%), whereas the control (N_1) registered the lowest value (26.18%). On a pooled basis, the integrated nutrient treatment N_4 continued to show the maximum mean HI (26.92%), followed closely by N_3 (26.85%) and N_2 (26.62%), while the minimum (26.53%) was associated with N_1 (control). The modest improvement under N_4 might be explained by the complementary benefits of combined nutrient sources, which ensured both immediate and sustained nutrient availability, enhancing photosynthetic efficiency and assimilate partitioning towards the grains.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D×N) revealed non-significant but notable variations in harvest index across years.

During 2023, the highest HI (28.26%) was recorded under D_3N_1 (1st July × Control), followed by D_3N_4 (27.23%) and D_3N_3 (27.21%), while the lowest (25.95%) was obtained from D_2N_1 (15th June × Control). In 2024, the combination D_3N_3 (1st July × 100% organic through FYM) produced the highest HI (27.35%), closely followed by D_1N_4 (27.17%), whereas the lowest value (24.93%) was recorded under D_1N_1 (1st June × Control).

The pooled mean indicated a similar pattern, with the highest HI (27.28%) achieved under D_3N_3 (1st July × 100% organic through FYM), followed by D_3N_4 (27.18%), while D_1N_1 (1st June × Control) registered the lowest (25.69%). These results suggest that late sowing, when combined with organic or integrated nutrient sources, may improve the physiological efficiency of assimilate distribution, leading to a higher harvest index even if the differences are not statistically significant.

The minor yet consistent variation in harvest index across sowing dates appears to be primarily influenced by environmental factors affecting biomass accumulation and assimilate partitioning. The relatively higher HI observed under 1st July sowing (D_3) can be attributed to more favorable weather conditions during the grain filling stage, promoting effective translocation of assimilates to the reproductive organs. Conversely, the lower HI under early sowing (D_1) may have resulted from thermal stress during the vegetative phase, which could have hampered grain filling and reduced the proportion of grain in total dry matter.

With regard to nutrient management, the integrated application of organic and inorganic sources (N_4) slightly enhanced the harvest index. This improvement may be due to the combined benefits of organic manure, which enriches soil structure, microbial activity, and water-holding capacity, along with inorganic fertilizers that provide an immediate nutrient supply. The complementary action of these nutrient sources ensures balanced growth and efficient partitioning of assimilates toward the grain rather than vegetative tissues.

Although the differences in harvest index among treatments were not large enough to reach statistical significance, the consistent trend implies that a balanced nutrient regime coupled with an appropriate sowing time can enhance the physiological efficiency of the crop.

These findings are in close agreement with the observations of Kumar *et al.* (2022), Devi (2021), and Manish *et al.* (2021), who reported that balanced and integrated nutrient management practices improve dry matter distribution toward reproductive parts, thereby slightly enhancing the harvest index in millets.

Table 4.22(a): Harvest index (HI) under different sowing dates and nutrient management system of finger millet

Treatments	Harvest index (%)		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1st June	26.37	26.44	26.40
D_2: 15th June	26.59	26.78	26.69
D_3: 1st July	27.39	26.84	27.12
SEm±	0.24	0.22	0.16
CD (P=0.05)	0.71	NS	NS
Nutrient management (N)			
	2023	2024	**Pooled**
N_1: Control (No fertilizer)	26.89	26.19	26.53
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	26.63	26.61	26.63
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	26.77	26.94	26.86
N_4: 50% Inorganic + 50% Organic through FYM	26.83	27.02	26.93
SEm±	0.28	0.26	0.19
CD (P=0.05)	NS	NS	NS

Table 4.22(b): Interaction on harvest index (HI) under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Harvest index (%)		
	2023	2024	Pooled
T_1: D_1N_1	26.45	24.94	25.69
T_2: D_1N_2	26.54	26.47	26.51
T_3: D_1N_3	26.27	27.16	26.71
T_4: D_1N_4	26.21	27.18	26.69
T_5: D_2N_1	25.96	27.32	26.64
T_6: D_2N_2	26.52	26.77	26.64
T_7: D_2N_3	26.82	26.30	26.56
T_8: D_2N_4	27.03	26.76	26.90
T_9: D_3N_1	28.27	26.31	27.28
T_{10}: D_3N_2	26.84	26.60	26.72
T_{11}: D_3N_3	27.21	27.35	27.29
T_{12}: D_3N_4	27.23	27.13	27.19
SEm±	0.48	0.45	0.33
CD (P=0.05)	NS	NS	NS

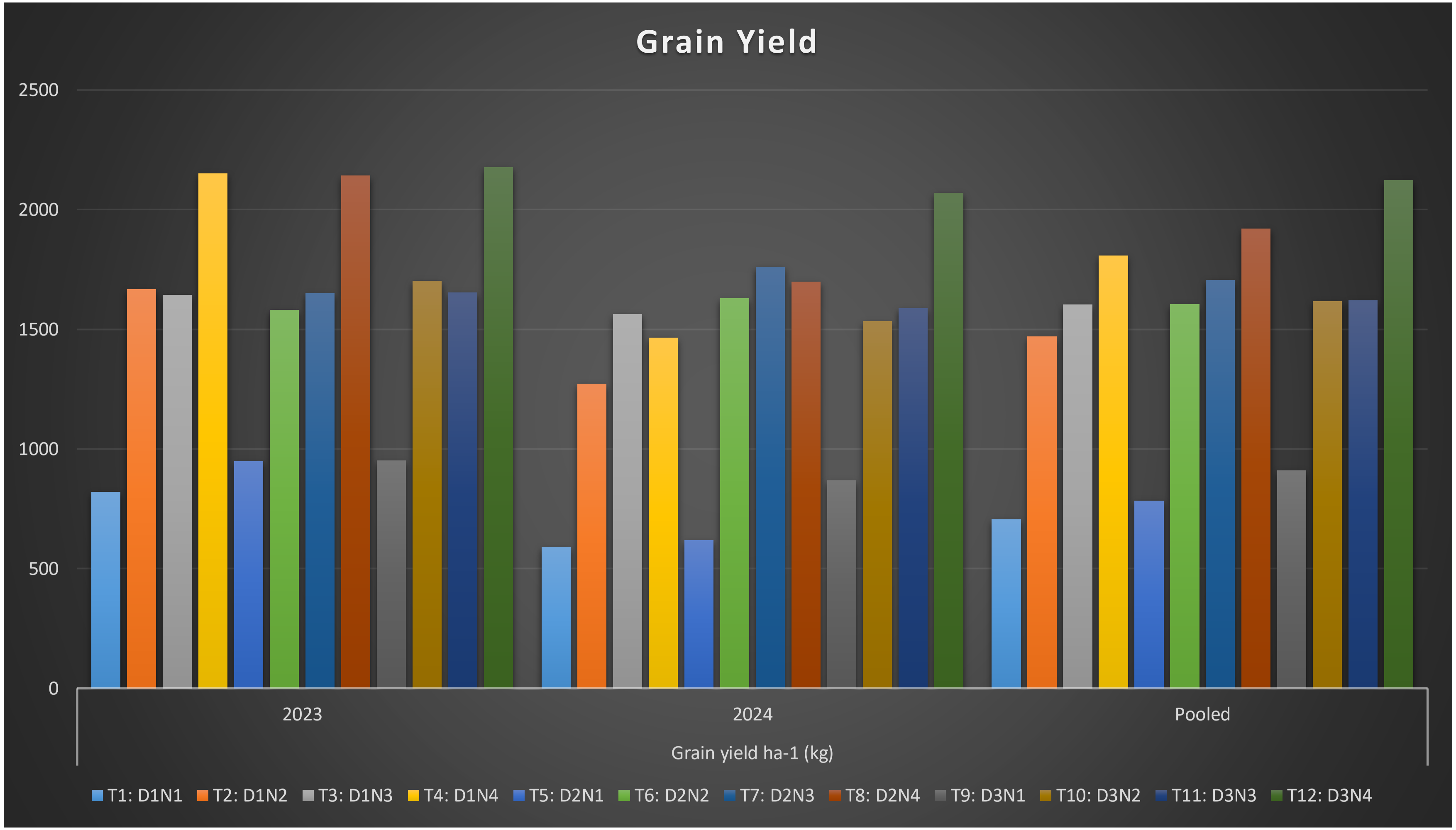


Fig. 4.4 Effect of different sowing dates and nutrient management on Grain yield (kg ha^{-1})

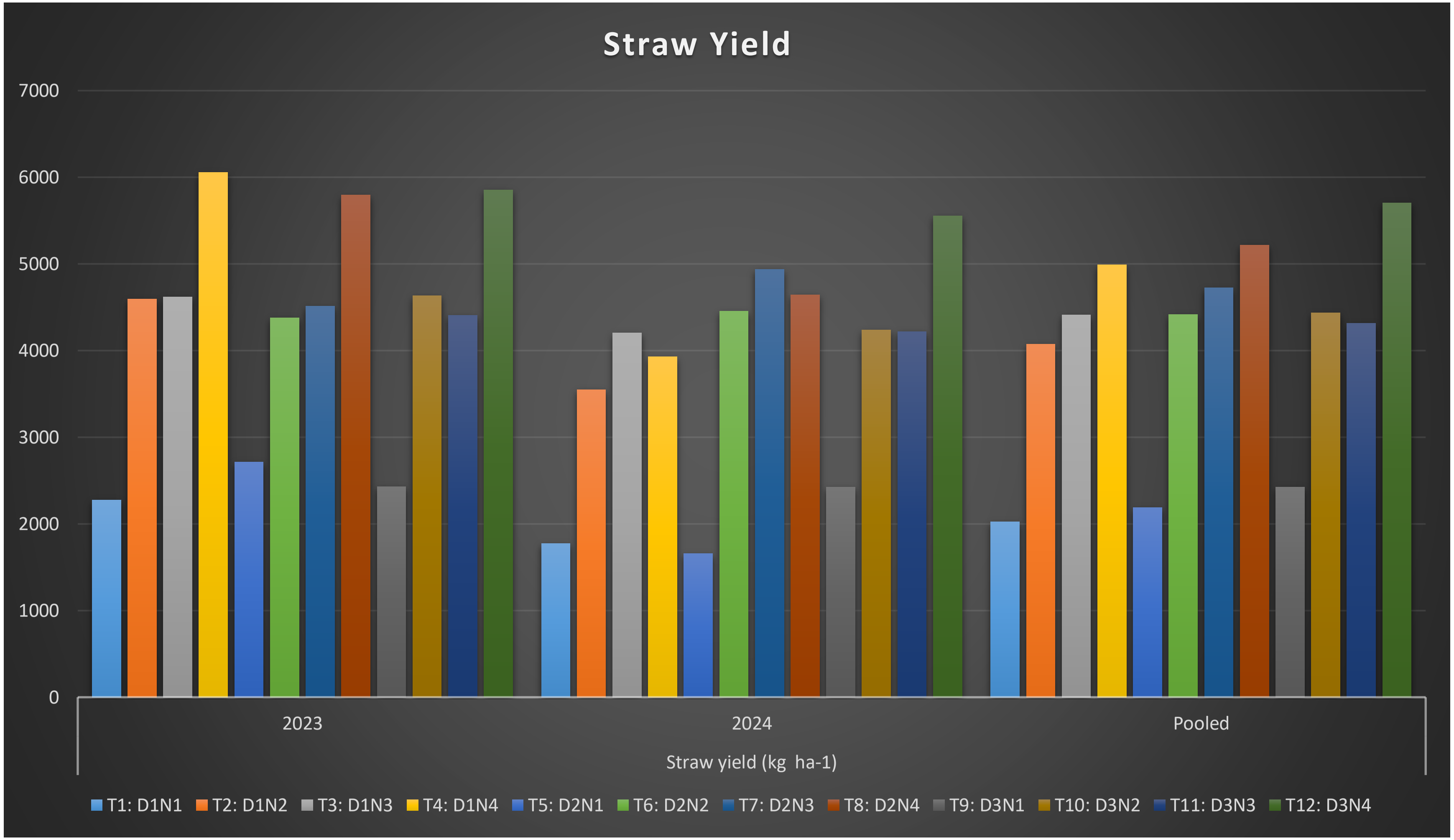


Fig. 4.5 Effect of different sowing dates and nutrient management on Straw yield (kg ha^{-1})

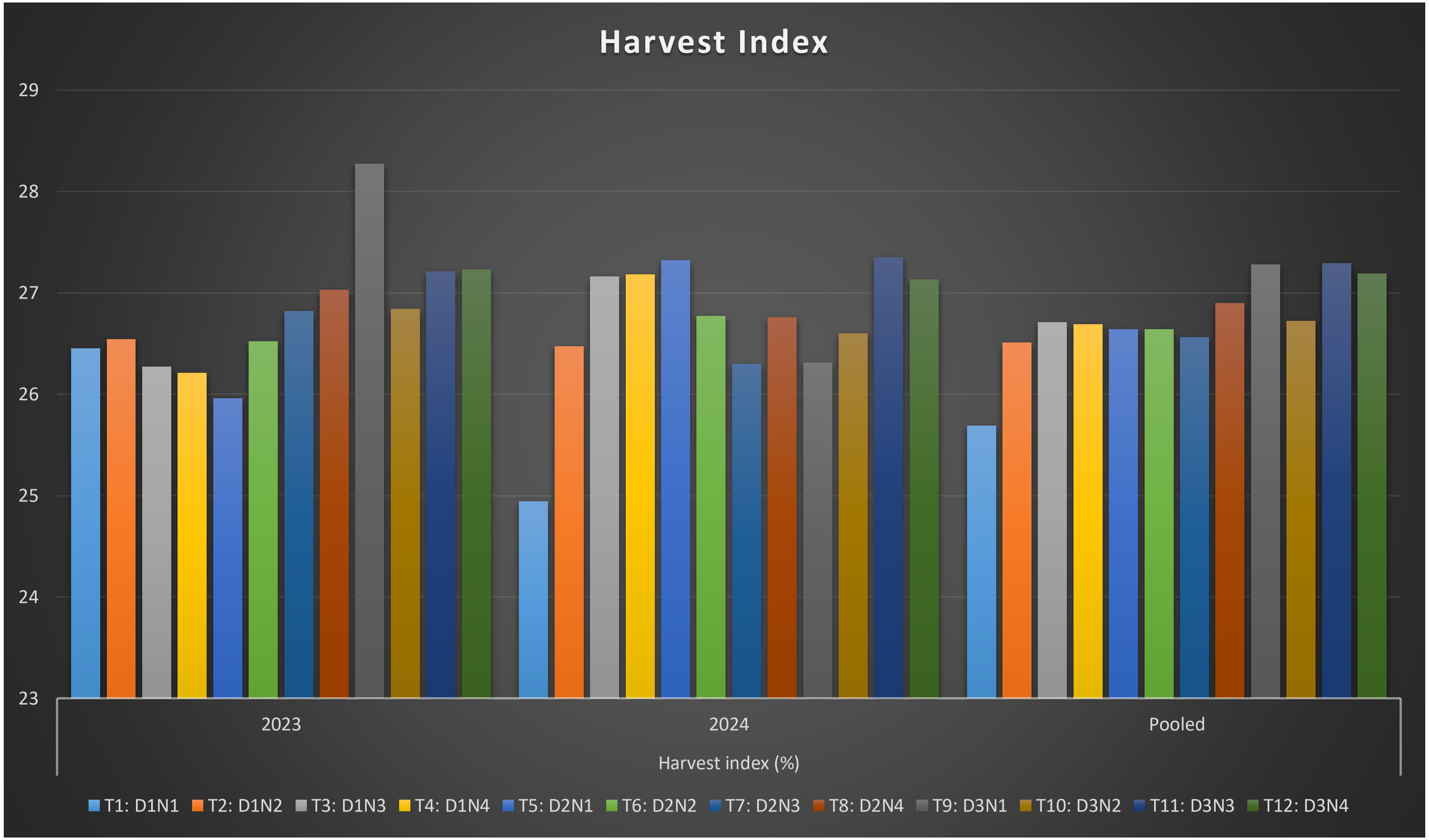


Fig. 4.6 Effect of different sowing dates and nutrient management on Harvest Index (%)

4.1.4 Quality analysis

4.1.4.1 Crude protein content (%)

Crude protein content data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.23(a) and 4.23(b).

The data presented revealed that the crude protein content of finger millet was significantly influenced by sowing dates, nutrient management practices, and their interaction effects during both years of the study (2023 and 2024).

In 2023, the crude protein content ranged between 6.22% and 6.77% across the sowing dates. The highest protein concentration (6.77%) was recorded under the 1st July sowing (D_3), followed by 1st June sowing (D_1) with 6.66%, while the lowest value (6.22%) was observed under 15th June sowing (D_2).

A similar response was noted in 2024, where the protein content varied from 6.311% to 6.72%. The 1st July sowing (D_3) again produced the highest value (6.72%), whereas D_2 (15th June) exhibited the minimum (6.31%). With respect to nutrient management, in 2023, the treatment N_3 (100% organic through FYM) registered the highest crude protein content (7.13%), followed by N_4 (50% inorganic + 50% organic through FYM) with 6.54%. The lowest value (6.06%) was obtained under the control (N_1). The same trend persisted in 2024, where N_3 (100% organic) maintained its superiority (7.05%), while the control (N_1) once again recorded the lowest protein content (6.20%).

The pooled mean over both years confirmed a consistent effect of sowing time and nutrient management on the crude protein content of finger millet. Among the sowing dates, the 1st July sowing (D_3) exhibited the highest mean crude protein value (6.75%), followed by 1st June (D_1) with 6.63%, whereas the lowest value (6.26%) was observed in 15th June sowing (D_2). Under nutrient management, the 100% organic through FYM (N_3) treatment recorded the maximum pooled crude protein content (7.09%), followed by N_4 (50% inorganic + 50% organic) (6.47%) and

N_2 (RDF: 40:30:20 kg ha^{-1} of N, P_2O_5, and K_2O) (6.50%). The minimum pooled mean (6.131%) was obtained under the control (N_1). The superiority of N_3 indicates that the slow and sustained release of nutrients from organic sources contributed to improved nitrogen assimilation and protein synthesis in grains.

Interaction Effect (D × N)

A significant interaction effect between sowing dates and nutrient management treatments (D×N) was observed for crude protein content during both years as well as in the pooled data.

In 2023, the combination D_3N_3 (1st July × 100% organic FYM) registered the highest protein content (7.363%), whereas the minimum (5.51%) was observed under D_2N_4 (15th June × 50% inorganic + 50% organic). A similar response was noted in 2024, where D_3N_3 again recorded the maximum (7.23%) and D_2N_4 the minimum (5.41%).

The pooled mean revealed that D_3N_3 consistently maintained the highest crude protein content (7.296%), followed by D_3N_4 (7.015%) and D_1N_3 (7.040%), while the lowest (5.466%) was obtained from D_2N_4. The superior performance of D_3N_3 emphasizes that late sowing in combination with full organic nutrient management created the most favorable conditions for nitrogen uptake and protein formation in finger millet grains.

The results clearly demonstrated that both sowing time and nutrient management exerted a substantial influence on the crude protein content of finger millet. The higher protein content observed under late sowing (1st July) could be attributed to favorable temperature and moisture conditions during the reproductive and grain-filling stages, which may have enhanced nitrogen assimilation and enzymatic activity associated with protein synthesis.

Conversely, early and mid-June sowings likely encountered relatively higher temperatures and possible moisture stress, reducing nitrogen metabolism efficiency and protein accumulation in the grains. The marked improvement in protein content under 100% organic nutrient management (N_3) can be explained by the continuous and balanced release of nutrients, particularly nitrogen, from farmyard manure (FYM). Organic manures also enhance soil organic carbon, microbial population, and enzymatic activities, which collectively improve nutrient mineralization and uptake. This steady nutrient supply during the critical stages of grain filling contributes to higher protein synthesis and accumulation. The integrated nutrient management treatment (N_4) also maintained relatively higher protein levels compared to purely inorganic fertilizer application. This synergistic effect arises from the combination of organic inputs improving soil structure and microbial activity, while inorganic fertilizers ensure immediate nutrient availability, together promoting efficient nutrient utilization by the crop.

The interaction results further emphasized that the combination of delayed sowing (1st July) with 100% organic nutrition (D_3N_3) was most effective in achieving higher crude protein content. This suggests that an optimal sowing window, coupled with organic or integrated nutrient supply, provides a balanced physiological and soil environment conducive to enhanced protein biosynthesis in finger millet.

The present findings are in agreement with those reported by Amarjeet *et al.* (2021), Reddy *et al*. (2020), Mathyam *et al*. (2023), who also observed that organic and integrated nutrient management systems significantly improved grain protein content in millets by enhancing nitrogen availability, uptake efficiency, and assimilation processes.

Table 4.23(a): Crude protein content under different sowing dates and nutrient management system of finger millet

Treatments	Crude protein content (%)		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1^{st} June	6.66	6.61	6.63
D_2: 15^{th} June	6.22	6.31	6.26
D_3: 1^{st} July	6.77	6.73	6.76
SEm±	0.06	0.09	0.05
CD (P=0.05)	0.16	0.28	0.15
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	6.06	6.21	6.13
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	6.48	6.52	6.50
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	7.13	7.05	7.09
N_4: 50% Inorganic + 50% Organic through FYM	6.54	6.42	6.47
SEm±	0.07	0.11	0.06
CD (P=0.05)	0.20	0.31	0.18

Table 4.23(b): Interaction effect on Crude protein content under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Crude protein content (%)		
	2023	2024	Pooled
T_1: D_1N_1	5.80	5.73	5.77
T_2: D_1N_2	6.44	6.62	6.53
T_3: D_1N_3	7.36	7.23	7.30
T_4: D_1N_4	7.03	6.88	6.96
T_5: D_2N_1	6.30	6.86	6.58
T_6: D_2N_2	6.06	6.10	6.08
T_7: D_2N_3	7.00	6.88	6.94
T_8: D_2N_4	5.52	5.42	5.47
T_9: D_3N_1	6.08	6.03	6.05
T_{10}: D_3N_2	6.93	6.85	6.89
T_{11}: D_3N_3	7.03	7.04	7.04
T_{12}: D_3N_4	7.07	6.96	7.02
SEm±	0.11	0.19	0.10
CD (P=0.05)	0.33	0.55	0.30

4.1.4.2 Carbohydrate content (%)

Carbohydrate content data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.24(a) and 4.24(b).

The data presented revealed that the carbohydrate content of finger millet grains was significantly influenced by sowing dates, nutrient management practices, and their interaction effects during both years of study (2023 and 2024).

During 2023, the carbohydrate content varied between 63.05% and 63.88% across the sowing dates. The crop sown on 15th June (D_2) recorded the maximum carbohydrate content (63.87%), closely followed by 1st June (D_1) with 63.61%, while the lowest value (63.05%) was obtained under 1st July (D_3) sowing. A similar pattern was evident in 2024, wherein the carbohydrate content ranged from 61.33% to 64.43%, with the highest content (64.43%) noted under D_1 (1st June) and the lowest (61.33%) under D_3 (1st July).

Under nutrient management, in 2023, the treatment receiving 100% organic nutrients through FYM (N_3) resulted in the highest carbohydrate content (66.33%), followed by the integrated nutrient treatment (N_4: 50% inorganic + 50% organic) with 65.48%, whereas the control treatment (N_1) recorded the lowest value (59.26%). The same trend persisted in 2024, where the N_3 treatment again registered the highest carbohydrate content (65.72%), and the control (N_1) remained the lowest at 60.77%.

Pooled data from both years were pooled, the effect of sowing dates and nutrient management on carbohydrate content remained consistent and significant. Among sowing dates, D_2 (15th June) recorded the highest mean carbohydrate content (64.10%), followed closely by D_1 (1st June) with 64.026%, while the lowest pooled mean (62.19%) was observed under D_3 (1st July).

With respect to nutrient management, the N_3 treatment (100% organic through FYM) exhibited the maximum pooled carbohydrate content (66.03%), followed by N_4 (50% inorganic + 50% organic) with 64.97%, and N_2 (RDF: 40:30:20

kg ha^{-1} N, P_2O_5, K_2O) with 62.731%. The lowest pooled mean (60.02%) was recorded in the control (N_1) treatment, indicating the importance of nutrient supplementation in improving carbohydrate accumulation.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D × N) revealed a significant effect on the carbohydrate content of finger millet during both experimental years as well as in the pooled analysis.

In 2023, the maximum carbohydrate content (66.87%) was observed in T_4 (D_1N_4: 1st June sowing with 50% inorganic + 50% organic nutrients), which was statistically at par with T_3 (D_1N_3) having 65.77%, while the lowest value (57.27%) occurred under T_1 (D_1N_1), i.e., 1st June sowing without fertilizer.

Similarly, in 2024, the highest carbohydrate content (67.50%) was recorded under T_3 (D_1N_3) and the lowest (57.20%) in T_9 (D_3N_1), representing 1st July sowing without any nutrient application.

The pooled data also exhibited a consistent pattern, where T_3 (D_1N_3) produced the highest carbohydrate content (66.63%), followed by T_4 (D_1N_4) with 66.52% and T_{11} (D_3N_3) with 66.00%, while the lowest pooled value (57.390%) was found under T_9 (D_3N_1).

The findings clearly demonstrate that both sowing time and nutrient management play a pivotal role in determining the carbohydrate concentration of finger millet grains. The mid-June sowing (D_2) consistently resulted in higher carbohydrate accumulation, likely due to favorable temperature and moisture conditions during critical vegetative and reproductive phases, which enhanced photosynthetic activity and assimilate partitioning towards the developing grains. Conversely, delayed sowing (D_3) might have experienced suboptimal climatic conditions, adversely affecting photosynthesis and carbohydrate synthesis.

The superior performance of 100% organic manure (FYM) in enhancing carbohydrate content can be attributed to its slow and sustained nutrient release, improved soil microbial activity, and better nutrient uptake efficiency. The improvement in soil structure and water-holding capacity under organic management may have further contributed to enhanced carbohydrate accumulation in the grains.

Similarly, the integrated nutrient management (N_4) system exhibited relatively higher carbohydrate content compared to inorganic fertilizer alone, emphasizing the synergistic benefit of combining organic and inorganic sources, ensuring both immediate nutrient supply and long-term soil fertility improvement.

The interaction effect ($D \times N$) confirmed that combining the optimum sowing time (15th June) with balanced nutrient application, particularly organic or integrated nutrient sources, resulted in maximum carbohydrate accumulation.

These findings are in agreement with the reports of Reddy *et al*. (2020), Mathyam *et al*. (2023), and Devi *et al.* (2021), who also observed superior carbohydrate content in finger millet and other cereals under organic and integrated nutrient management practices as compared to conventional inorganic fertilization.

Table 4.24(a): Carbohydrate content under different sowing dates and nutrient management system of finger millet

Treatments	Carbohydrate content (%)		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1^{st} June	63.61	64.43	64.03
D_2: 15^{th} June	63.88	64.33	64.10
D_3: 1^{st} July	63.05	61.34	62.19
SEm±	0.31	0.23	0.20
CD (P=0.05)	0.90	0.69	0.57
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	59.26	60.78	60.03
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	62.97	62.49	62.73
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	66.33	65.73	66.04
N_4: 50% Inorganic + 50% Organic through FYM	65.48	64.46	64.97
SEm±	0.35	0.27	0.23
CD (P=0.05)	1.04	0.78	0.66

Table 4.24(b): Interaction effect on carbohydrate content under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Carbohydrate content (%)		
	2023	2024	Pooled
T$_1$: D_1N_1	57.28	61.21	59.24
T$_2$: D_1N_2	64.54	62.87	63.70
T$_3$: D_1N_3	65.77	67.50	66.64
T$_4$: D_1N_4	66.87	66.17	66.52
T$_5$: D_2N_1	62.94	63.92	63.44
T$_6$: D_2N_2	62.25	64.28	63.26
T$_7$: D_2N_3	66.06	64.84	65.46
T$_8$: D_2N_4	64.25	64.25	64.24
T$_9$: D_3N_1	57.57	57.20	57.39
T$_{10}$: D_3N_2	62.14	60.31	61.23
T$_{11}$: D_3N_3	67.17	64.84	66.01
T$_{12}$: D_3N_4	65.32	62.97	64.15
SEm±	0.61	0.46	0.39
CD (P=0.05)	1.78	1.37	1.16

4.1.4.3 Crude fiber content (%)

Carbohydrate content data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.25(a) and 4.25(a).

The data presented indicated that the crude fiber content of finger millet grains was significantly influenced by sowing dates, nutrient management treatments, and their interaction (D×N) during both years of experimentation (2023 and 2024).

In 2023, the crude fiber content varied from 3.87% to 4.09% among different sowing dates. The highest fiber content (4.09%) was recorded when the crop was sown on 1st July (D_3), followed by 15th June (D_2) with 4.07%, whereas the lowest value (3.878%) was observed under 1st June (D_1) sowing.

A similar trend persisted in 2024, where the crude fiber content ranged between 3.58% and 4.05%. The D_3 treatment (1st July) again recorded the maximum value (4.053%), while the minimum (3.58%) was noted under D_1 (1st June). Under nutrient management, in 2023, the treatment receiving 100% organic nutrients through FYM (N_3) produced the highest crude fiber content (4.25%), followed by N_4 (50% inorganic + 50% organic) with 4.09%, whereas the lowest (3.72%) was obtained from the control (N_1).

A comparable pattern was observed in 2024, with N_4 recording the highest value (4.06%), followed by N_3 (3.98%), and the lowest (3.388%) again found under N_1 (control).

The pooled analysis of both years revealed a consistent and significant influence of sowing dates and nutrient management practices on the crude fiber content of finger millet. Among sowing dates, the highest pooled mean crude fiber content (4.07%) was obtained under D_3 (1st July), followed by D_2 (15th June) with 3.94%, while the lowest pooled mean (3.72%) was observed under D_1 (1st June). With regard to nutrient management, the N_4 treatment (50% inorganic + 50% organic) recorded the maximum pooled mean fiber content (4.08%), followed closely by N_3 (100% organic through FYM) with 4.06%, and N_2 (RDF: 40:30:20 kg ha^{-1} of N, P_2O_5, and K_2O) with 3.95%. The lowest pooled mean value (3.554%) was noted under the control (N_1) treatment.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D×N) exhibited significant variations in crude fiber content during both individual years and in the pooled mean.

In 2023, the highest crude fiber content (4.41%) was registered under T_{11} (D_3N_3), i.e., 1st July sowing with 100% organic manure, followed by T_6 (D_2N_2) with 4.34% and T_4 (D_1N_4) with 4.07%. The lowest value (3.50%) was recorded under T_1 (D_1N_1) (1st June sowing with no fertilizer).

A similar pattern was noticed in 2024, where T_{11} (D_3N_3) again produced the highest fiber content (4.52%), while the lowest (2.91%) was obtained under T_1 (D_1N_1).

The pooled data across both years reaffirmed these trends. The maximum pooled fiber content (4.466%) was recorded under T_{11} (D_3N_3), followed by T_6 (D_2N_2) with 4.14%, and T_8 (D_2N_4) with 4.10%, while the minimum pooled value (3.21%) was observed in T_1 (D_1N_1).

The results of the present investigation clearly demonstrate that both sowing time and nutrient management significantly influenced the crude fiber content of finger millet.

The higher crude fiber content associated with late sowing (1st July) may be attributed to the extended vegetative phase and enhanced lignification of cell walls under slightly cooler and more humid conditions. Such environments are known to promote the accumulation of structural carbohydrates, including cellulose and hemicellulose, thereby increasing overall fiber levels.

In contrast, early sowing (1st June) exposed the crop to higher temperatures, leading to faster growth and lesser fiber deposition in plant tissues.

Regarding nutrient management, the organic manure (100% FYM) and integrated nutrient management (N_4) treatments consistently enhanced crude fiber content compared to inorganic or control plots. The improvement can be linked to the gradual and sustained nutrient release from organic sources, enriched soil microbial activity, and better soil physical conditions, all of which support continuous nutrient uptake and structural biomass synthesis. The combined application of organic and inorganic sources (N_4) maintained higher fiber accumulation, highlighting the advantage of balanced nutrient availability throughout crop growth.

The interaction effect (D_3N_3) proved to be particularly significant, as the combination of late sowing (1st July) and 100% organic manure (FYM) produced the highest fiber content, suggesting that favorable climatic conditions coupled with organic nutrient availability optimize fiber biosynthesis and deposition in grains.

These results are in close agreement with the findings of Devi (2021), Amarjeet *et al.* (2021) and Vijay Kumar *et al* (2025) who also reported that organic and integrated nutrient practices not only enhance crude fiber content but also improve the overall nutritional quality of millets through improved soil fertility, microbial dynamics, and nutrient-use efficiency.

Table 4.25(a): Crude fiber content under different sowing dates and nutrient management system of finger millet

Treatments	Crude fiber content (%)		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1^{st} June	3.88	3.58	3.72
D_2: 15^{th} June	4.08	3.81	3.95
D_3: 1^{st} July	4.10	4.05	4.08
SEm±	0.03	0.03	0.02
CD (P=0.05)	0.09	0.09	0.05
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	3.72	3.39	3.55
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	3.98	3.93	3.96
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	4.25	3.88	4.07
N_4: 50% Inorganic + 50% Organic through FYM	4.10	4.06	4.08
SEm±	0.04	0.04	0.02
CD (P=0.05)	0.11	0.11	0.06

Table 4.25(b): Interaction effect on Crude fiber content under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Crude fiber content (%)		
	2023	2024	Pooled
T_1: D_1N_1	3.51	2.91	3.21
T_2: D_1N_2	3.71	3.77	3.73
T_3: D_1N_3	4.19	3.56	3.88
T_4: D_1N_4	4.08	4.08	4.08
T_5: D_2N_1	3.77	3.55	3.66
T_6: D_2N_2	4.34	3.96	4.14
T_7: D_2N_3	4.15	3.55	3.85
T_8: D_2N_4	4.02	4.19	4.11
T_9: D_3N_1	3.88	3.70	3.79
T_{10}: D_3N_2	3.89	4.07	3.97
T_{11}: D_3N_3	4.41	4.52	4.47
T_{12}: D_3N_4	4.19	3.92	4.06
SEm±	0.06	0.07	0.04
CD (P=0.05)	0.19	0.19	0.12

4.1.4.4 Calcium content (%)

Carbohydrate content data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.26(a) and 4.26(b). The calcium content of finger millet grains was markedly affected by different sowing dates during both years of experimentation (2023 and 2024) as well as in the pooled mean data.

In 2023, sowing on 1st July (D_3) resulted in the highest calcium concentration (1.43%), which was followed by 15th June (D_2) with 1.28%, while the lowest calcium content (1.07%) was observed under 1st June (D_1). A similar pattern was observed in 2024, wherein D_3 (1st July) again exhibited the maximum calcium content (1.44%), while D_1 (1st June) showed the minimum (1.148%). When the data were pooled across both years, sowing on 1st July (D_3) continued to record the highest mean calcium content (1.44%), which was significantly superior to D_2 (1.31%) and D_1 (1.10%). These results suggest that delayed sowing toward early July creates favorable conditions for calcium accumulation in finger millet grains, possibly due to more conducive temperature and soil moisture conditions during the crop's reproductive phase. Nutrient management practices significantly influenced calcium content during both years of study and in the pooled mean. During 2023, application of 100% organic nutrients through FYM (N_3) produced the highest calcium content (1.42%), followed by the integrated treatment (N_4: 50% inorganic + 50% organic through FYM) with 1.37%, whereas the lowest content (1.06%) was obtained under the control (N_1). A comparable trend was recorded in 2024, where N_3 (100% organic) registered the maximum calcium content (1.42%), and the control (N_1) the minimum (1.13%). In the pooled mean, N_3 (100% organic through FYM) achieved the highest calcium content (1.42%), which was statistically on par with N_4 (1.38%), while the lowest (1.09%) was noted in the control (N_1). The results clearly emphasize that organic nutrient sources substantially enhance calcium accumulation in finger millet grains due to improved soil fertility and biological activity.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D × N) was statistically significant during both years as well as in the pooled mean. In 2023, the combination of D_3N_3 (1st July × 100% organic through FYM) produced the highest calcium content (1.62%), closely followed by D_3N_4 (1st July × 50% inorganic + 50% organic) with 1.56%, whereas the lowest (0.98%) was recorded under D_1N_1 (1st June × control). Similarly, in 2024, D_3N_3 again outperformed all other treatments with 1.660% calcium, while D_1N_1 exhibited the lowest (1.04%). Upon pooling the data, D_3N_3 (1st July × 100% organic through FYM) maintained the highest mean calcium content (1.64%), followed by D_3N_4 (1.56%), and the lowest (1.01%) was again observed under D_1N_1. This clearly indicates that late sowing combined with organic nutrient management, especially 100% FYM application, markedly enhances calcium enrichment in finger millet grains.

The experimental findings indicate that both sowing time and nutrient management significantly influenced calcium accumulation in finger millet. The enhanced calcium concentration under late sowing (1st July) could be attributed to more favorable agro-climatic conditions during the grain-filling stage, such as moderate temperature and better soil moisture retention, which promote efficient nutrient uptake and translocation. Furthermore, the superior performance of organic nutrient management (100% FYM) may be explained by improvements in soil structure, microbial population, and nutrient mineralization rate, leading to better nutrient availability throughout crop growth. The integrated nutrient management approach (50% inorganic + 50% organic) also produced notable improvement, underscoring the importance of balanced nutrient supply through both organic and inorganic sources to sustain soil health and enhance grain quality. These observations are in accordance with the findings of and Rao and Nagamani (2022), Vijay Kumar *et al* (2025) who reported enhanced mineral content, including calcium, in finger millet grains under organic management. Similarly, Sharma (2022) noted that delayed sowing favored nutrient enrichment due to prolonged photosynthetic activity and efficient nutrient remobilization during grain development.

Table 4.26(a): Calcium content under different sowing dates and nutrient management system of finger millet

Treatments	**Calcium content (%)**		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1^{st} June	1.08	1.15	1.10
D_2: 15^{th} June	1.29	1.36	1.32
D_3: 1^{st} July	1.44	1.45	1.45
SEm±	0.01	0.02	0.01
C.D. (P=0.05)	0.05	0.06	0.03
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	1.06	1.13	1.10
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	1.20	1.30	1.25
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	1.43	1.42	1.43
N_4: 50% Inorganic + 50% Organic through FYM	1.37	1.40	1.38
SEm±	0.02	0.02	0.01
C.D. (P=0.05)	0.04	0.07	0.05

Table 4.26(b): Interaction effect on calcium content under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Calcium content (%)		
	2023	2024	Pooled
T_1: D_1N_1	0.99	1.04	1.02
T_2: D_1N_2	0.99	1.26	1.12
T_3: D_1N_3	1.25	1.20	1.23
T_4: D_1N_4	1.05	1.08	1.07
T_5: D_2N_1	1.02	1.15	1.08
T_6: D_2N_2	1.23	1.30	1.26
T_7: D_2N_3	1.40	1.41	1.41
T_8: D_2N_4	1.49	1.55	1.52
T_9: D_3N_1	1.18	1.21	1.19
T_{10}: D_3N_2	1.37	1.34	1.35
T_{11}: D_3N_3	1.63	1.66	1.64
T_{12}: D_3N_4	1.57	1.57	1.56
SEm±	0.03	0.04	0.03
CD (P=0.05)	0.09	0.12	0.07

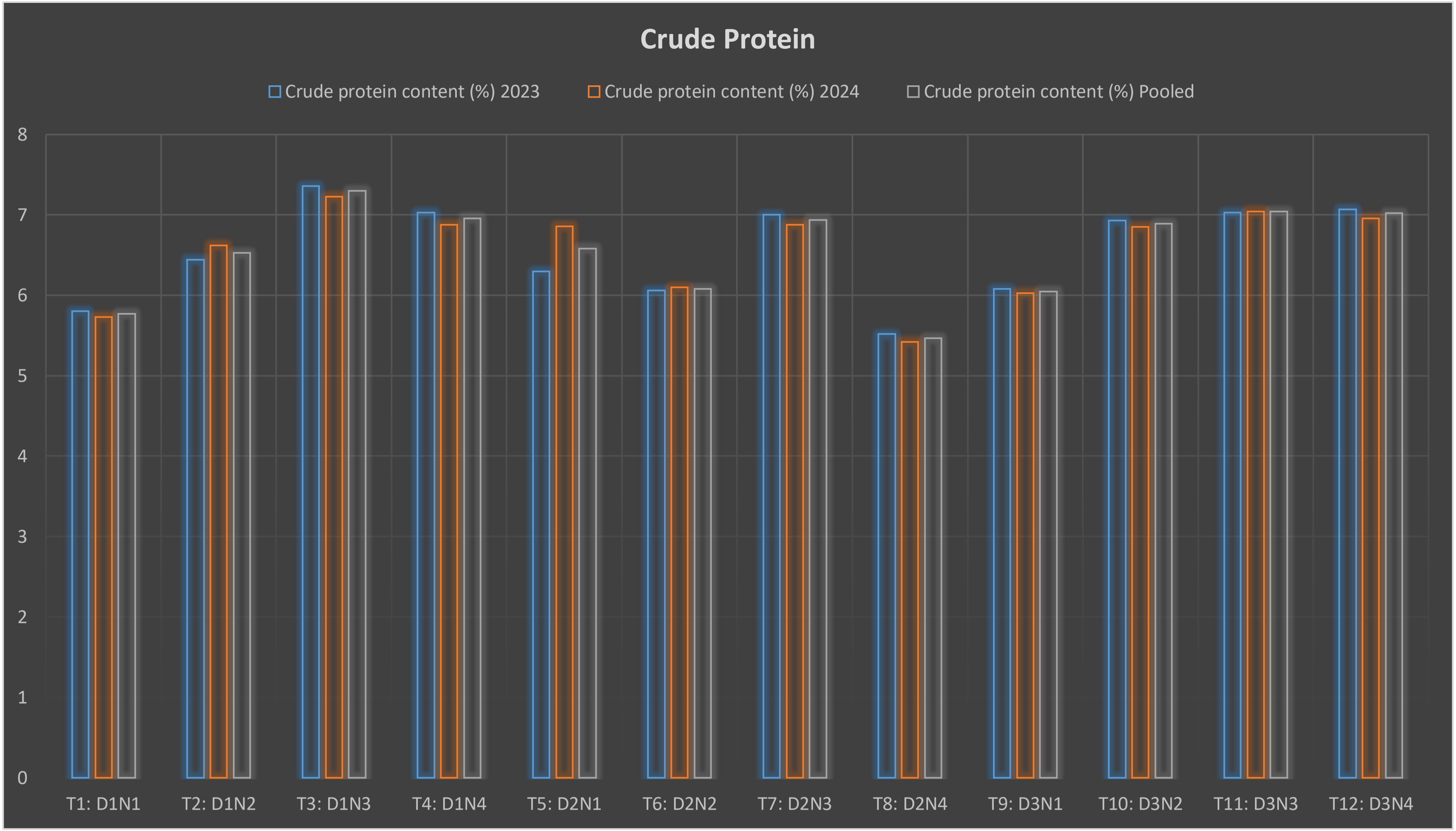


Fig. 4.7 Effect of different sowing dates and nutrient management on Crude Protein content (%)

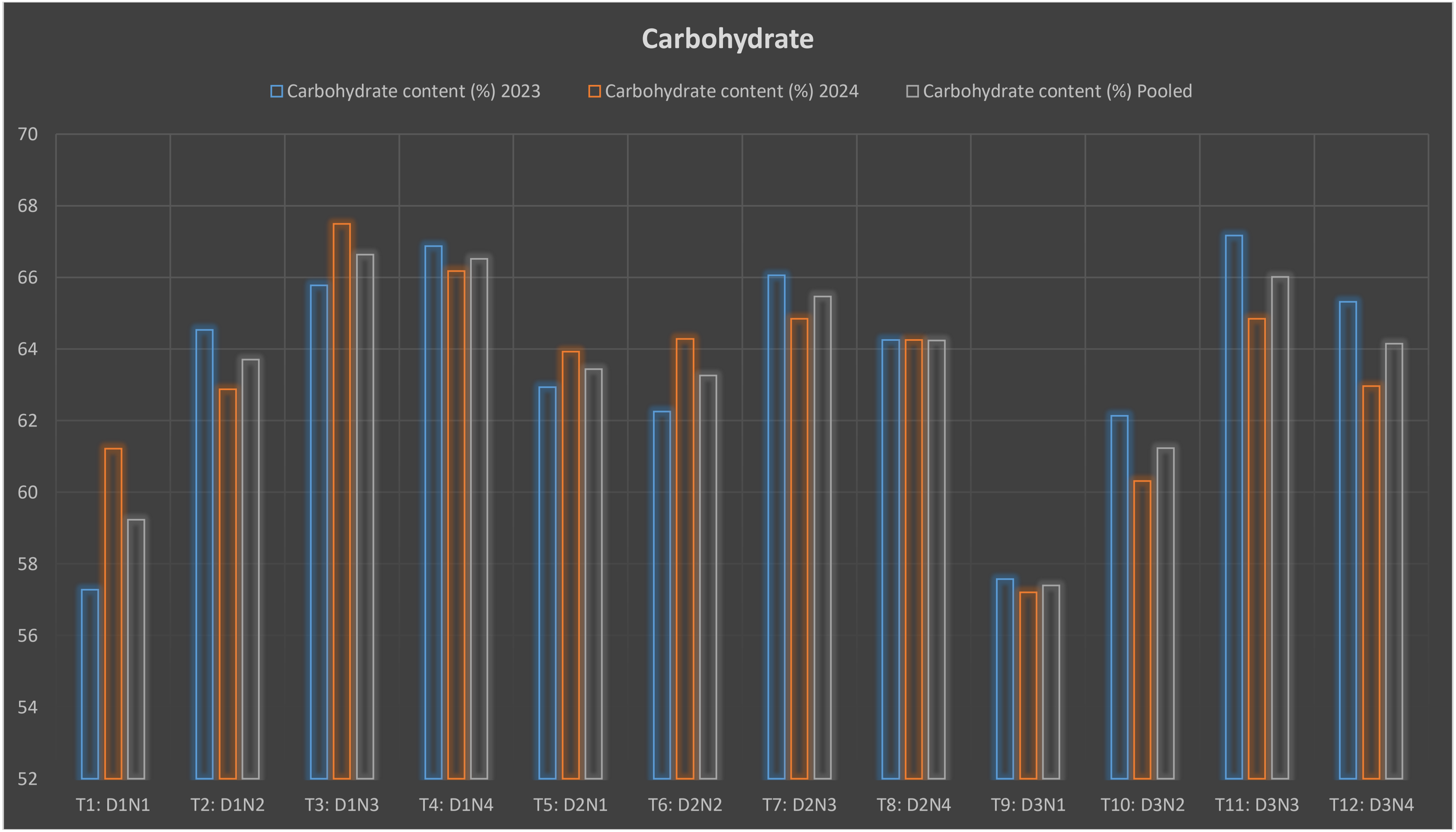


Fig. 4.8 Effect of different sowing dates and nutrient management on Carbohydrate content (%)

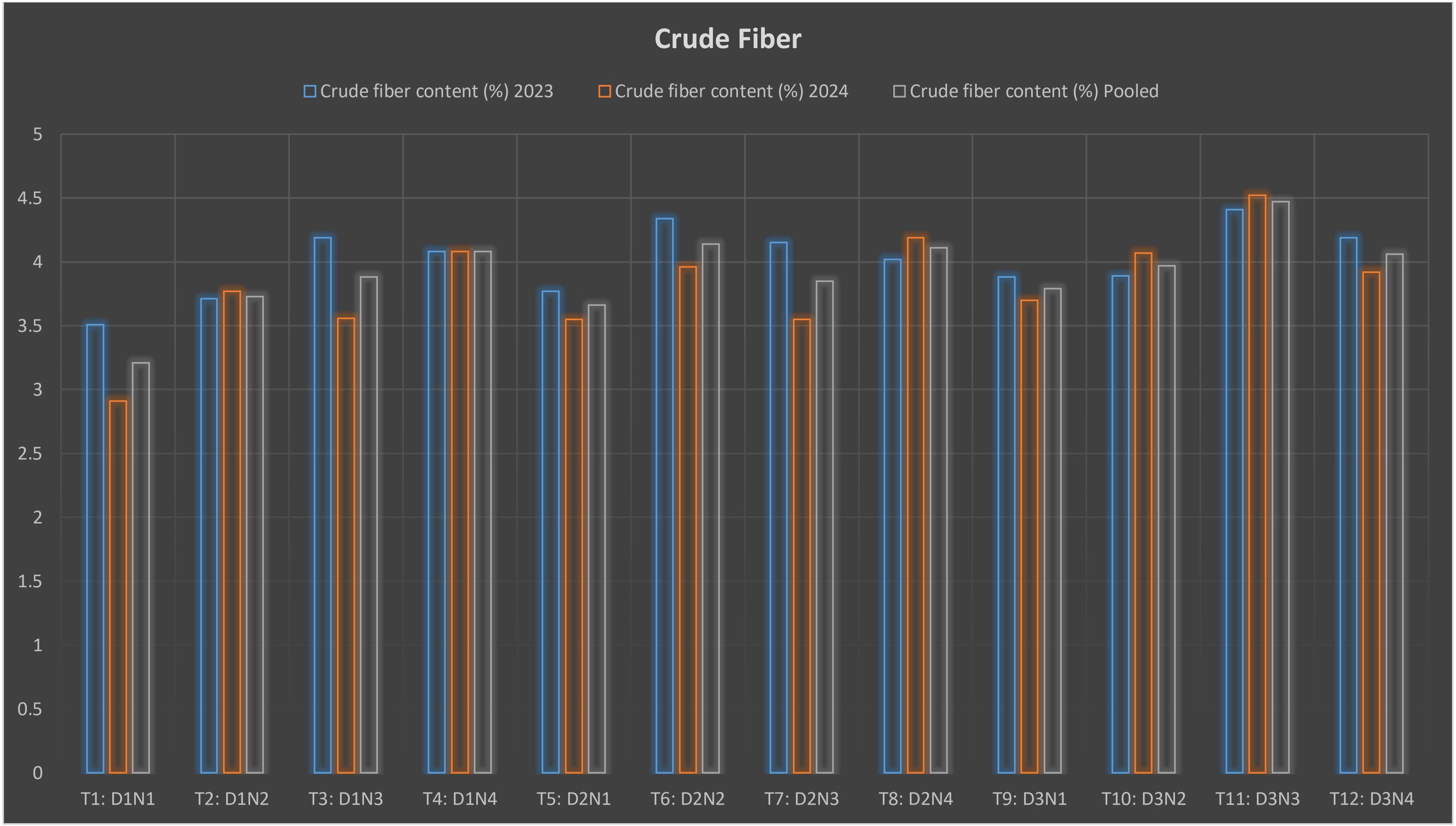


Fig. 4.9 Effect of different sowing dates and nutrient management on Crude Fiber content (%)

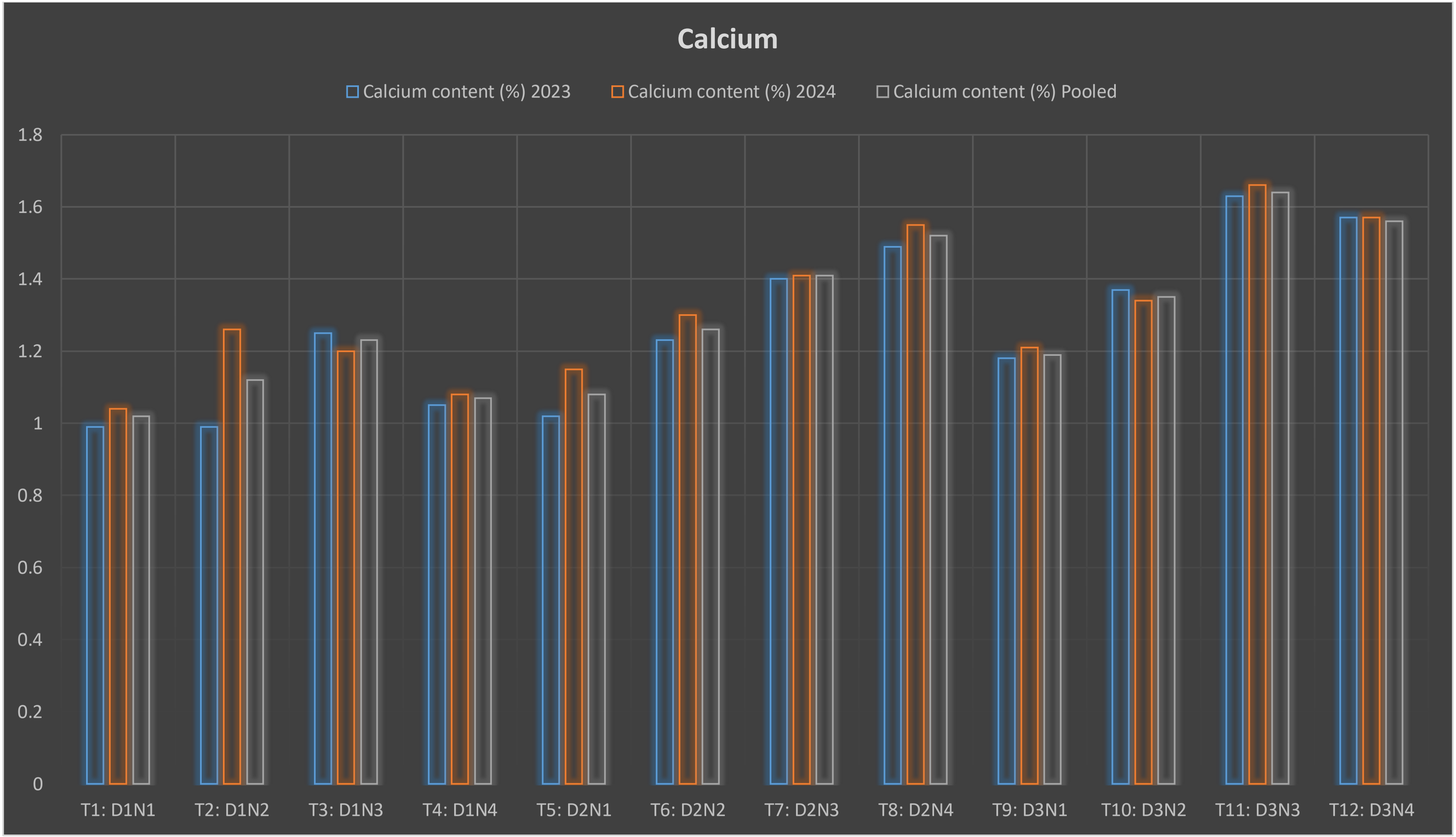


Fig. 4.10 Effect of different sowing dates and nutrient management on Calcium content (%)

4.1.5 Nutrient content and uptake by plant parameters

4.1.5.1 Nitrogen content (%) in grain and straw

Nitrogen content data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.27(a) and 4.27(b).

The observations presented clearly demonstrate that nitrogen concentration in both grain and straw was significantly affected by sowing dates, nutrient management strategies, and their interactions during the two consecutive cropping seasons (2023 and 2024). These trends were further reinforced by the pooled analysis, indicating consistent treatment effects across years.

Effect of Sowing Dates (D)

Nitrogen Content in Grain: A notable influence of sowing time on grain nitrogen content was evident in both experimental years. During 2023, the crop sown on 1st June (D_1) recorded the highest nitrogen concentration in grain (0.95%), closely followed by 15th June (D_2) with 0.95%. The lowest value (0.85%) was associated with 1st July (D_3), signifying the disadvantage of delayed planting. A similar pattern emerged in 2024, where nitrogen content slightly declined across treatments but D_1 (0.89%) and D_2 (0.901%) continued to perform better compared to the late sown crop (D_3: 0.68%). The pooled mean further confirmed that D_2 (15th June) maintained the highest grain nitrogen content (0.93%), whereas the lowest content (0.774%) was recorded under D_3, reiterating the negative impact of sowing delay.

Nitrogen Content in Straw: Although the influence of sowing dates on straw nitrogen was statistically significant, the numerical variation among treatments was narrow. Nevertheless, the pooled results indicated a marginal increase in straw nitrogen with delayed planting, where D_3 recorded the highest value (1.40%), followed by D_2 (1.39%) and D_1 (1.38%). This suggests that late sowing may reduce nitrogen remobilization from vegetative parts to the grain, resulting in a slightly higher accumulation in straw.

Effect of Nutrient Management (N)

Nitrogen Content in Grain: Nitrogen management practices exerted a pronounced effect on nitrogen concentration in grain across both years. In 2023, the recommended dose of fertilizers (N_2: 40:30:20 kg N, P_2O_5, K_2O ha^{-1}) recorded the highest grain nitrogen content (1.08%). This treatment was followed by N_4 (50% inorganic + 50% FYM) (1.00%) and N_3 (100% FYM) (0.90%). The lowest nitrogen content (0.69%) was observed under the unfertilized control (N_1). A similar response was observed in 2024, where N_2 (1.131%) continued to outperform all other treatments, while the control recorded the lowest nitrogen content (0.657%). The pooled means showed that N_2 remained significantly superior (1.10%), whereas the lowest nitrogen accumulation (0.67%) occurred under N_1. Organic manuring alone (N_3) and integrated nutrient management (N_4) showed intermediate effects, suggesting gradual nutrient release and improved soil health.

Nitrogen Content in Straw: A parallel trend was recorded for straw nitrogen. Pooled data revealed that N_2 again produced the highest nitrogen concentration (1.55%), followed by N_4 (1.43%) and N_3 (1.31%). The control (1.26%) remained significantly inferior. These results highlight the importance of balanced nutrient supply for effective nitrogen uptake and assimilation within vegetative tissues.

Interaction Effect (D × N)

The combined influence of sowing dates and nutrient management (D × N) showed significant variability in nitrogen content of both grain and straw.

Nitrogen in grain: In 2023, the treatment T_2 (D_1N_2) achieved the highest grain nitrogen concentration (1.18%), and this superiority was maintained in the pooled analysis (1.13%). The next best treatment was T_{10} (D_3N_2) with 1.10% grain nitrogen. The lowest pooled value (0.53%) was observed under T_9 (D_3N_1), where both late sowing and no fertilization adversely affected nitrogen accumulation.

Nitrogen in straw: For straw nitrogen, the pooled data indicated that T_{10} (D_3N_2) was the most effective treatment (1.57%), followed by T_2 (D_1N_2) with 1.55%.

The minimum straw nitrogen (1.23%) was obtained under T_1 (D_1N_1). These results clearly show that the response to nutrient management is accentuated when combined with optimum sowing dates.

The significant variations in nitrogen content across sowing dates can be attributed to changes in environmental conditions, particularly soil moisture and temperature, which directly affect nitrogen mineralization, root activity, and nutrient uptake. Early sowing (1st–15th June) provided favorable conditions for vegetative development, which resulted in increased nitrogen absorption and efficient partitioning to the grain. Delayed sowing (1st July), by contrast, shortened the effective growth period and exposed the crop to less favorable climatic conditions, limiting nitrogen uptake and reducing grain nitrogen content. However, reduced translocation efficiency toward grain may have caused slightly higher nitrogen retention in the straw.

Nutrient management played an equally critical role. The superior performance of the recommended fertilizer dose (N_2) is likely due to the immediate availability of nutrients, which supports rapid uptake and higher assimilation. Integrated nutrient management (N_4) also improved nitrogen content, possibly because organic manure enhances microbial activity, soil structure, and nutrient synchronization.

These findings agree with earlier studies by Reddy *et al.* (2020), Kumar *et al.* (2022) and Vijay Kumar *et al* 2025, who reported that timely sowing and balanced nutrient supply substantially improve nitrogen uptake, assimilation, and overall crop nutrition in cereals.

Table 4.27(a): Nitrogen content (%) in grain and straw under different sowing dates and nutrient management system of finger millet

Treatments	Nitrogen content (%)					
	Grain			Straw		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	0.96	0.90	0.92	1.38	1.38	1.39
D_2: 15th June	0.96	0.90	0.93	1.39	1.40	1.39
D_3: 1st July	0.85	0.69	0.77	1.42	1.38	1.40
SEm±	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.04	0.01	0.02	0.03	NS	0.01
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)						
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	1.09	1.13	1.10	1.58	1.53	1.56
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	0.90	0.86	0.88	1.32	1.31	1.32
N_4: 50% Inorganic + 50% Organic through FYM	1.01	0.68	0.85	1.45	1.43	1.44
SEm±	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.03	0.02	0.01	0.03	NS	0.02

Tabble 4.27(b): Interaction effect on nitrogen content (%) in grain and straw under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Nitrogen content (%)					
	Grain			Straw		
	2023	2024	Pooled	2023	2024	Pooled
T$_1$: D$_1$N$_1$	0.78	0.75	0.77	1.22	1.26	1.23
T$_2$: D$_1$N$_2$	1.18	1.09	1.14	1.56	1.56	1.56
T$_3$: D$_1$N$_3$	0.87	0.78	0.82	1.34	1.31	1.32
T$_4$: D$_1$N$_4$	1.00	0.97	0.99	1.39	1.43	1.41
T$_5$: D$_2$N$_1$	0.70	0.76	0.74	1.26	1.27	1.27
T$_6$: D$_2$N$_2$	1.09	1.08	1.09	1.54	1.53	1.54
T$_7$: D$_2$N$_3$	0.98	0.85	0.91	1.34	1.31	1.33
T$_8$: D$_2$N$_4$	1.06	0.95	1.00	1.46	1.46	1.46
T$_9$: D$_3$N$_1$	0.61	0.46	0.53	1.28	1.31	1.30
T$_{10}$: D$_3$N$_2$	0.99	1.22	1.11	1.64	1.51	1.57
T$_{11}$: D$_3$N$_3$	0.86	0.95	0.90	1.29	1.32	1.31
T$_{12}$: D$_3$N$_4$	0.97	0.11	0.54	1.49	1.40	1.44
SEm±	0.02	0.01	0.01	0.02	0.02	0.01
CD (P=0.05)	0.06	0.03	0.04	0.04	NS	0.04

4.1.5.2 Phosphorus content (%) in grain and straw

Phosphorus content data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.28(a) and 4.28(b).

The observations presented clearly demonstrate that phosphorus (P) concentration in grain and straw was significantly influenced by nutrient management during both study years (2023 and 2024) as well as in the pooled mean. Sowing dates significantly affected phosphorus content in grain, whereas their effect on straw phosphorus was statistically non-significant. Furthermore, the interaction between sowing dates and nutrient management (D × N) exhibited a significant influence on grain P concentration.

Effect of Sowing Dates (D)

Grain Phosphorus Content: A considerable variation in grain phosphorus content was observed among sowing dates in both years. In 2023, the maximum grain phosphorus concentration (0.15%) was recorded under D_3 (1st July sowing), followed by D_2 (15th June) with 0.14%, and the lowest value (0.13%) was obtained under D_1 (1st June). A similar response was noted in 2024, with D_3 (0.15%) again outperforming D_2 (0.14%) and D_1 (0.14%). The pooled mean reinforced this trend, showing that D_3 accumulated the highest P content in grain (0.15%), followed by D_2 (0.14%), while D_1 (0.14%) remained comparatively lower. These observations suggest that late sowing slightly favored P concentration in grain, possibly due to reduced biomass dilution.

Straw Phosphorus Content: The phosphorus content in straw did not vary significantly due to sowing dates in either experimental year or in the pooled analysis. However, numerical differences indicated comparatively higher straw phosphorus (0.29%) under D_2, followed by D_1 (0.28%) and D_3 (0.28%). This implies that mid-June sowing may enhance phosphorus retention in vegetative parts, although the differences were not statistically meaningful.

Effect of Nutrient Management (N)

Grain Phosphorus Content: Nutrient management exerted a strong and consistent effect on grain phosphorus concentration in both years. During 2023, the RDF treatment (N_2: 40:30:20 kg N, P_2O_5, K_2O ha^{-1}) resulted in the highest P content (0.19%), followed by N_4 (50% inorganic + 50% FYM) with 0.16%, and N_3 (100% FYM) with 0.13%. The control (N_1) recorded the lowest phosphorus concentration (0.093%). This pattern persisted in 2024, with N_2 (0.200%) continuing to outperform the other treatments. Integrated nutrient management (N_4) recorded moderate improvement (0.16%), while FYM alone (N_3) showed comparatively lower P content. The pooled mean analysis clearly established N_2 as the most effective treatment with a phosphorus concentration of 0.19%, followed by N_4 (0.16%), whereas N_1 (0.09%) remained significantly inferior. These results highlight the importance of balanced mineral fertilization for efficient phosphorus uptake.

Straw Phosphorus Content: A similar pattern emerged for straw phosphorus. The pooled mean revealed that N_2 consistently yielded the highest straw phosphorus concentration (0.33%), succeeded by N_4 (0.30%), while the control (N_1) recorded the minimum value (0.23%). This improvement may be linked to the enhanced solubility and availability of phosphorus under recommended nutrient application, supporting greater nutrient assimilation in vegetative tissues.

Interaction Effect (D × N)

Grain Phosphorus Content: The sowing date × nutrient management interaction was significant for grain phosphorus content across years. In 2023, the treatment combination T_{10} (D_3N_2) produced the highest P concentration (0.20%), followed by T_2 (D_1N_2) (0.19%) and T_6 (D_2N_2) (0.18%). The minimum value (0.08%) was observed under T_1 (D_1N_1). In 2024, the superiority of T_{10} was again evident, with the highest grain phosphorus (0.20%), while T_5 (D_2N_1) recorded the lowest (0.09%). The pooled mean confirmed the sustained dominance of T_{10} (0.20%), followed by T_2 (0.19%) and T_6 (0.19%), whereas T_1 (0.09%) remained the least effective. These results indicate that late sowing combined with RDF substantially enhances P concentration in grain.

Straw Phosphorus Content: Although the interaction effect was statistically non-significant for straw, pooled mean values indicated numerically higher straw phosphorus under T_{10} (0.34%), followed by T_6 (0.32%) and T_8 (0.31%), suggesting that RDF and partially organic nutrient sources contributed to enhanced P accumulation.

The increased grain phosphorus concentration under late sowing (1st July) may be associated with reduced vegetative growth and slower biomass accumulation, resulting in higher nutrient concentration per unit of dry matter. Conversely, early and mid-June sowing dates provided favorable soil moisture and temperature conditions that improved phosphorus availability, root growth, and nutrient absorption.

The superior performance of RDF (N_2) across all parameters can be attributed to the direct supply of readily available phosphorus, facilitating rapid uptake and improved translocation to reproductive tissues. Treatments involving integrated nutrient management (N_4) also enhanced phosphorus levels, likely due to improved soil biological activity, gradual nutrient release, and better synchronization between plant demand and nutrient supply.

These observations concur with the findings of Patil *et al.* (2020), Bharathi *et al*. (2021), Amarjeet *et al.* (2021) and Rao *et al*. (2022), who reported that balanced fertilizer application and combined use of organic and inorganic nutrient sources significantly improve phosphorus utilization efficiency and P accumulation in cereals and small millets.

Table 4.28(a): Phosphorus content (%) in grain and straw under different sowing dates and nutrient management system of finger millet

Treatments	Phosphorus content (%)					
	Grain			Straw		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	0.13	0.14	0.15	0.29	0.30	0.29
D_2: 15th June	0.14	0.15	0.15	0.30	0.30	0.29
D_3: 1st July	0.16	0.15	0.16	0.28	0.29	0.28
SEm±	0.00	0.00	0.14	0.00	0.01	0.00
CD (P=0.05)	0.01	NS	0.01	NS	NS	NS
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	0.09	0.10	0.09	0.23	0.23	0.24
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	0.19	0.20	0.19	0.33	0.34	0.33
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	0.13	0.13	0.13	0.29	0.29	0.28
N_4: 50% Inorganic + 50% Organic through FYM	0.16	0.16	0.17	0.31	0.30	0.31
SEm±	0.00	0.00	0.15	0.01	0.01	0.00
CD (P=0.05)	0.00	0.01	0.01	0.02	0.02	0.01

Table 4.28(b): Interaction effect on phosphorus content (%) in grain and straw

Interaction (D×N)	Phosphorus content (%)					
	Grain			Straw		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	0.08	0.11	0.10	0.22	0.22	0.22
T_2: D_1N_2	0.19	0.19	0.20	0.33	0.34	0.33
T_3: D_1N_3	0.13	0.13	0.12	0.28	0.30	0.29
T_4: D_1N_4	0.16	0.16	0.16	0.30	0.31	0.31
T_5: D_2N_1	0.09	0.10	0.10	0.23	0.24	0.24
T_6: D_2N_2	0.18	0.20	0.19	0.32	0.33	0.33
T_7: D_2N_3	0.13	0.13	0.13	0.29	0.30	0.30
T_8: D_2N_4	0.17	0.16	0.16	0.32	0.30	0.32
T_9: D_3N_1	0.11	0.10	0.10	0.24	0.23	0.24
T_{10}: D_3N_2	0.21	0.21	0.21	0.34	0.34	0.34
T_{11}: D_3N_3	0.13	0.14	0.14	0.28	0.29	0.28
T_{12}: D_3N_4	0.15	0.17	0.16	0.29	0.28	0.28
SEm±	0.01	0.01	0.15	0.01	0.01	0.01
CD (P=0.05)	0.02	NS	0.02	NS	NS	NS

4.1.5.3 Potassium content (%) in grain and straw

Potassium content data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.29(a) and 4.29(b).

The observations presented demonstrate that potassium (K) concentration in both grain and straw was significantly influenced by sowing dates, nutrient management practices, and their interaction effects (D × N) during both experimental years (2023 and 2024) as well as in the pooled analysis. The consistent significance across all sources of variation highlights the sensitivity of potassium uptake and partitioning to both management and environmental factors.

Effect of Sowing Dates (D)

Grain Potassium Content: A significant variation in grain potassium levels was recorded across sowing dates. In 2023, grain K concentration ranged between 0.50% and 0.51%. The highest values (0.51%) were obtained under D_1 (1st June) and D_2 (15th June), while D_3 (1st July) exhibited the lowest potassium content (0.50%). The 2024 results corroborated these findings, with D_2 showing the highest grain K content (0.51%), followed by D_1 (0.50%), and the lowest value (0.49%) recorded under D_3. The pooled mean further confirmed this trend, where D_2 (15th June) maintained the highest potassium concentration (0.519%), followed by D_1 (0.505%), while the delayed sowing date D_3 (1st July) resulted in the lowest grain K content (0.499%).

Straw Potassium Content: In contrast to grain, potassium content in straw increased under delayed sowing. During 2023, D_3 recorded the highest straw K content (2.57%), while D_1 recorded the lowest (2.49%). A similar pattern emerged in 2024, with D_3 (2.57%) again being superior. The pooled data revealed D_3 as the most favorable for straw potassium (2.57%), followed by D_2 (2.53%). These results imply that while timely sowing (mid-June) improved potassium accumulation in grain, late sowing favored potassium retention in the vegetative parts, possibly due to constraints in translocation during a shorter grain-filling period.

Effect of Nutrient Management (N)

Grain Potassium Content: Nutrient management had a strong and significant influence on grain potassium content. In 2023, the RDF treatment (N_2: 40:30:20 kg N, P_2O_5, K_2O ha^{-1}) produced the highest grain K content (0.59%), followed by N_4 (50% inorganic + 50% FYM) (0.536%). The lowest potassium concentration (0.424%) occurred under N_1 (control). This pattern remained consistent in 2024, with N_2 (0.571%) and N_4 (0.54%) outperforming the other treatments. The pooled mean again highlighted N_2 as the superior treatment (0.58%), followed by N_4 (0.54%), whereas N_1 remained the least effective (0.42%).

Straw Potassium Content: Potassium concentration in straw followed a similar pattern to grain. The pooled analysis showed that N_2 resulted in the highest straw potassium content (2.76%), followed by N_4 (2.60%) and N_3 (2.50%). The lowest K content (2.28%) was recorded under N_1. The consistently superior results under RDF can be attributed to the direct and balanced supply of K_2O, which enhances root activity, nutrient uptake, and overall metabolic functioning.

Interaction Effect (D × N)

Grain Potassium Content: The interaction between sowing dates and nutrient management was significant for grain potassium in both years. In 2023, the highest grain potassium content (0.60%) was recorded under T_2 (D_1N_2), followed by T_{10} (D_3N_2) (0.58%). The lowest value (0.42%) was observed under T_1 (D_1N_1). In 2024, a similar response was noted, with T_2 again producing the highest K content (0.58%) and T_5 (D_2N_1) the lowest (0.41%). The pooled data showed that T_6 (D_2N_2) recorded the maximum potassium content in grain (0.59%), closely followed by T_2 (0.59%) and T_{10} (0.56%), while T_1 (0.41%) had the lowest K concentration. These results indicate that the application of RDF, irrespective of sowing date, substantially elevated grain K accumulation.

Straw Potassium Content: The pooled mean for straw potassium revealed the highest accumulation (2.90%) under T_{10} (D_3N_2), followed by T_6 (D_2N_2) (2.71%). The lowest value (2.24%) was reported under T_5 (D_2N_1). These results demonstrate that the combination of RDF and either mid-June or late sowing conditions significantly enhanced potassium accumulation in vegetative biomass, likely due to improved nutrient uptake efficiency.

The variation in potassium content due to sowing dates suggests that crop phenological stages and environmental conditions play a vital role in nutrient dynamics. Higher grain potassium under mid-June sowing could be linked to optimal soil moisture and temperature, which favor root development and nutrient uptake during the early growth phase. Conversely, higher straw potassium under late sowing might be attributed to incomplete nutrient translocation resulting from a shortened growth duration.

The superiority of RDF (N_2) across grain and straw potassium content is directly related to the timely availability of K_2O, which supports essential physiological processes such as enzyme activation, carbohydrate transport, and osmotic regulation. Integrated nutrient management (N_4) also performed well, indicating that the combined application of organic and inorganic sources enhances nutrient availability, improves soil structure, and sustains nutrient release.

These findings align with studies of Amarjeet *et al.* (2021), Rao *et al.* (2022), and Kumar *et al.* (2022), who similarly reported that balanced fertilization and appropriate sowing times significantly improve potassium uptake and accumulation in cereal crops and small millets.

Table 4.29(a): Potassium content (%) in grain and straw under different sowing dates and nutrient management system of finger millet

Treatments	Potassium content (%)					
	Grain			Straw		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	0.51	0.51	0.51	2.50	2.53	2.52
D_2: 15th June	0.51	0.52	0.52	2.53	2.53	2.54
D_3: 1st July	0.51	0.49	0.50	2.57	2.58	2.57
SEm±	0.03	0.00	0.00	0.01	0.01	0.01
CD (P=0.05)	NS	0.01	0.01	0.02	0.02	0.02
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	0.42	0.42	0.42	2.29	2.29	2.28
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	0.60	0.57	0.58	2.75	2.77	2.77
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	0.49	0.49	0.48	2.48	2.53	2.50
N_4: 50% Inorganic + 50% Organic through FYM	0.54	0.54	0.54	2.62	2.59	2.60
SEm±	0.03	0.00	0.00	0.01	0.01	0.01
CD (P=0.05)	NS	0.01	0.01	0.03	0.04	0.01

Table 4.29(b): Interaction effect on potassium content (%) in grain and straw under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Potassium content (%)					
	Grain			Straw		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	0.42	0.42	0.41	2.32	2.31	2.32
T_2: D_1N_2	0.60	0.58	0.59	2.64	2.69	2.67
T_3: D_1N_3	0.48	0.48	0.49	2.46	2.56	2.51
T_4: D_1N_4	0.55	0.54	0.55	2.57	2.54	2.56
T_5: D_2N_1	0.42	0.41	0.42	2.24	2.25	2.24
T_6: D_2N_2	0.60	0.59	0.60	2.73	2.70	2.71
T_7: D_2N_3	0.50	0.49	0.50	2.52	2.55	2.54
T_8: D_2N_4	0.55	0.58	0.57	2.65	2.64	2.65
T_9: D_3N_1	0.43	0.43	0.42	2.31	2.30	2.31
T_{10}: D_3N_2	0.58	0.54	0.57	2.88	2.93	2.90
T_{11}: D_3N_3	0.49	0.50	0.50	2.46	2.49	2.48
T_{12}: D_3N_4	0.51	0.51	0.51	2.65	2.60	2.63
SEm±	0.05	0.01	0.00	0.02	0.02	0.01
CD (P=0.05)	NS	0.03	0.02	0.05	0.06	0.03

4.1.5.4 Nitrogen uptake by grain and straw (kg ha^{-1})

Nitrogen uptake by grain and straw data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.30(a) and 4.30(b).

The experimental results revealed that nitrogen uptake by both grain and straw was markedly influenced by the sowing time and nutrient management across both experimental years as well as in the pooled average.

Effect of Sowing Dates (D)

The experimental results revealed that nitrogen uptake by both grain and straw was markedly influenced by the sowing time across both experimental years as well as in the pooled average.

During 2023, the 15th June sowing (D_2) recorded the highest grain nitrogen uptake (20.63 kg ha^{-1}), followed by 1st July (D_3) with 18.32 kg ha^{-1}. The lowest uptake (17.34 kg ha^{-1}) occurred under the earliest sowing on 1st June (D_1). A similar pattern emerged in 2024, with D_2 again outperforming the other treatments by achieving the highest nitrogen uptake (15.88 kg ha^{-1}), while D_1 remained inferior (9.87 kg ha^{-1}).

The pooled mean further strengthened this trend; D_2 consistently registered maximum nitrogen uptake in both grain (18.25 kg ha^{-1}) and straw (47.55 kg ha^{-1}). This was followed by D_3 with 15.15 kg ha^{-1} (grain) and 50.07 kg ha^{-1} (straw). Conversely, the lowest pooled values were associated with D_1 (13.60 kg ha^{-1} in grain and 37.07 kg ha^{-1} in straw). These findings suggest that mid-June sowing offers a more favourable environment for root growth and nutrient absorption, resulting in improved nitrogen uptake.

Effect of Nutrient Management (N)

Nitrogen uptake was strongly influenced by nutrient management strategies, and the trend remained consistent across the two experimental years and in the pooled analysis.

In 2023, the highest grain nitrogen uptake was obtained under the integrated nutrient management treatment (N_4: 50% inorganic + 50% FYM), which recorded 28.34 kg ha^{-1} in grain and 71.24 kg ha^{-1} in straw. This was followed by RDF (N_2), while the control (N_1) showed drastically lower uptake values (6.27 kg ha^{-1} in grain and 23.388 kg ha^{-1} in straw). The results in 2024 mirrored those of the previous year, with N_4 again producing superior uptake (12.61 kg ha^{-1} grain; 53.93 kg ha^{-1} straw). N_2 and N_3 registered intermediate uptake, and the control maintained the lowest values.

Pooled data strengthened these results, showing that N_4 achieved the maximum nitrogen uptake (20.47 kg ha^{-1} in grain and 62.58 kg ha^{-1} in straw). The control remained significantly inferior (5.36 kg ha^{-1} and 20.68 kg ha^{-1}, respectively). These findings demonstrate that integrated nutrient supply enhances nitrogen availability and uptake, owing to the combined benefits of readily available inorganic nutrients and the slow-release characteristics of organic sources.

Interaction Effect (D × N)

A significant interactive influence of sowing dates and nutrient management on nitrogen uptake was also observed.

For grain nitrogen uptake, the highest pooled uptake (25.07 kg ha^{-1}) was achieved under D_3N_4 (T_{12}). This was closely followed by D_3N_2 (T_{10}) with 22.05 kg ha^{-1}. The lowest uptake was again associated with D_1N_1 (T_1), which recorded only 4.28 kg ha^{-1}. For straw nitrogen uptake, T_{12} (D_3N_4) also produced the maximum pooled value of 73.53 kg ha^{-1}, whereas the minimum (13.51 kg ha^{-1}) was observed under T_1 (D_1N_1). The interaction results indicate that late sowing (1st July) when combined with integrated nutrient supply provides a favourable environment for enhanced nitrogen availability, microbial activity, and plant uptake efficiency.

The overall findings clearly highlight that both sowing date and nutrient management practices play a decisive role in determining nitrogen uptake in foxtail millet. The superior performance of the mid-June sowing (D_2) can be attributed to its alignment with optimum moisture and temperature regimes during the early vegetative phase, leading to vigorous root development and enhanced nitrogen assimilation. Similar observations were made by Sharma *et al.* (2021), who reported enhanced nitrogen uptake in millet crops under favourable monsoon-aligned sowing windows.

The pronounced impact of integrated nutrient management (N_4) on nitrogen uptake may be due to the synergistic effects of inorganic and organic nutrient sources. While inorganic fertilizers provide immediate nutrient availability, the addition of FYM improves soil structure, organic carbon content, microbial biomass, and nutrient mineralization processes by Reddy and Vengadessan (2022), Amarjeet *et al.* (2021) and Kumar *et al.* (2022). This enhances root growth and consequently nitrogen uptake.

The significant D×N interactions further emphasise that combining an appropriate sowing window with a balanced nutrient management approach is crucial for maximizing nutrient use efficiency. Studies by Mubeena *et al.* (2019) and Mathyam *et al.* (2023) also confirm that integrated nutrient management strategies substantially increase nitrogen uptake in small millets.

Table 4.30(a): Nitrogen uptake (kg ha^{-1}) by grain and straw under different sowing dates and nutrient management system of finger millet

Treatments	Nitrogen uptake (kg ha^{-1})					
	Grain			Straw		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	17.35	9.88	13.60	44.85	29.29	37.07
D_2: 15th June	20.64	15.88	18.26	51.80	43.31	47.56
D_3: 1st July	18.33	12.00	15.15	53.94	46.21	50.08
SEm±	1.48	0.67	0.96	3.27	1.57	2.16
CD (P=0.05)	NS	1.97	2.82	NS	4.61	6.34
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	6.28	4.45	5.36	23.39	17.99	20.69
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	21.23	19.16	20.20	54.06	47.64	50.85
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	19.21	14.11	16.67	52.11	38.88	45.49
N_4: 50% Inorganic + 50% Organic through FYM	28.34	12.61	20.48	71.24	53.93	62.58
SEm±	1.71	0.77	1.11	3.78	1.82	2.50
CD (P=0.05)	5.02	2.27	3.26	11.07	5.33	7.32

Table 4.30(b): Interaction effect on nitrogen uptake (kg ha^{-1}) by grain and straw under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Nitrogen uptake (kg ha^{-1})					
	Grain			Straw		
	2023	2024	Pooled	2023	2024	Pooled
T$_1$: D_1N_1	5.28	3.30	4.29	15.96	11.06	13.51
T$_2$: D_1N_2	21.63	13.82	17.72	48.66	40.28	44.47
T$_3$: D_1N_3	16.59	8.54	12.56	50.12	27.34	38.74
T$_4$: D_1N_4	25.88	13.82	19.84	64.70	38.51	51.61
T$_5$: D_2N_1	6.98	5.24	6.11	25.81	17.09	21.45
T$_6$: D_2N_2	22.07	19.52	20.80	53.15	47.65	50.41
T$_7$: D_2N_3	24.41	17.69	21.05	60.95	50.54	55.75
T$_8$: D_2N_4	29.07	21.09	25.08	67.26	57.97	62.61
T$_9$: D_3N_1	6.58	4.82	5.71	28.40	25.81	27.11
T$_{10}$: D_3N_2	20.00	24.12	22.05	60.37	54.98	57.67
T$_{11}$: D_3N_3	16.63	16.10	16.36	45.26	38.74	42.00
T$_{12}$: D_3N_4	30.09	2.92	16.50	81.76	65.31	73.54
SEm±	2.96	1.34	1.92	6.54	3.14	4.32
CD (P=0.05)	NS	3.92	5.63	NS	9.23	12.69

4.1.5.5 Phosphorus uptake by grain and straw (kg ha^{-1})

Phosphorus uptake by grain and straw data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.31(a) and 4.31(b).

The results of the experiment showed that phosphorus uptake by grain and straw was noticeably influenced by the sowing dates and nutrient management in both the years of study as well as in the pooled analysis.

Effect of Sowing Dates (D)

The results of the experiment showed that phosphorus uptake by grain and straw was noticeably influenced by the sowing dates in both the years of study as well as in the pooled analysis.

In 2023, the 1st July sowing (D_3) recorded the highest grain phosphorus uptake (3.22 kg ha^{-1}), followed closely by 15th June (D_2) with 3.14 kg ha^{-1}. The minimum uptake (2.65 kg ha^{-1}) was observed under 1st June (D_1). A comparable trend was observed in 2024, wherein both D_2 (2.63 kg ha^{-1}) and D_3 (2.94 kg ha^{-1}) performed significantly better than D_1 (1.65 kg ha^{-1}), although D_2 and D_3 did not differ statistically from each other.

When the data were averaged across years, D_3 consistently exhibited superior phosphorus uptake, registering 3.08 kg ha^{-1} in grain and 10.31 kg ha^{-1} in straw. This was followed by D_2, which recorded 2.88 kg ha^{-1} in grain and 10.12 kg ha^{-1} in straw. The lowest pooled values were associated with D_1 (2.15 kg ha^{-1} in grain and 7.86 kg ha^{-1} in straw).

These observations indicate that late sowing (1st July) offers more favourable moisture and temperature conditions for root activity and phosphorus absorption, resulting in improved P uptake.

Effect of Nutrient Management (N)

Phosphorus uptake was also significantly influenced by nutrient management practices in both experimental years and in the pooled mean.

During 2023, the integrated nutrient management treatment (N_4: 50% inorganic + 50% FYM) recorded the highest phosphorus uptake in grain (4.56 kg ha^{-1}) and straw (14.95 kg ha^{-1}). This treatment was followed by RDF (N_2), while the lowest uptake was recorded under the control (N_1), with only 0.88 kg ha^{-1} in grain and 3.43 kg ha^{-1} in straw. In 2024, N_4 again secured the highest phosphorus uptake (4.30 kg ha^{-1} grain; 11.12 kg ha^{-1} straw). N_2 and N_3 showed intermediate performance, while N_1 remained the poorest.

The pooled mean reaffirmed N_4 as the most effective nutrient management strategy, resulting in 3.98 kg ha^{-1} phosphorus uptake in grain and 13.04 kg ha^{-1} in straw. N_2 ranked second (3.58 kg ha^{-1}; 10.91 kg ha^{-1}), whereas N_1 consistently recorded the lowest values (0.81 and 3.78 kg ha^{-1}, respectively). These results underline that supplying 50% nutrients through organic sources enhances microbial activity and nutrient mineralization, thereby improving phosphorus availability and uptake.

Interaction Effect (D × N)

A significant interaction between sowing dates and nutrient management was observed for phosphorus uptake.

In the pooled analysis of grain phosphorus uptake, the highest value was recorded under D_3N_4 (T_{12}) with 4.56 kg ha^{-1}. This was closely followed by D_2N_4 (T_8) with 4.16 kg ha^{-1}. The lowest uptake was observed under the control combination D_1N_1 (T_1), which registered only 0.51 kg ha^{-1}. A similar trend was noted for straw phosphorus uptake, wherein T_{12} (D_3N_4) recorded the highest (14.66 kg ha^{-1}), followed by T_8 (D_2N_4), which recorded 13.31 kg ha^{-1}. Again, the minimum value (2.44 kg ha^{-1}) was observed in T_1 (D_1N_1).

These results clearly indicate that the combination of late sowing and integrated nutrient management leads to improved phosphorus uptake by synchronizing organic nutrient release with plant demand and creating favourable conditions for root growth and nutrient absorption.

The overall findings demonstrate that both the timing of sowing and the nutrient management strategy exert a considerable influence on the phosphorus uptake of the crop. The enhanced phosphorus uptake recorded under later sowing (1^{st} July) may be attributed to favourable soil moisture and moderate temperatures during the early growth stages, conditions that promote efficient root development and phosphorus solubilization.

The superiority of the integrated nutrient management treatment (N_4) is likely due to the combined benefits of inorganic fertilizers that supply readily available nutrients and organic manure that improves soil physical and chemical properties. FYM contributes to better soil structure, greater microbial activity, and reduced phosphorus fixation, ultimately improving the availability and mobility of P in the root zone.

Furthermore, the pronounced D × N interactions confirm that phosphorus uptake is maximized when an appropriate sowing window is complemented with a balanced nutrient supply system. The synergistic effects of good crop establishment and improved soil fertility create optimal conditions for nutrient assimilation throughout the crop’s growth period.

This aligns with the findings Mubeena *et al.* (2019) and Mathyam *et al.* (2023) who reported that integrated nutrient sources significantly improved phosphorus uptake in various cereals and millets.

Table 4.31(a): Phosphorus uptake (kg ha^{-1}) by grain and straw under different sowing dates and nutrient management system of finger millet

Treatments	Phosphorus uptake (kg ha^{-1})					
	Grain			Straw		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	2.66	1.65	2.15	9.44	6.28	7.86
D_2: 15th June	3.15	2.64	2.89	11.02	9.23	10.13
D_3: 1st July	3.23	2.95	3.08	10.96	9.67	10.31
SEm±	0.24	0.10	0.16	0.66	0.33	0.43
CD (P=0.05)	NS	0.31	0.47	NS	0.97	1.27
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	0.89	1.75	0.82	4.33	3.23	3.79
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	3.80	3.36	3.58	11.31	10.52	10.92
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	2.78	2.12	2.45	11.33	8.69	10.01
N_4: 50% Inorganic + 50% Organic through FYM	4.57	3.41	3.99	14.96	11.13	13.04
SEm±	0.28	0.12	0.19	0.76	0.38	0.50
CD (P=0.05)	0.81	0.35	0.54	2.24	1.13	1.47

Table 4.31(b): Interaction effect on phosphorus uptake (kg ha^{-1}) by grain and straw under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Phosphorus uptake (kg ha^{-1})					
	Grain			Straw		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	0.55	1.08	0.51	2.92	1.97	2.45
T_2: D_1N_2	3.50	2.45	2.98	10.22	8.72	9.47
T_3: D_1N_3	2.41	1.41	1.91	10.60	6.18	8.40
T_4: D_1N_4	4.16	2.28	3.22	14.05	8.23	11.14
T_5: D_2N_1	0.87	1.02	0.77	4.70	3.22	3.95
T_6: D_2N_2	3.70	3.57	3.63	11.25	10.33	10.79
T_7: D_2N_3	3.31	2.64	2.98	13.46	11.44	12.46
T_8: D_2N_4	4.70	3.64	4.16	14.70	11.92	13.31
T_9: D_3N_1	1.25	1.10	1.17	5.38	4.51	4.95
T_{10}: D_3N_2	4.20	4.08	4.14	12.45	12.51	12.48
T_{11}: D_3N_3	2.61	2.31	2.47	9.92	8.44	9.18
T_{12}: D_3N_4	4.83	4.30	4.57	16.11	13.22	14.67
SEm±	0.48	0.21	0.32	1.32	0.66	0.87
CD (P=0.05)	NS	0.61	NS	NS	1.94	2.53

4.1.5.6 Potassium uptake by grain and straw (kg ha^{-1})

Potassium uptake by grain and straw data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.32(a) and 4.32(b).

Effect of Sowing Dates (D)

The results presented clearly indicate that the potassium uptake by finger millet grain and straw was markedly influenced by different sowing dates during both the experimental years and in the pooled analysis.

During 2023, the crop sown on 1st July (D_3) exhibited the maximum potassium uptake in grain (10.53 kg ha^{-1}) as well as straw (97.50 kg ha^{-1}). This was followed by 15th June sowing (D_2), which reported uptake values of 10.93 kg ha^{-1} in grain and 93.73 kg ha^{-1} in straw. The lowest uptake values were observed under the earliest sowing date, 1st June (D_1), registering 9.30 kg ha^{-1} (grain) and 81.01 kg ha^{-1} (straw). A comparable trend was documented in 2024, wherein D_3 again outperformed the other sowing dates, recording 9.17 kg ha^{-1} and 86.54 kg ha^{-1} for grain and straw, respectively. Conversely, the minimum uptake (5.56 and 52.94 kg ha^{-1}) was associated with D_1. In the pooled analysis, delayed sowing up to 1st July (D_3) resulted in the highest mean potassium uptake (9.85 kg ha^{-1} in grain and 92.02 kg ha^{-1} in straw), followed by D_2, while D_1 consistently recorded the lowest values (7.43 and 66.97 kg ha^{-1}). Overall, the findings suggest that later sowing, particularly during the first week of July, provides favorable environmental conditions for crop growth, leading to enhanced nutrient acquisition and consequently higher potassium uptake.

Effect of Nutrient Management (N)

Potassium uptake was also significantly influenced by nutrient management practices in both study years and the pooled dataset.

In 2023, the integrated nutrient treatment N_4 (50% inorganic + 50% FYM) recorded the highest potassium uptake, with 15.06 kg ha^{-1} in grain and 128.81 kg ha^{-1} in straw. This was followed by the recommended dose of fertilizers N_2 (40:30:20 kg NPK ha^{-1}), which reported uptake values of 11.588 and 93.87 kg ha^{-1}, respectively. The unfertilized control (N_1) showed the lowest uptake in both components of the crop.

The performance pattern remained consistent in 2024, where N_4 again resulted in the greatest uptake (11.24 and 98.15 kg ha^{-1} for grain and straw), while the least values were associated with N_1. The pooled mean further reinforced the superiority of N_4, which exhibited the highest potassium uptake (13.15 kg ha^{-1} in grain and 113.48 kg ha^{-1} in straw). In contrast, N_1 recorded the minimum uptake (3.48 and 37.23 kg ha^{-1}). The overall response indicates that integrating organic and inorganic sources enhances soil fertility, nutrient availability, microbial activity, and cation exchange capacity, all of which collectively contribute to improved potassium absorption by the crop.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management had a significant impact on potassium uptake during both individual years and in the combined analysis.

In 2023, the treatment combination T_{12} (D_3N_4) 1st July sowing integrated with 50% inorganic + 50% FYM recorded the maximum uptake (15.91 kg ha^{-1} in grain and 145.97 kg ha^{-1} in straw). In contrast, the lowest uptake values (2.85 and 30.37 kg ha^{-1}) were observed under T_1 (D_1N_1), which involved early sowing with no fertilizer application. A similar trend was evident in 2024, where T_{12} (D_3N_4) again performed the best (13.15 and 121.14 kg ha^{-1}), while T_1 registered the lowest uptake. The pooled data further confirmed that T_{12} consistently produced the highest uptake (14.53 and 133.56 kg ha^{-1}), followed by T_8 (D_2N_4), whereas T_1 remained the least productive treatment.

This combined effect highlights that optimum sowing time coupled with integrated nutrient application creates synergistic conditions for enhanced nutrient uptake, particularly potassium, due to improved root proliferation, better soil structure, and sustained nutrient release.

The substantial variation in potassium uptake observed among sowing dates can be attributed primarily to differences in crop establishment, growth period, and root development. Later sowing, especially around early July, appears to harmonize crop phenology with prevailing moisture and temperature conditions, promoting higher nutrient absorption efficiency.

Similarly, nutrient management treatments exerted a strong influence on potassium uptake. The integrated nutrient approach (N_4), which combined inorganic fertilizers with organic sources such as FYM, proved superior in enhancing nutrient availability throughout the growth cycle. Organic matter contributes to improved soil physical properties, increased microbial mineralization, and enhanced cation exchange capacity, which together support greater potassium mobility and uptake by the plant. The significant D × N interaction suggests that the benefits of integrated nutrient management are maximized when applied under the most suitable sowing date. The combination of D_3 and N_4 consistently produced the highest uptake, indicating a synergistic effect between favorable climatic conditions and balanced nutrient supply.

These findings align with earlier reports by Mubeena *et al.* (2019) and Mathyam *et al.* (2023), who also emphasized the importance of timely sowing and integrated nutrient management in optimizing nutrient uptake and improving overall productivity in finger millet.

Table 4.32(a): Potassium uptake (kg ha^{-1}) by grain and straw under different sowing dates and nutrient management system of finger millet

Treatments	Potassium uptake (kg ha^{-1})					
	Grain			Straw		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	9.31	5.57	7.43	81.01	52.95	66.98
D_2: 15th June	10.93	9.14	10.04	93.73	79.44	86.58
D_3: 1st July	10.54	9.18	9.85	97.51	86.54	92.02
SEm±	0.90	0.37	0.53	5.59	2.75	3.70
CD (P=0.05)	2.64	1.07	1.55	16.40	8.06	10.85
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	3.91	3.05	3.48	42.49	31.97	37.23
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	11.59	9.56	10.58	93.87	86.71	90.29
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	10.47	7.98	9.23	97.83	75.06	86.44
N_4: 50% Inorganic + 50% Organic through FYM	15.06	11.25	13.15	128.81	98.16	113.49
SEm±	1.56	0.42	0.61	6.46	3.18	4.27
CD (P=0.05)	4.59	1.25	1.80	18.94	9.32	12.53

Table 4.32(b): Interaction effect on potassium uptake (kg ha^{-1}) by grain and straw under different sowing dates and nutrient management system

Interaction (D×N)	Potassium uptake (kg ha^{-1})					
	Grain			Straw		
	2023	2024	Pooled	2023	2024	Pooled
T$_1$: D$_1$N$_1$	2.86	1.84	2.35	30.37	20.40	25.38
T$_2$: D$_1$N$_2$	10.89	7.42	9.15	82.07	69.59	75.83
T$_3$: D$_1$N$_3$	9.20	5.30	7.25	92.47	53.42	72.95
T$_4$: D$_1$N$_4$	14.28	7.71	10.99	119.13	68.36	93.75
T$_5$: D$_2$N$_1$	4.18	2.83	3.50	45.97	30.16	38.07
T$_6$: D$_2$N$_2$	12.08	10.63	11.36	93.16	84.11	88.63
T$_7$: D$_2$N$_3$	12.47	10.23	11.35	114.47	98.49	106.48
T$_8$: D$_2$N$_4$	14.99	12.89	13.94	121.34	104.96	113.15
T$_9$: D$_3$N$_1$	4.71	4.48	4.59	51.13	45.35	48.24
T$_{10}$: D$_3$N$_2$	11.80	10.65	11.22	106.39	106.43	106.41
T$_{11}$: D$_3$N$_3$	9.73	8.42	9.08	86.54	73.27	79.90
T$_{12}$: D$_3$N$_4$	15.91	13.15	14.53	145.97	121.14	133.56
SEm±	0.78	0.74	1.06	11.19	5.50	7.40
CD (P=0.05)	2.30	2.15	3.12	32.81	16.12	21.69

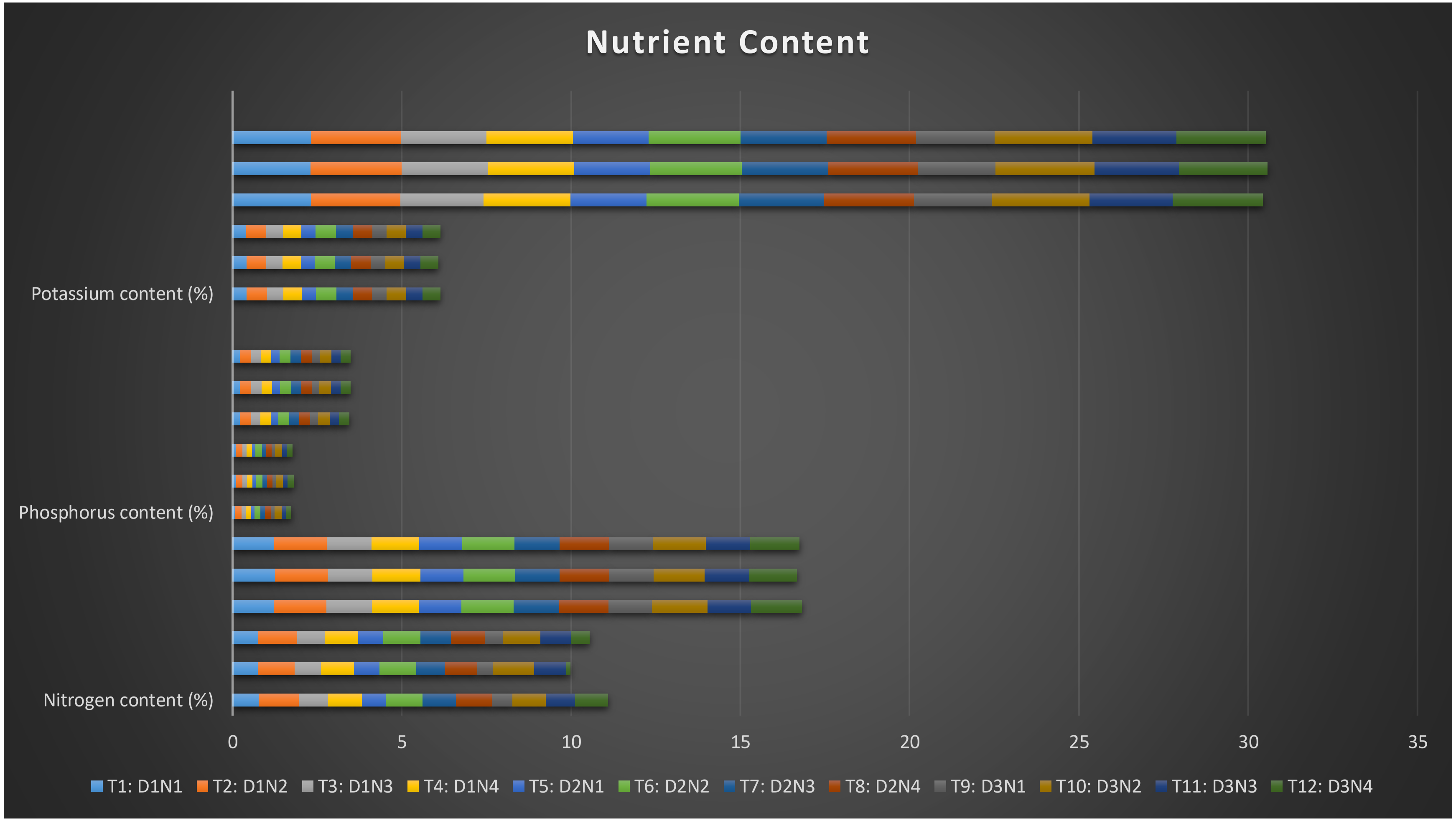


Fig. 4.11 Effect of different sowing dates and nutrient management on Nutrient content (%)

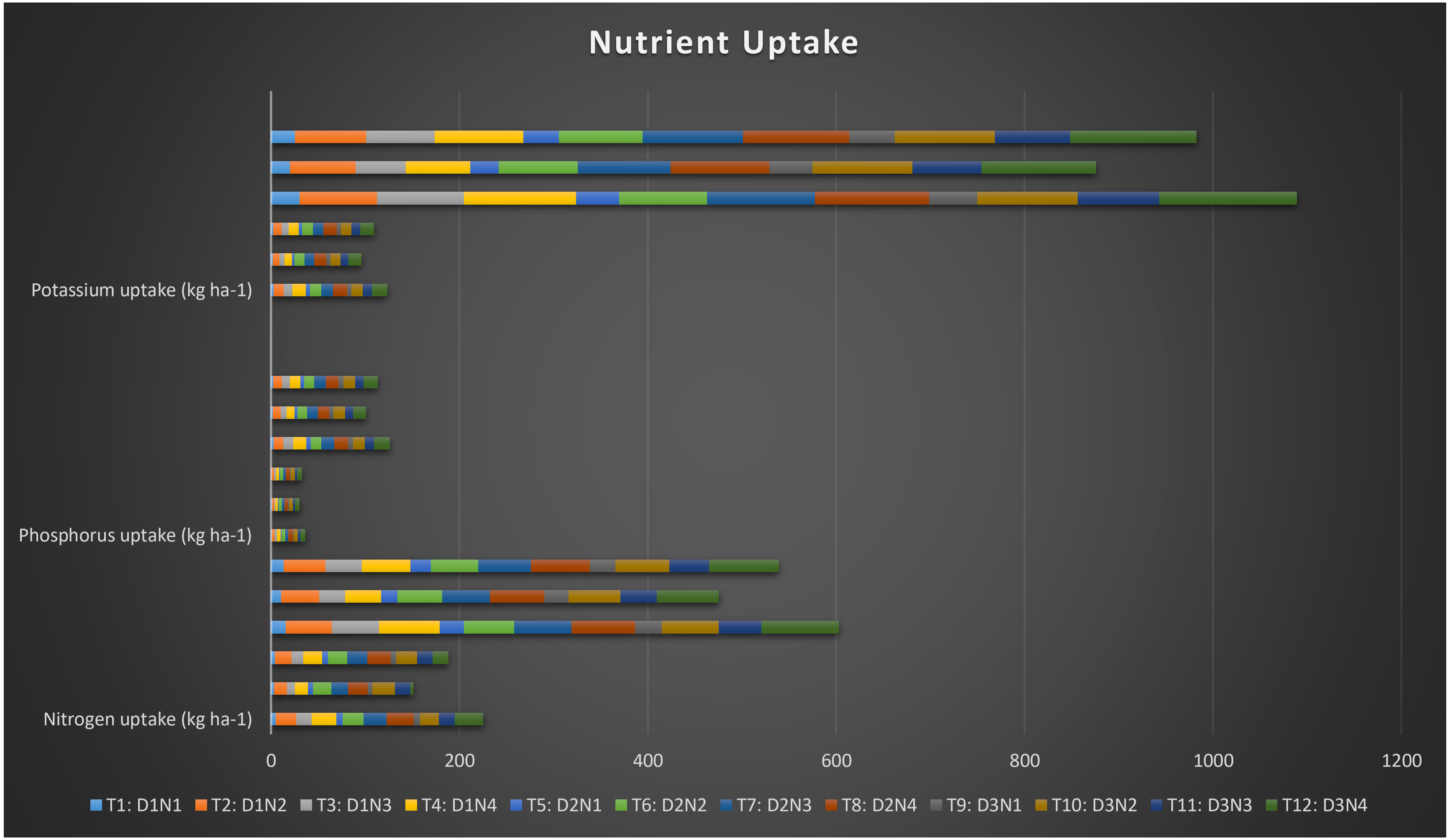


Fig. 4.12 Effect of different sowing dates and nutrient management on Nutrient uptake (kg ha^{-1})

4.1.6 Fertility status of the soil after harvest parameters

4.1.6.1 Soil pH (%)

Soil pH data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.33(a) and 4.33(b).

Effect of Sowing Dates (D)

The results presented reveal that soil pH exhibited only slight differences across the sowing dates during both experimental years as well as in the combined analysis.

In 2023, the crop sown on 1st June (D_1) recorded the highest soil pH (4.96), followed by 1st July (D_3) with 4.78, while the lowest value (4.77) was noted in the 15th June sowing (D_2)**.** A similar pattern continued in 2024**,** with D_1 maintaining a relatively higher soil pH (4.86). Sowing on 1st July (D_3) resulted in a pH of 4.96, whereas the minimum pH (4.87) again occurred under D_2**.**

In the pooled mean, D_1 recorded the maximum soil pH (4.91), while D_2 showed the lowest (4.82). These minor variations across dates may be associated with shifts in soil moisture dynamics, temperature fluctuations, and physiological activity of the crop, each of which can influence nutrient transformations, root respiration, and microbial processes responsible for modulating pH values.

Effect of Nutrient Management (N)

Soil pH responded more distinctly to nutrient management regimes than to sowing dates, showing significant differences in both years as well as in the pooled dataset.

In 2023**,** the recommended dose of fertilizers (N_2: RDF) resulted in the highest soil pH (5.22). This was followed by the 100% organic treatment (N_3)**,** which recorded 4.98. Control plots (N_1, no fertilizer) consistently exhibited the lowest pH

(4.43). The trend remained consistent in 2024, where N_2 again maintained the highest pH (5.36), followed by N_3 (4.86). The lowest (4.45) was once more associated with the unfertilized plots (N_1).

In the pooled analysis, soil pH values ranged between 4.44 (N_1) and 5.29 (N_2). The integrated nutrient application (N_4: 50% inorganic + 50% organic) maintained intermediate values (4.81). The relatively higher pH under N_2 could be attributed to improved nutrient balance and the soil's buffering ability against acidification, whereas organic inputs (N_3 and N_4) may have moderated pH through organic acid production and gradual mineralization.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management exhibited noticeable differences in soil pH during both seasons and in the pooled data.

In 2023, the maximum soil pH (5.613) was associated with T_3 (D_1N_3: 1st June + 100% FYM), followed by T_{10} (D_3N_2: 1st July + RDF) with 5.18. The lowest pH (4.27) occurred in T_1 (D_1N_1: 1st June + Control). In 2024, T_{10} (D_3N_2) again produced the highest soil pH (5.66), whereas the minimum (4.32) was recorded under T_8 (D_2N_4: 15th June + 50% inorganic + 50% organic).

Across the pooled mean, T_{10} (D_3N_2) consistently resulted in the maximum pH (5.42), followed by T_6 (D_2N_2) with 5.26. The minimum pH value (4.313) remained under the control treatment, T_1 (D_1N_1).

These findings illustrate that the combination of RDF (N_2) with later sowing (D_3) was most effective in maintaining a relatively higher soil pH. Conversely, the absence of nutrient inputs (N_1) led to a slight decline in soil pH, suggesting enhanced acidification in unfertilized soils.

The overall results suggest that although sowing dates exerted limited influence on soil reaction, nutrient management practices contributed appreciably to observed changes in pH.

Slight differences across sowing dates may reflect variations in root growth patterns, soil moisture availability, and microbial activity factors that directly influence organic matter decomposition and cation exchange processes.

The relatively higher soil pH under RDF (N_2) and integrated nutrient application (N_4) indicates that the balanced supply of nutrients helps moderate soil acidity and sustain favorable chemical conditions for crop growth. Organic sources, while beneficial for soil health, tend to produce mild organic acids during decomposition, which may lower or stabilize pH at moderate levels.

The D × N interaction further emphasizes that pairing recommended fertilizers with appropriate sowing windows (particularly 1st July) can enhance soil chemical stability.

These findings align with observations by Singh (2021), Mubeena *et al.* (2019) and Mathyam *et al.* (2023), who reported improved soil pH and reduced acidification in millet-based systems under balanced and integrated nutrient management approaches.

Table 4.33(a): Soil pH under different sowing dates and nutrient management system of finger millet

Treatments	Soil pH		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1st June	4.97	4.87	4.91
D_2: 15th June	4.78	4.88	4.83
D_3: 1st July	4.78	4.97	4.88
SEm±	0.05	0.07	0.04
CD (P=0.05)	0.13	0.20	0.11
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	4.43	4.46	4.44
N_2: RDF - 40:30:20 kg/ha (N, P_2O_5, K_2O)	5.22	5.37	5.30
N_3: 100% Organic through FYM	4.99	4.86	4.93
N_4: 50% Inorganic + 50% Organic through FYM	4.72	4.91	4.82
SEm±	0.05	0.08	0.05
CD (P=0.05)	0.16	0.22	0.14

Table 4.33(b): Interaction effect on soil pH under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Soil pH		
	2023	2024	Pooled
T_1: D_1N_1	4.27	4.37	4.31
T_2: D_1N_2	5.19	5.18	5.19
T_3: D_1N_3	5.61	4.93	5.27
T_4: D_1N_4	4.79	4.96	4.88
T_5: D_2N_1	4.50	4.69	4.60
T_6: D_2N_2	5.28	5.25	5.26
T_7: D_2N_3	4.68	4.68	4.68
T_8: D_2N_4	4.63	4.89	4.76
T_9: D_3N_1	4.54	4.32	4.42
T_{10}: D_3N_2	5.19	5.67	5.43
T_{11}: D_3N_3	4.66	4.97	4.81
T_{12}: D_3N_4	4.75	4.89	4.81
SEm±	0.09	0.14	0.08
CD (P=0.05)	0.27	NS	0.23

4.1.6.2 Soil organic carbon (%)

Soil organic carbon (%) data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.34(a) and 4.34(b).

Effect of Sowing Dates (D)

The observations presented indicate that soil organic carbon (SOC) values exhibited slight yet consistent variations across different sowing dates during both experimental years, as well as in the pooled data.

In 2023, SOC content ranged narrowly between 1.13% and 1.15%. The highest value (1.15%) was recorded under D_1 (1st June) and D_3 (1st July), while the lowest SOC (1.13%) was associated with D_2 (15th June).

A similar trend emerged in 2024, wherein D_1 maintained the maximum SOC (1.18%), closely followed by D_3 (1.12%). The lowest SOC (1.12%) was again observed under D_2, reaffirming the pattern recorded in the previous year.

The pooled mean further strengthened this observation, with D_1 demonstrating the highest SOC content (1.17%) and D_2 registering the lowest (1.12%). The slightly elevated SOC levels under early sowing (1st June) may be attributed to longer crop duration, better residue incorporation, enhanced root proliferation, and possibly slower decomposition rates, compared with sowing on 15th June.

Effect of Nutrient Management (N)

Nutrient management practices exerted a more pronounced influence on SOC compared to sowing dates during both years and in the combined analysis.

In 2023, the highest SOC content (1.27%) was observed under N_3 (100% Organic through FYM). This was followed by the unfertilized control (N_1) with 1.22%. The lowest SOC (0.99%) occurred under N_4 (50% inorganic + 50% organic).

The trend was comparable in 2024, with N_3 once more producing the highest SOC (1.25%), while N_1 recorded 1.18%. The lowest SOC (1.05%) was associated with N_2 (RDF).

Across the pooled data, N_3 consistently yielded the highest SOC (1.26%), followed by N_1 (1.20%). The lowest mean SOC (1.04%) occurred under N_4, indicating that combined inorganic and organic nutrient sources tended to maintain lower carbon levels than organic-only treatments. The substantial improvement in SOC under N_3 can be attributed to continuous organic matter addition, stimulation of microbial activity, and slower mineralization rates. In contrast, treatments dominated by chemical fertilizers (N_2 and N_4) might have encouraged rapid decomposition, resulting in reduced SOC accumulation.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management significantly affected SOC levels across both years and in the pooled mean. During 2023, the highest SOC (1.44%) was recorded under T_7 (D_2N_3: 15th June + 100% FYM), followed by T_{11} (D_3N_3: 1st July + 100% FYM) with 1.41%. The minimum SOC (0.77%) was noted in T_8 (D_2N_4), where organic and inorganic inputs were combined. In 2024, T_7 again produced the maximum SOC (1.38%), while the lowest value (0.81%) occurred under T_{10} (D_3N_2: 1st July + RDF).

When the data were pooled, T_7 remained the most effective combination, registering a mean SOC of 1.41%, closely followed by T_{11} (1.38%). Conversely, T_8 (D_2N_4) recorded the lowest pooled SOC value (0.86%). The notable enhancement in SOC under organic nutrient treatments (particularly N_3) combined with mid or late sowing (D_2 or D_3) suggests that the addition of FYM improved organic matter buildup, root biomass, and microbial processes that contribute to soil carbon stabilization.

The findings clearly illustrate that nutrient management practices, particularly the application of FYM, exerted a strong and positive influence on SOC accumulation.

The substantial improvement under N_3 (100% Organic) can be attributed to continuous organic inputs, improved soil biological activity, and the gradual release of nutrients, all of which promote carbon sequestration within the soil matrix.

Although sowing dates exhibited comparatively smaller effects, early (D_1) and late (D_3) sowing both showed slightly higher SOC levels than mid-June sowing. These differences may be associated with variations in crop duration, soil temperature, and moisture availability, which influence rates of organic matter decomposition and residue incorporation.

Lower SOC under combined nutrient treatments (N_4) and RDF-only treatments (N_2) indicates that chemical fertilizers alone may not adequately support long-term carbon buildup due to rapid mineralization and limited organic residue return.

The D×N interaction further reinforces the role of organic-based nutrient management in sustaining and improving soil carbon content under favorable sowing conditions. These results align with earlier findings by Singh (2021), Mathyam *et al.* (2023) and Kumar *et al.* (2022), who reported similar improvements in SOC with the application of FYM in millet-based cropping systems.

Table 4.34(a): Soil organic carbon (%) under different sowing dates and nutrient management system of finger millet

Treatments	Soil organic carbon (%)		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1^{st} June	1.15	1.18	1.18
D_2: 15^{th} June	1.13	1.13	1.12
D_3: 1^{st} July	1.15	1.13	1.14
SEm±	0.01	0.01	0.01
CD (P=0.05)	0.03	0.02	0.02
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	1.22	1.18	1.21
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	1.09	1.06	1.07
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	1.27	1.26	1.26
N_4: 50% Inorganic + 50% Organic through FYM	1.00	1.09	1.04
SEm±	0.01	0.01	0.01
CD (P=0.05)	0.03	0.02	0.02

Table 4.34(b): Interaction effect on soil organic carbon (%) under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Soil organic carbon (%)		
	2023	2024	Pooled
T_1: D_1N_1	1.18	1.21	1.20
T_2: D_1N_2	1.27	1.30	1.28
T_3: D_1N_3	0.95	1.04	1.00
T_4: D_1N_4	1.22	1.21	1.21
T_5: D_2N_1	1.24	1.09	1.17
T_6: D_2N_2	1.06	1.05	1.06
T_7: D_2N_3	1.44	1.39	1.42
T_8: D_2N_4	0.78	0.96	0.86
T_9: D_3N_1	1.25	1.24	1.25
T_{10}: D_3N_2	0.95	0.82	0.89
T_{11}: D_3N_3	1.42	1.35	1.38
T_{12}: D_3N_4	0.99	1.10	1.05
SEm±	0.02	0.02	0.01
CD (P=0.05)	0.05	0.06	0.04

4.1.6.3 Available N (kg ha^{-1})

Soil available N (%) data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.35(a) and 4.35(b).

Effect of Sowing Dates (D)

The results presented reveal that the variation in soil available nitrogen among different sowing dates, although modest, was consistent across both years of experimentation and in the pooled mean.

During 2023, the highest nitrogen availability (270.25 kg ha^{-1}) was recorded under D_1 (1st June), followed by D_2 (15th June) with 255.19 kg ha^{-1}, while the lowest value (251.15 kg ha^{-1}) occurred under D_3 (1st July). A similar trend was recorded in 2024, where D_1 again exhibited the maximum soil nitrogen (266.64 kg ha^{-1}), followed by D_2 at 260.06 kg ha^{-1}. The minimum nitrogen availability (263.69 kg ha^{-1}) was associated with D_3.

Across the pooled data, D_1 consistently produced the highest mean nitrogen content (268.44 kg ha^{-1}), whereas D_3 exhibited the lowest (257.42 kg ha^{-1}). The consistently superior performance of the early sowing date (1st June) may be attributed to a longer growing period, greater root biomass development, and more efficient nutrient uptake and residue recycling, which contributed to enhanced residual nitrogen in the soil after crop harvest.

Effect of Nutrient Management (N)

Nutrient management had a substantial influence on soil available nitrogen, and the differences among treatments were significant in individual years as well as in the pooled analysis.

In 2023, the highest nitrogen availability (366.51 kg ha^{-1}) was observed under N_2 (RDF: 40:30:20 kg $N:P_2O_5:K_2O$ ha^{-1}), followed by N_4 (50% Inorganic + 50% Organic) with 305.61 kg ha^{-1}. The lowest nitrogen content (144.27 kg ha^{-1})

occurred in the N_1 (Control) treatment. An identical pattern was recorded in 2024, with N_2 maintaining the maximum nitrogen availability (367.37 kg ha^{-1}), followed by N_4 (311.16 kg ha^{-1}). Again, the lowest nitrogen (147.08 kg ha^{-1}) was found in N_1. The pooled mean further confirmed the superiority of N_2, which recorded the highest available nitrogen (366.94 kg ha^{-1}). This was followed by N_4 (308.39 kg ha^{-1}), while the lowest nitrogen (145.67 kg ha^{-1}) was associated with N_1.

The marked increase in soil nitrogen under N_2 and N_4 can be attributed to direct nitrogen addition through fertilizer application, coupled with the beneficial effects of organic matter on nitrogen mineralization. On the other hand, the consistently low nitrogen under control plots reflects continuous nutrient removal without replenishment.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D × N) was significant across both years and in the combined mean.

In 2023, the highest nitrogen availability (382.35 kg ha^{-1}) was recorded under T_2 (D_1N_2: 1st June + RDF), closely followed by T_6 (D_2N_2) with 375.50 kg ha^{-1}. The minimum nitrogen (141.01 kg ha^{-1}) occurred in T_5 (D_2N_1). During 2024, T_2 again produced the highest nitrogen level (380.01 kg ha^{-1}), followed by T_6 (364.94 kg ha^{-1}). The lowest nitrogen availability (142.53 kg ha^{-1}) was recorded under T_1 (D_1N_1).

The pooled analysis reaffirmed this trend, with T_2 (D_1N_2) recording the maximum nitrogen content (381.18 kg ha^{-1}), followed by T_6 (370.22 kg ha^{-1}). The lowest available nitrogen (142.68 kg ha^{-1}) was found in T_1 (D_1N_1). The superiority of the treatment combination D_1N_2 suggests that early sowing coupled with RDF application created favorable conditions for nitrogen release and mineralization, resulting in higher nitrogen retention after crop harvest. Conversely, the consistently low nitrogen levels in control treatments highlight the need for external nutrient supplementation to sustain soil fertility.

The overall findings clearly show that both sowing dates and nutrient management practices significantly influenced the soil available nitrogen status. Early sowing (1st June) appeared advantageous, likely due to extended crop duration, improved nutrient absorption, and favorable root–soil interactions that promoted nitrogen retention.

Among nutrient management practices, RDF (N_2) consistently achieved the highest nitrogen values. This can be attributed to the immediate availability of mineral nitrogen from fertilizers and the stimulation of microbial processes involved in nitrogen cycling. Treatments combining organic and inorganic sources (N_4) also enhanced nitrogen status, possibly due to the slow and steady release of nitrogen from FYM.

Organic nutrient treatment alone (N_3) resulted in moderate nitrogen levels, reflecting slower decomposition rates and gradual nutrient release from organic materials. The control plots (N_1), having received no additional nitrogen, showed the lowest values, confirming the depletion of native soil nitrogen through crop uptake.

These outcomes are consistent with the observations of Singh (2021), Mubeena *et al.* (2019) and Mathyam *et al*. (2023), who reported that balanced and integrated nutrient management enhances nitrogen availability and improves the fertility of cereal-based cropping systems.

Table 4.35(a): Soil available N (%) under different sowing dates and nutrient management system of finger millet

Treatments	Soil available nitrogen – N (kg ha^{-1})		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1^{st} June	270.26	266.65	268.44
D_2: 15^{th} June	255.20	260.06	257.63
D_3: 1^{st} July	251.16	263.69	257.43
SEm±	0.85	0.98	0.76
CD (P=0.05)	2.49	2.87	2.21
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	144.27	147.08	145.67
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	366.52	367.38	366.94
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	219.06	228.25	223.65
N_4: 50% Inorganic + 50% Organic through FYM	305.62	311.16	308.39
SEm±	0.98	1.13	0.87
CD (P=0.05)	2.87	3.32	2.56

Table 4.35(b): Interaction effect on soil available N (%) under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Soil available nitrogen – N (kg ha^{-1})		
	2023	2024	Pooled
T_1: D_1N_1	142.84	142.54	142.68
T_2: D_1N_2	382.35	380.02	381.18
T_3: D_1N_3	231.54	225.10	228.32
T_4: D_1N_4	324.28	318.92	321.60
T_5: D_2N_1	141.02	146.54	143.78
T_6: D_2N_2	375.51	364.94	370.23
T_7: D_2N_3	213.59	227.50	220.54
T_8: D_2N_4	290.65	301.29	295.98
T_9: D_3N_1	148.95	152.17	150.56
T_{10}: D_3N_2	341.69	357.17	349.43
T_{11}: D_3N_3	212.07	232.14	222.11
T_{12}: D_3N_4	301.91	313.28	307.59
SEm±	1.69	1.96	1.51
CD (P=0.05)	4.97	5.74	4.44

4.1.6.4 Available P (kg ha^{-1})

Soil available P (%) data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.36(a) and 4.36(b).

Effect of Sowing Dates (D)

The data presented indicate that the soil available phosphorus content showed minor variation across the different sowing dates in both experimental years as well as in the pooled mean.

In 2023, soil available phosphorus ranged from 11.99 to 12.67 kg ha^{-1}, with the highest value (12.67 kg ha^{-1}) recorded under D_3 (1st July), followed closely by D_1 (1st June). The lowest phosphorus content (11.99 kg ha^{-1}) was observed at the mid-June sowing (D_2). A slightly different trend was observed in 2024, where D_2 (15th June) produced the highest available phosphorus level (12.57 kg ha^{-1}), followed by D_3 (12.45 kg ha^{-1}), while the minimum value (12.06 kg ha^{-1}) occurred under D_1 (1st June).

When the two year results were pooled, D_3 (1st July) consistently maintained the highest soil phosphorus content (12.56 kg ha^{-1}), whereas D_1 (1st June) exhibited the lowest pooled value (12.13 kg ha^{-1}). Although the differences among sowing dates were not large, the relatively higher phosphorus availability under July sowing may be associated with reduced uptake due to slower crop growth and enhanced microbial mineralization under improved soil moisture conditions.

Effect of Nutrient Management (N)

Nutrient management practices exerted a significant influence on soil available phosphorus during each year and in the pooled dataset.

In 2023, the maximum phosphorus content (16.20 kg ha^{-1}) was registered under N_2 (RDF: 40:30:20 kg ha^{-1} of $N:P_2O_5:K_2O$). This was followed by the integrated treatment N_4 (50% Inorganic + 50% Organic) with 13.84 kg ha^{-1}. The control treatment (N_1) recorded the lowest phosphorus content (7.57 kg ha^{-1}). This trend persisted in 2024, where N_2 again produced the highest available phosphorus (16.69 kg ha^{-1}), followed by N_4. The lowest value (7.99 kg ha^{-1}) was again associated with N_1.

On pooling the data, N_2 maintained its superiority with the highest mean value of 16.44 kg ha^{-1}, significantly surpassing all other nutrient management practices. It was followed by N_4 (13.87 kg ha^{-1}), while N_3 (100% Organic through FYM) showed moderate phosphorus availability (11.20 kg ha^{-1}). The least soil phosphorus (7.78 kg ha^{-1}) was recorded under N_1 (Control). The consistently higher phosphorus content under RDF can be attributed to the direct application of P fertilizers and the steady release of phosphorus into the soil. The intermediate performance of N_4 further highlights the role of organics in reducing phosphorus fixation and enhancing solubility through organic acid formation.

Interaction Effect (D × N)

The combined effect of sowing dates and nutrient management showed a significant influence on soil available phosphorus across both years and in the pooled mean.

In 2023, the highest phosphorus content (16.38 kg ha^{-1}) was observed in T_{10} (D_3N_2: 1st July + RDF), followed by T_2 (D_1N_2) and T_6 (D_2N_2). The minimum value (7.09 kg ha^{-1}) occurred in T_1 (D_1N_1: Control). A similar pattern emerged in 2024, with T_{10} (D_3N_2) again showing the highest phosphorus content (16.99 kg ha^{-1}), followed by T_6 (D_2N_2). The lowest value (7.07 kg ha^{-1}) was again associated with the control treatment, T_1 (D_1N_1). In the pooled analysis, T_{10} (D_3N_2) consistently remained the best-performing treatment, registering 16.69 kg ha^{-1} of available phosphorus. T_6 (D_2N_2) and T_2 (D_1N_2) followed closely. The minimum pooled value (7.08 kg ha^{-1}) was recorded in T_1 (D_1N_1). These results demonstrate that the RDF treatment combined with late sowing (1st July) tends to leave a higher residual phosphorus content in the soil. This may be due to comparatively lower plant uptake during late sowing and favourable moisture conditions that facilitate phosphorus solubilization and reduce fixation.

The results highlight that both sowing dates and nutrient management practices play important roles in determining the post-harvest soil phosphorus status. Although the variation among sowing dates was modest, July sowing tended to retain slightly higher amounts of available phosphorus, likely due to reduced uptake and enhanced mineralization under higher moisture levels.

Nutrient management exhibited a much stronger impact, with RDF (N_2) consistently producing the highest available phosphorus content. This is expected, as mineral P fertilizers provide an immediate and concentrated source of phosphorus, which contributes directly to the soil pool. Integrated nutrient management (N_4) further enhanced phosphorus availability, likely due to improved soil structure and reduced P fixation caused by organic matter decomposition.

Control plots showed the lowest values, indicating nutrient depletion due to continuous removal by crops without replenishment. The organic treatment (N_3) showed moderate values, suggesting that while FYM improves soil health and long-term fertility, it may not supply sufficient immediately available phosphorus compared to mineral fertilizers.

These observations align with the findings of Kumar *et al*. (2021) and Singh and Singh and Vemireddy (2022)**,** who reported that combined application of fertilizers and organic manures enhances phosphorus availability by improving soil biological activity, reducing fixation, and promoting gradual nutrient release.

Table 4.36(a): Soil available P (%) under different sowing dates and nutrient management system of finger millet

Treatments	Soil available phosphorus – P (kg ha^{-1})		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D$_1$: 1st June	12.21	12.06	12.13
D$_2$: 15th June	12.00	12.58	12.29
D$_3$: 1st July	12.67	12.45	12.56
SEm±	0.14	0.13	0.10
CD (P=0.05)	0.42	0.37	0.29
Nutrient management (N)			
	2023	**2024**	**Pooled**
N$_1$: Control (No fertilizer)	7.57	8.00	7.79
N$_2$: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	16.20	16.69	16.44
N$_3$: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	11.55	10.86	11.20
N$_4$: 50% Inorganic + 50% Organic through FYM	13.84	13.90	13.88
SEm±	0.17	0.15	0.11
CD (P=0.05)	0.49	0.42	0.33

Table 4.36(b): Interaction effect on soil available P (%) under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Soil available phosphorus – P (kg ha^{-1})		
	2023	**2024**	**Pooled**
T_1: D_1N_1	7.09	7.07	7.08
T_2: D_1N_2	16.13	16.14	16.14
T_3: D_1N_3	11.98	10.65	11.32
T_4: D_1N_4	13.61	14.40	14.02
T_5: D_2N_1	7.74	8.26	8.00
T_6: D_2N_2	16.09	16.95	16.53
T_7: D_2N_3	10.28	10.77	10.53
T_8: D_2N_4	13.85	14.33	14.08
T_9: D_3N_1	7.88	8.67	8.27
T_{10}: D_3N_2	16.39	16.99	16.69
T_{11}: D_3N_3	12.39	11.17	11.79
T_{12}: D_3N_4	14.06	12.98	13.53
SEm±	0.29	0.25	0.19
CD (P=0.05)	0.83	0.73	0.57

4.1.6.5 Available K (kg ha^{-1})

Soil available K (%) data were recorded as influenced by different sowing dates and nutrient management for the year 2023, 2024 and in pooled are presented in Tables 4.37(a) and 4.37(b).

Effect of Sowing Dates

The data presented demonstrate that soil available potassium levels were influenced by different sowing dates during both years of experimentation (2023 and 2024) as well as in the pooled analysis.

During 2023, the maximum potassium availability (277.94 kg ha^{-1}) was noted under the late sowing date D_3 (1st July), followed closely by D_2 (15th June) with 278.41 kg ha^{-1}. The minimum value (275.51 kg ha^{-1}) occurred under the earliest sowing date D_1 (1st June). A comparable trend was observed in 2024, wherein D_3 again recorded the highest potassium content (280.15 kg ha^{-1}), followed by D_2 (279.86 kg ha^{-1}). As in the previous year, D_1 resulted in the lowest available potassium (272.98 kg ha^{-1}).

The pooled data supported this general pattern, with D_2 (15th June) registering the highest mean potassium availability (279.13 kg ha^{-1}), while D_1 (1st June) remained the lowest (274.25 kg ha^{-1}). Although numerical variations existed among sowing dates, the pooled analysis indicated that the differences were marginal and statistically nonsignificant, implying a relatively stable soil potassium status irrespective of sowing time.

Effect of Nutrient Management

Nutrient management practices significantly affected soil available potassium during both years and in the pooled dataset.

In 2023, the highest potassium content (339.03 kg ha^{-1}) was recorded under N_2 (RDF: 40:30:20 kg ha^{-1} N:P_2O_5:K_2O). This was followed by the integrated nutrient treatment N_4 (50% inorganic + 50% organic), which yielded 315.77 kg ha^{-1}. The control treatment N_1, which did not receive any fertilizers, registered the lowest potassium level (195.48 kg ha^{-1}). The 2024 data mirrored this pattern, with the RDF treatment (N_2) yielding the maximum available potassium (337.45 kg ha^{-1}), followed by N_4 (313.07 kg ha^{-1}). The control (N_1) again recorded the least potassium availability (192.42 kg ha^{-1}). Pooled results confirmed the consistent superiority of N_2, which produced the highest mean value (338.24 kg ha^{-1}), significantly outperforming all other nutrient treatments. Integrated nutrient management (N_4) ranked second with 314.42 kg ha^{-1}, whereas the control (N_1) recorded the minimum value (193.95 kg ha^{-1}). These results clearly indicate that recommended fertilizer application substantially enhances available potassium in soil, while the absence of nutrient inputs results in considerable depletion.

Interaction Effect (D × N)

A significant interaction between sowing dates and nutrient management practices was observed for soil available potassium during both years and in the pooled analysis.

In 2023, the combination D_2N_2 (15th June × RDF) resulted in the highest potassium availability (341.77 kg ha^{-1}), closely followed by D_3N_2 (1st July × RDF), which recorded 341.84 kg ha^{-1}. The lowest value (190.42 kg ha^{-1}) was associated with D_2N_1 (15th June × Control). In 2024, D_3N_2 recorded the highest available potassium (344.47 kg ha^{-1}), while D_2N_1 again resulted in the lowest (187.01 kg ha^{-1}). The pooled data reiterated this trend, with D_3N_2 (1st July × RDF) maintaining the highest mean potassium content (343.16 kg ha^{-1}), followed by D_2N_2 (341.52 kg ha^{-1}). The minimum pooled value (188.72 kg ha^{-1}) was recorded under D_2N_1.

These findings suggest that the combination of favorable sowing dates with adequate nutrient supply, particularly RDF, optimizes soil potassium availability.

The variation in soil available potassium across sowing dates may be attributed to differences in nutrient uptake dynamics, soil moisture conditions, and microbial activity associated with various sowing windows. Slightly higher potassium levels under mid-June and July sowings could be linked to favorable moisture regimes and enhanced potassium mineralization from soil colloids during these periods.

The substantial increase in potassium availability under the recommended fertilizer dose (N_2) and integrated nutrient management (N_4) can be explained by improved nutrient supply, enhanced root proliferation, and increased microbial activity, which collectively enhance nutrient cycling. The presence of organic matter in N_4 likely contributed to improved soil structure and greater cation exchange capacity, facilitating potassium retention.

The significant interaction effects further highlight the importance of synchronizing sowing time with appropriate nutrient management. Treatments involving RDF under D_2 and D_3 consistently exhibited higher residual potassium levels, suggesting efficient nutrient utilization and favorable soil conditions for potassium release and retention.

Overall, the results underscore that optimal sowing windows, coupled with balanced nutrient management strategies, are essential for maintaining soil potassium fertility and ensuring productive crop growth. These observations align with the findings of Amarjeet *et al.* (2021) and Singh *et al.* (2022)**,** who reported that combined application of fertilizers and organic manures enhances potassium availability by improving soil biological activity, reducing fixation, and promoting gradual nutrient release.

Table 4.37(a): Soil available K (%) under different sowing dates and nutrient management system of finger millet

Treatments	Soil available potassium – K (kg ha^{-1})		
Sowing dates (D)			
	2023	**2024**	**Pooled**
D_1: 1st June	275.52	272.98	274.26
D_2: 15th June	278.41	279.87	279.14
D_3: 1st July	277.94	280.16	279.04
SEm±	0.91	0.74	0.60
CD (P=0.05)	2.66	2.17	1.75
Nutrient management (N)			
	2023	**2024**	**Pooled**
N_1: Control (No fertilizer)	195.49	192.43	193.95
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	339.03	337.45	338.24
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	258.87	267.72	263.29
N_4: 50% Inorganic + 50% Organic through FYM	315.77	313.07	314.42
SEm±	1.05	0.85	0.69
CD (P=0.05)	3.09	2.49	2.03

Table 4.37(b): Interaction effect on Soil available K (%) under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Soil available potassium – K		
	2023	2024	Pooled
T_1: D_1N_1	199.31	189.32	194.32
T_2: D_1N_2	333.48	326.61	330.05
T_3: D_1N_3	256.05	267.34	261.70
T_4: D_1N_4	313.20	308.68	310.94
T_5: D_2N_1	190.43	187.02	188.73
T_6: D_2N_2	341.77	341.28	341.53
T_7: D_2N_3	265.22	271.24	268.22
T_8: D_2N_4	316.24	319.91	318.08
T_9: D_3N_1	196.72	200.94	198.83
T_{10}: D_3N_2	341.85	344.48	343.17
T_{11}: D_3N_3	255.33	264.57	259.96
T_{12}: D_3N_4	317.88	310.62	314.24
SEm±	1.82	1.48	1.19
CD (P=0.05)	5.33	4.33	3.52

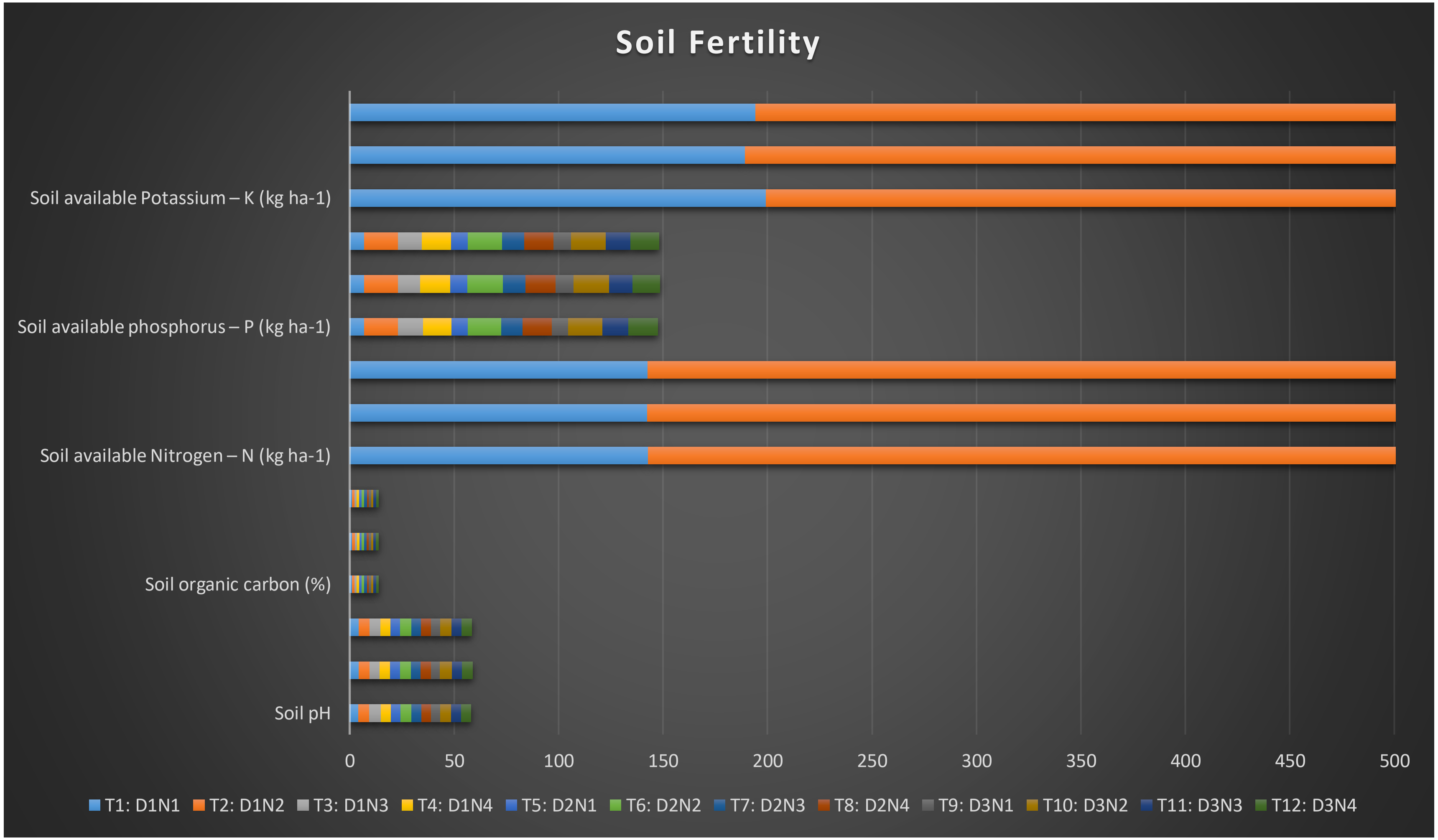


Fig. 4.13 Effect of different sowing dates and nutrient management on Soil Fertility

4.1.7 Economics

The economic viability of any treatment is closely linked to its effectiveness and the additional inputs invested relative to the returns generated. Data on economic analysis are presented in Tables 4.38(a) and 4.38(b).

4.1.7.1 Cost of cultivation and

4.1.7.2 Gross return (₹ ha^{-1})

Effect of Sowing Dates (D)

The findings summarized in Table 4.37 indicate that the cost of cultivation remained constant across all sowing dates during both 2023 and 2024, and in the pooled analysis, since identical production operations and inputs were used for each sowing window. Consequently, no statistical variation was observed, with the cost of cultivation fixed at ₹27,88 ha^{-1} for all sowing dates. In contrast, gross returns varied significantly among sowing dates. In 2023, the highest gross return (C97, 23 ha^{-1}) was achieved when the crop was sown on 1st July (D_3), followed by D_2 (₹94,83 ha^{-1}). The earliest sowing date, D_1 (1st June), recorded the lowest return (₹94,21 ha^{-1}). A similar pattern emerged in 2024, where D_3 again produced superior returns (₹90,870.96 ha^{-1}), followed by D_2 (₹85,622.95 ha^{-1}). The minimum return (₹73,378.59 ha^{-1}) was obtained under D_1. The pooled mean further confirmed this trend, with sowing on 1st July (D_3) resulting in the highest gross return (₹94,055.26 ha^{-1}), followed by D_2 (₹90,230.88 ha^{-1}), while D_1 registered the lowest value (₹83,796.89 ha^{-1}). These results clearly suggest that delayed sowing towards early July tended to be more profitable, likely due to improved environmental conditions during key growth stages, resulting in better crop performance and higher financial returns.

Effect of Nutrient Management (N)

Nutrient management treatments had a pronounced effect on both cost of cultivation and gross returns during each year and in the pooled data.

The cost of cultivation varied substantially among treatments. The lowest cost (₹21,08 ha^{-1}) occurred under N_1 (Control), owing to the absence of fertilizer inputs. The maximum cost (₹32,35 ha^{-1}) was incurred under N_2 (RDF), followed by the integrated treatment N_4 (₹30,55 ha^{-1}) and the organic-based treatment N_3 (₹27,560 ha^{-1}). With respect to gross returns, N_4 consistently outperformed all other treatments. In 2023, the highest gross return (₹1,29,141.20 ha^{-1}) was achieved under N_4, followed by N_2 (₹98,977.6 ha^{-1}) and N_3 (₹98,948.33 ha^{-1}). The control treatment (N_1) produced the lowest return (₹54,384.6 ha^{-1}). In 2024, the same pattern persisted, with N_4 again yielding the maximum return (₹1,04,647.02 ha^{-1}), followed by N_2 (₹88,704.3 ha^{-1}) and N_3 (₹88,620.86 ha^{-1}), while N_1 recorded the lowest (₹41,558.6 ha^{-1}). The pooled mean reaffirmed these results: N_4 recorded the highest gross return (₹1,17,027.42 ha^{-1}), followed by N_2 (₹93,840.96 ha^{-1}) and N_3 (₹98,604.28 ha^{-1}). The control treatment (N_1) consistently generated the lowest return (₹47,971.35 ha^{-1}). The superior performance of N_4 indicates that integrated nutrient management (INM) substantially enhances economic returns, likely due to its positive influence on nutrient availability, soil health, and yield sustainability.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management had no significant effect on the cost of cultivation, as input costs were determined solely by nutrient treatments and remained unaffected by sowing time. However, the interaction significantly influenced gross returns in both years and in the pooled mean. In 2023, the highest gross return (₹1,30,585.28 ha^{-1}) was recorded under D_3N_4 (1st July × 50% inorganic + 50% organic), followed by D_1N_4 (₹1,29,104.37 ha^{-1}) and D_3N_2 (₹99,303.13 ha^{-1}). The lowest return (₹49,157.73 ha^{-1}) was obtained under D_1N_1 (Control). This trend remained consistent in 2024, wherein D_3N_4 again yielded the highest return (₹1,24,121.94 ha^{-1}), while D_1N_1 recorded the least (₹35,470.23 ha^{-1}). The pooled data further highlighted the economic advantage of this combination, with D_3N_4 producing the maximum return (₹1,74,333.98 ha^{-1}), followed by D_1N_4 (₹1,27,025.78 ha^{-1}) and D_3N_3 (₹1,27,353.61 ha^{-1}). Once again, D_1N_1 yielded the lowest return (₹88,176.91 ha^{-1}). Overall, the interaction results indicate that aligning the optimal sowing date with integrated nutrient application significantly enhances economic profitability.

The findings of this study underscore the importance of sowing time and nutrient management in determining economic returns from finger millet cultivation. While sowing dates did not influence the cost of cultivation, they contributed significantly to variations in gross returns. The highest economic benefits were achieved when the crop was sown in early July, likely due to favorable rainfall distribution, improved moisture availability, and conducive temperature during critical growth periods.

Among nutrient management strategies, the integrated approach (N_4) consistently recorded the highest returns across years. This superiority is attributable to the combined advantages of mineral fertilizers and organic manure, which enhance nutrient availability, promote microbial activity, improve soil physical properties, and support sustained yield improvement.

The significant interaction effects further reinforce the need for synchronizing sowing operations with an optimal nutrient supply strategy. The combination of early July sowing with integrated nutrient management (D_3N_4) produced the highest profitability, demonstrating that both agronomic and nutrient-related factors must be jointly optimized to achieve maximum economic efficiency.

This integrated approach not only enhances short-term returns but also contributes to long-term soil fertility and productive sustainability, making it a highly suitable option for finger millet cultivation. The higher profitability achieved under integrated nutrient management corroborates earlier findings by Singh and Arya (1999) and Verma *et al.* (2019 who also reported increased net returns and B:C ratio in millets under combined nutrient applications.

Table 4.38(a): Cost of cultivation and gross return under different sowing dates and nutrient management system of finger millet

Treatments	**Cost of cultivations (₹ ha^{-1})**			**Gross return (₹ ha^{-1})**		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	27885.00	27885.00	27885.00	94215.27	73378.51	83796.89
D_2: 15th June	27885.00	27885.00	27885.00	94838.80	85622.96	90230.89
D_3: 1st July	27885.00	27885.00	27885.00	97239.55	90870.96	94055.26
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	21080.00	21080.00	21080.00	54384.64	41558.06	47971.36
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	32350.00	32350.00	32350.00	98977.60	88704.32	93840.96
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	27560.00	27560.00	27560.00	98948.39	98260.18	98604.28
N_4: 50% Inorganic + 50% Organic through FYM	30550.00	30550.00	30550.00	129414.18	104640.70	117027.44

Table 4.38(b): Interaction effect on cost of cultivation and gross return under different sowing dates and nutrient management system

Interaction (D×N)	Cost of cultivations (₹ ha^{-1})			Gross return (₹ ha^{-1})		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	21080.00	21080.00	21080.00	49157.73	35470.24	88176.91
T_2: D_1N_2	32350.00	32350.00	32350.00	100013.18	76340.64	96213.74
T_3: D_1N_3	27560.00	27560.00	27560.00	98585.79	93841.68	108482.95
T_4: D_1N_4	30550.00	30550.00	30550.00	129104.37	87861.52	47025.78
T_5: D_2N_1	21080.00	21080.00	21080.00	56932.18	37119.37	96299.66
T_6: D_2N_2	32350.00	32350.00	32350.00	94840.01	97759.30	102352.34
T_7: D_2N_3	27560.00	27560.00	27560.00	99030.13	105674.56	115245.76
T_8: D_2N_4	30550.00	30550.00	30550.00	128552.87	101938.65	54574.30
T_9: D_3N_1	21080.00	21080.00	21080.00	57064.02	52084.58	97046.32
T_{10}: D_3N_2	32350.00	32350.00	32350.00	102079.62	92013.02	97246.77
T_{11}: D_3N_3	27560.00	27560.00	27560.00	99229.24	95264.32	127353.61
T_{12}: D_3N_4	30550.00	30550.00	30550.00	130585.29	124121.94	74.33

4.7.3 Net returns (₹ ha^{-1}) and
4.7.4 B:C ratio

Effect of Sowing Dates (D)

The results presented in Table 4.39(a) and 4.39(b) reveal that sowing dates exerted a considerable influence on both net return (₹ ha^{-1}) and the benefit cost (B:C) ratio during the two years of experimentation (2023 and 2024), as well as in the pooled analysis.

In 2023, the crop sown on 1st July (D_3) realized the highest net return (₹69,354.55 ha^{-1}), followed by the 15th June sowing (D_2), which produced ₹66,953.80 ha^{-1}. The lowest economic gain (₹66,330.27 ha^{-1}) occurred under the earliest sowing date, 1st June (D_1). A similar pattern emerged in 2024, where D_3 again secured the maximum net return (₹62,985.96 ha^{-1}), while D_2 and D_1 yielded ₹57,737.96 ha^{-1} and ₹45,493.51 ha^{-1}, respectively. The pooled mean further reinforced this trend, with D_3 (1st July) producing the highest net return (₹66,170.26 ha^{-1}). This was followed by D_2 (₹62,345.89 ha^{-1}), whereas the minimum pooled return (₹55,911.89 ha^{-1}) was realized under D_1.

A similar trend was observed for the B:C ratio. In 2023, the highest B:C ratio (2.43) was recorded under D_3, with D_2 (2.360) and D_1 (2.30) following in descending order. The 2024 data also reflected the superiority of D_3 (2.11) compared to D_1 (1.58). The pooled evaluation confirmed that D_3 achieved the greatest profitability (2.32), followed by D_2 (2.17), while D_1 recorded the lowest ratio (1.94). Overall, sowing during the early July window was found to be the most remunerative, likely due to climatic conditions that supported better crop growth and higher productivity.

Effect of Nutrient Management (N)

Nutrient management practices significantly affected net return and the B:C ratio across both experimental years and in the pooled dataset.

In 2023, the integrated nutrient treatment N_4 (50% inorganic + 50% organic through FYM) achieved the highest net return (₹98,864.17 ha^{-1}). This was followed by the fully organic treatment N_3 (₹71,388.36 ha^{-1}) and the recommended dose of fertilizers (N_2), which yielded ₹66,627.60 ha^{-1}. The control (N_1) recorded the minimum return (₹33,304.64 ha^{-1}). The 2024 results followed the same pattern, with N_4 again producing the highest net return (₹74,090.70 ha^{-1}), followed by N_3 (₹70,700.18 ha^{-1}) and N_2 (₹56,354.32 ha^{-1}). The lowest return (₹20,478.06 ha^{-1}) was recorded under N_1. The pooled data indicated the continued superiority of N_4 (₹86,477.43 ha^{-1}), followed by N_3 (₹71,044.28 ha^{-1}) and N_2 (₹61,490.96 ha^{-1}). The minimum pooled net return (₹26,891.35 ha^{-1}) was associated with the control.

The B:C ratio showed a similar trend, with N_4 recording the highest values in both years (3.23 in 2023 and 2.42 in 2024) and in the pooled mean (2.83). N_3 ranked second (2.59, 2.56, and 2.57), while N_1 consistently recorded the lowest values (1.58, 0.97, and 1.276). The superior economic response of N_4 can be attributed to the combined advantages of organic and inorganic nutrient sources, which promote sustained nutrient availability, improved soil health, and enhanced yield efficiency.

Interaction Effect (D × N)

The interaction between sowing dates and nutrient management (D×N) significantly influenced both net return and B:C ratio across the two years and in the pooled analysis.

In 2023, the combination D_3N_4 (1st July × 50% inorganic + 50% organic) generated the highest net return (₹1,00,035.28 ha^{-1}), followed closely by D_1N_4 (₹98,554.37 ha^{-1}). The lowest return (₹28,077.73 ha^{-1}) occurred under the control treatment D_1N_1. A comparable pattern appeared in 2024, where D_3N_4 again recorded the highest net return (₹93,571.94 ha^{-1}), while the combination D_1N_1 resulted in the lowest (₹14,390.24 ha^{-1}). The pooled data clearly established the superiority of D_3N_4 (₹96,803.62 ha^{-1}), followed by D_2N_4 (₹84,695.76 ha^{-1}), whereas the minimum pooled return (₹21,233.98 ha^{-1}) was noted under D_1N_1.

Similarly, the pooled B:C ratio was highest under D_3N_4 (3.17), followed by D_2N_4 (2.77) and D_3N_3 (2.53). The lowest B:C ratio (1.00) was observed for the control (D_1N_1). These results clearly demonstrate that the combination of late sowing (1st July) and integrated nutrient management (N_4) produces the most favorable economic outcomes.

The study clearly shows that both sowing time and nutrient management significantly influence the economic performance of finger millet cultivation. The enhanced net returns and B:C ratio under the 1st July sowing (D_3) may be attributed to improved crop establishment and more favorable climatic conditions during critical growth phases, leading to superior yield and economic output.

The outstanding profitability achieved under N_4 (integrated nutrient management) indicates the value of combining chemical fertilizers with organic manures. This combination promotes sustained nutrient release, improves soil physical properties, and enhances microbial activity, thereby supporting higher productivity.

The significant D×N interactions highlight that optimal profitability is achieved when appropriate sowing time is aligned with balanced nutrient inputs. The combination of early July sowing and integrated nutrient management (D_3N_4) consistently produced the highest net returns and B:C ratio, suggesting its suitability for achieving both economic and agronomic sustainability in finger millet production.

These findings are consistent with earlier reports by Roy *et al.* (2018), Narayan *et al.* (2018) and Verma *et al.* (2019 and who also observed enhanced economic returns in millets with integrated nutrient application.

Table 4.39(a): Net return and B:C ratio under different sowing dates and nutrient management system of finger millet

Treatments	Net return (₹ ha^{-1})			B:C ratio (₹ ha^{-1})		
Sowing dates (D)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
D_1: 1st June	66330.27	45493.51	55911.90	2.31	1.58	1.94
D_2: 15th June	66953.80	57737.96	62345.89	2.36	1.99	2.17
D_3: 1st July	69354.55	62985.96	66170.26	2.43	2.21	2.33
Nutrient management (N)						
	2023	**2024**	**Pooled**	**2023**	**2024**	**Pooled**
N_1: Control (No fertilizer)	33304.64	20478.06	26891.35	1.58	0.97	1.28
N_2: RDF – N, P_2O_5 and K_2O : 40-30-20 kg ha^{-1}	66627.60	56354.32	61490.96	2.06	1.74	1.90
N_3: 100% Organic through FYM on N equivalent basis (10 t ha^{-1})	71388.39	70700.18	71044.29	2.59	2.56	2.58
N_4: 50% Inorganic + 50% Organic through FYM	98864.18	74090.70	86477.44	3.24	2.43	2.83

Table 4.39(b): Interaction effect on net return and B:C ratio under different sowing dates and nutrient management system of finger millet

Interaction (D×N)	Net return (₹ ha^{-1})			B:C ratio		
	2023	2024	Pooled	2023	2024	Pooled
T_1: D_1N_1	28077.73	14390.24	21233.98	1.33	0.68	1.01
T_2: D_1N_2	67663.18	43990.64	55826.92	2.09	1.36	1.73
T_3: D_1N_3	71025.79	66281.68	68653.73	2.58	2.40	2.49
T_4: D_1N_4	98554.37	57311.52	77932.95	3.23	1.87	2.55
T_5: D_2N_1	35852.18	16039.37	25945.78	1.70	0.76	1.23
T_6: D_2N_2	62490.01	65409.30	63949.66	1.93	2.02	1.98
T_7: D_2N_3	71470.13	78114.56	74792.35	2.59	2.83	2.71
T_8: D_2N_4	98002.87	71388.65	84695.76	3.21	2.34	2.77
T_9: D_3N_1	35984.02	31004.58	33494.31	1.71	1.47	1.59
T_{10}: D_3N_2	69729.62	59663.02	64696.31	2.15	1.84	2.00
T_{11}: D_3N_3	71669.24	67704.32	69686.79	2.60	2.46	2.53
T_{12}: D_3N_4	100035.28	93571.94	96803.62	3.27	3.07	3.17

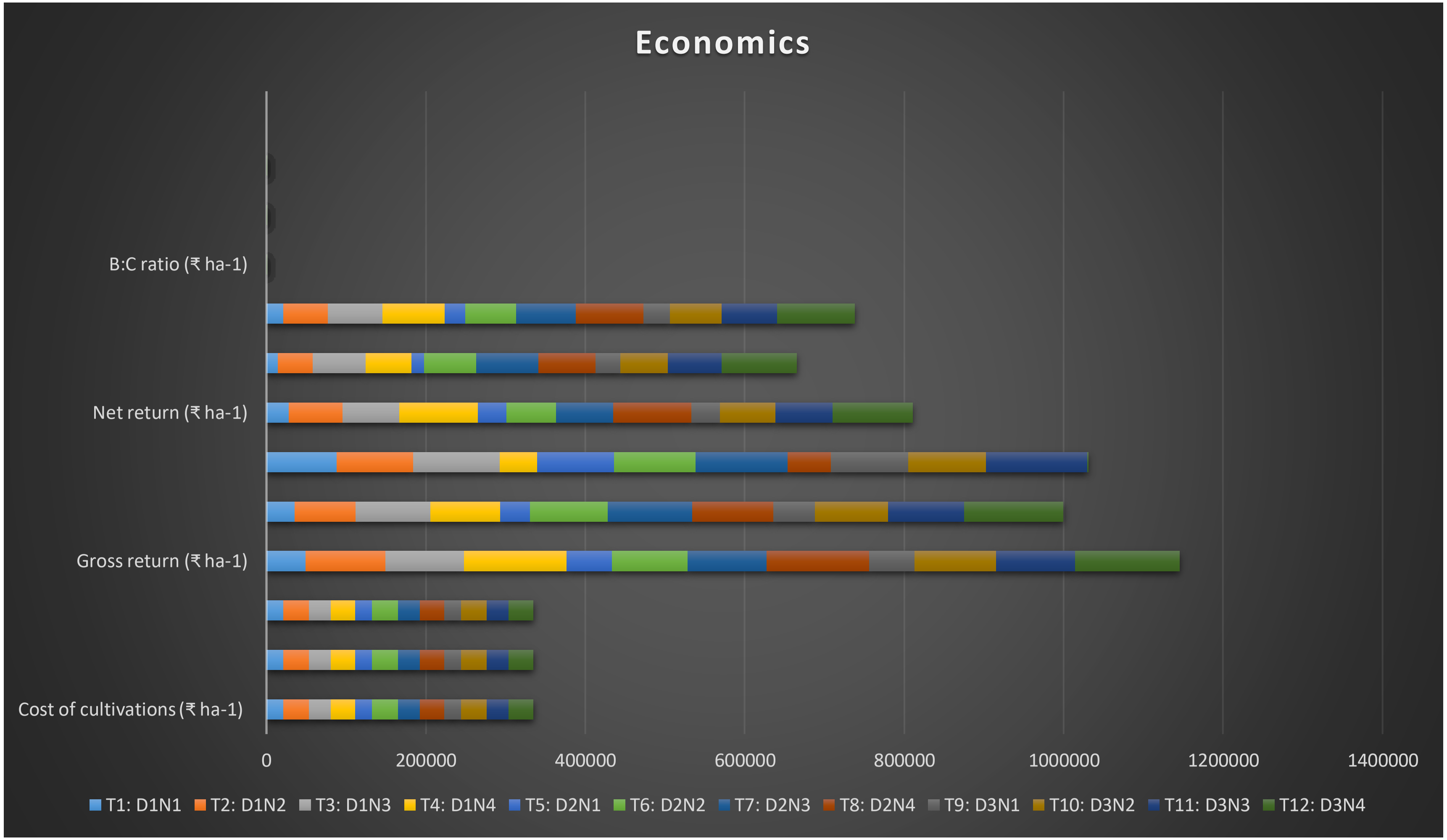


Fig. 4.14 Effect of different sowing dates and nutrient management on Economics

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

The present study was conducted at the research farm (agronomy field) of the ICAR Research Complex for NEH Region, Umiam, Meghalaya to evaluate the "Effect of sowing dates and nutrient management on productivity, profitability and quality of finger millet [*Eleusine coracana* (L.) Gaertn.]" during the *kharif* season of 2023 and 2024 with the following objectives:

1. To study the effect of sowing dates and nutrient management on growth, yield and quality of finger millet.
2. To find out suitable sowing dates and nutrient management for finger millet.
3. To find out the economics of various treatments.

The experiment was laid in Factorial Randomized Block Design (FRBD) with three replications. The experiment primarily consists of two factors; Sowing dates and nutrient management. The first factor is divided into three sowing dates, and the second factor into four different nutrient management strategies. The treatments will be replicated three times. The prominent results of the present investigation are summarized below:

5.1 Summary

5.1.1 Growth attributes

The growth performance of finger millet was significantly influenced by the different sowing dates, nutrient management practices, and their interactions during both years of experimentation. The pooled analysis further confirmed the consistency of these effects across seasons.

Effect of Sowing Dates:

- Sowing on 1st July (D_3) significantly enhanced early establishment, as reflected by the highest plant population and germination percentage at both 25 and 50 DAS. Although early plant height (25 DAS) and final height were significantly higher under 15th June sowing (D_2), biomass accumulation showed a distinct advantage for D_3, which produced the greatest fresh and dry matter at successive stages. Leaf area index differed significantly among dates, with the maximum LAI recorded under 1st June (D_1). Crop growth rate (CGR) responded variably across stages: CGR during 25–50 DAS was significantly higher under D_2, whereas during 50–75 DAS the maximum CGR occurred under D_3. Phenological events differed significantly, with D_2 taking the longest time to 50% flowering, while D_1 required the maximum days to maturity; D_3 matured earliest.

Effect of Nutrient Management:

- The integrated nutrient treatment N_4 (50% inorganic + 50% organic) resulted in significant improvement in most growth parameters. N_4 produced the tallest plants at harvest, the highest plant population, superior germination percentage, and the maximum number of effective tillers per plant and per unit area. Fresh and dry biomass accumulation also peaked under N_4. Leaf area development showed a significant increase, with N_4 recording the highest pooled LAI. CGR during the later growth phase (50–75 DAS) was significantly enhanced with N_4. Differences in RGR and NAR were statistically non-significant, although numerical trends favoured N_4. Phenology showed slight but non-significant prolongation under enriched nutrient regimes, with N_4 exhibiting the maximum days to maturity.

Interaction (D × N):

- The combined treatment D_3N_4 expressed the most vigorous crop growth. This interaction significantly increased plant height, plant population, germination percentage, and effective tillers, and also produced the highest fresh and dry biomass across stages. CGR during 50–75 DAS was significantly superior in D_3N_4, while variation in RGR and NAR under interactions remained statistically non-significant, though trends were favourable.

5.1.2 Yield attributes and yield

The combined assessment of yield attributes and yield revealed that both sowing dates and nutrient management practices played decisive roles in influencing the productivity of finger millet. Across the two years of study and pooled observations, most yield-contributing traits showed significant (S) variations due to treatments, whereas a few parameters remained non-significant (NS).

Effect of Sowing Dates (D):

- Sowing on 1st July (D_3) consistently improved key yield attributes. The number of panicles m^{-2}, number of fingers per ear, grains per finger, and grains per earhead were all significantly higher under D_3 compared with earlier sowing dates. However, finger length, test weight, grain yield per plant, and harvest index displayed non-significant differences, though numerical values tended to favour D_3. In terms of final productivity, grain and straw yields were significantly highest with D_3, whereas D_1 recorded the lowest values.

Effect of Nutrient Management (N):

- Nutrient management had a pronounced effect on most yield parameters. The integrated treatment N_4 (50% inorganic + 50% organic) produced significantly higher values for panicles m^{-2}, fingers per ear, grains per finger, grains per earhead, grain yield per plant, and final grain and straw yields. Finger length also responded significantly, being greatest under N_4. Test weight and harvest index remained non-significant, although higher numerical values were generally associated with N_3 and N_4.

Interaction Effects (D × N):

- The combined influence of sowing dates and nutrient levels was significant for major yield attributes, including panicles m^{-2}, fingers per ear, and grains per earhead. The interaction D_3N_4 consistently achieved the highest values for these traits, while unfertilized early sowing combinations recorded the lowest. Interaction effects on finger length, test weight, grain yield per plant, and harvest index were non-significant, though numerical superiority was again associated with D_3N_4. Grain and straw yields were significantly highest in D_3N_4, confirming the synergistic advantage of timely sowing with integrated nutrient supply.

5.1.3 Quality parameters

The quality attributes of finger millet, including crude protein, carbohydrate content, crude fiber, and calcium concentration, were significantly influenced by sowing dates, nutrient management practices, and their interactions (D × N) during both years of experimentation (2023 and 2024) as well as in the pooled mean. The combined summary of these parameters is presented below.

Effect of Sowing Dates (D):

- All quality traits responded significantly to sowing dates. Sowing on 1st July (D_3) resulted in the highest crude protein, crude fibre, and calcium content, indicating improved nutrient accumulation under later sowing. In contrast, 15th June (D_2) recorded the significantly highest carbohydrate content, while D_3 registered the lowest. Thus, quality responses varied with sowing time: delayed sowing provided superior protein, fibre, and mineral content, whereas mid-June sowing favoured carbohydrate retention.

Effect of Nutrient Management (N):

- Nutrient treatments exerted a significant influence on all quality parameters. The 100% organic FYM treatment (N_3) consistently produced the highest crude protein, carbohydrate content, and calcium concentration. Crude fibre was also significantly enhanced under N_4 (50% inorganic + 50% organic), closely followed by N_3. Minimum values for all parameters occurred in the unfertilized control (N_1), confirming the strong nutritional advantage of organic nutrient sources. No parameter under nutrient management showed non-significant effects.

Interaction Effects (D × N):

- Interactions between sowing date and nutrient management showed significant differences for all quality traits. The combination D_3N_3 (1st July × 100% Organic FYM) achieved the highest crude protein, crude fibre, and calcium content, while the lowest values were consistently associated with D_1N_1 (1st June × Control). Carbohydrate content followed the same pattern, with D_1N_3 producing the maximum and D_3N_1 the least. No interaction effects were non-significant, indicating strong and consistent responsiveness of all quality traits to combined treatments.

5.1.4 Nutrient analysis

The nutrient composition and uptake of nitrogen (N), phosphorus (P), and potassium (K) in finger millet were significantly affected by sowing dates, nutrient management practices, and their interactions. Variations in sowing time and nutrient supply produced distinct patterns in nutrient concentration in grain and straw, as well as total nutrient removal.

Effect of Sowing Dates (D)

- Nitrogen: Grain N content declined significantly with delayed sowing, with D_2 recording the maximum and D_3 the minimum. In contrast, straw N concentration and total N uptake (grain and straw) increased under late sowing, with D_3 showing the highest values.
- Phosphorus: Grain P content and uptake were significantly higher under D_3, while straw P content remained non-significant across sowing dates.
- Potassium: Grain K content was highest under D_2, whereas straw K content and total K uptake increased significantly under late sowing (D_3). Thus, delayed

sowing favoured higher P and K assimilation, while mid-June sowing optimised grain N concentration.

Effect of Nutrient Management (N)

- Nitrogen: Grain and straw N concentrations were highest under RDF (N_2), while integrated nutrient management (N_4) produced the highest N uptake in both grain and straw.
- Phosphorus: Grain P content peaked under N_2, whereas P uptake (grain and straw) was maximised under N_4. Straw P content showed no non-significant trends.
- Potassium: Grain and straw K concentration were highest under N_2, while K uptake was greatest under N_4. Across all nutrients, the unfertilized control (N_1) consistently recorded the lowest concentrations and uptake.

Interaction Effects (D × N)

- Most nutrient parameters exhibited significant D × N interactions, indicating strong dependence on coordinated timing and nutrient supply.
- Nitrogen: The highest grain and straw N uptake were achieved under D_3N_4, whereas the lowest values occurred under D_1N_1.
- Phosphorus: Grain P content showed significant interaction effects, with the maximum under D_3N_2; grain P uptake was highest under D_3N_4. Straw P content, however, was non-significant.
- Potassium: Grain and straw K concentration and uptake were significantly influenced by interactions. The highest uptake occurred under D_3N_4, while the lowest values consistently belonged to D_1N_1.

5.1.5 Soil analysis

Post-harvest soil analysis showed that soil fertility attributes responded differently to sowing dates, nutrient management, and their interaction. Sowing dates caused only marginal and largely non-significant variations in soil chemical properties, whereas nutrient management exerted a highly significant influence on all measured parameters. The interaction (D × N) further highlighted that the combined choice of sowing time and nutrient input strategy plays an important role in sustaining soil fertility under finger millet cultivation.

- Soil pH: Sowing dates had a non-significant effect on soil pH, with only slight fluctuations across treatments. In contrast, nutrient management brought about significant changes, with RDF (N_2) consistently raising soil pH and the control (N_1) maintaining the lowest values. A significant D × N interaction was observed, where D_3N_2 resulted in the highest pH, suggesting that the liming effect of fertilizers is enhanced under slightly delayed sowing.
- Soil Organic Carbon (SOC): SOC differed marginally among sowing dates (non-significant), with early sowing (D_1) showing slightly higher values. Nutrient management significantly influenced SOC, with 100% organic nutrition (N_3) registering the highest SOC due to enhanced organic matter addition. Integrated nutrition (N_4) showed comparatively lower SOC, possibly due to faster mineralization. The D × N interaction was significant, with D_2N_3 yielding the maximum SOC content.
- Available Nitrogen (N): Available N exhibited non-significant differences among sowing dates, although early sowing (D_1) generally retained higher nitrogen. Nutrient management had a highly significant effect, with RDF (N_2) recording the highest available N and the control (N_1) the lowest. The interaction was significant, and early sowing combined with RDF (D_1N_2) maximized soil N availability.
- Available Phosphorus (P): Sowing dates produced non-significant differences in available P, with only mild increases under late sowing (D_3). Nutrient management significantly enhanced soil P, particularly under RDF (N_2), followed by INM (N_4). A significant interaction effect was recorded, with D_3N_2 yielding the highest P levels, demonstrating that phosphorus availability improved most when fertilization was synchronized with later sowing.
- Available Potassium (K): Differences in potassium among sowing dates were non-significant, though slightly higher values appeared under D_2. Nutrient management significantly raised soil K, with RDF (N_2) ranking highest, followed

by INM (N_4), while the control maintained low K levels. The interaction effect was also significant, with D_3N_2 producing the highest K content.

5.1.6 Economics

The economic evaluation of finger millet production demonstrated that sowing dates, nutrient management practices, and their interactions had varying degrees of influence on profitability.

Effect of Sowing Dates:

- Sowing dates had no significant effect on the cost of cultivation, which remained constant across all treatments. However, gross return, net return, and B:C ratio were significantly affected by sowing time. Among the dates tested, sowing on 1st July (D_3) consistently delivered the highest returns, reflected in superior gross and net income as well as the greatest B:C ratio during both years and in pooled analysis. Early sowing (D_1) recorded the lowest economic benefits. These results clearly indicate that early July sowing is the most profitable time for finger millet under the given conditions.

Effect of Nutrient Management:

- Nutrient management exerted a highly significant influence on all economic parameters. Although RDF (N_2) incurred the highest cultivation cost, the integrated nutrient treatment N_4 (50% inorganic + 50% FYM) proved the most profitable, generating the highest gross returns, net returns, and B:C ratios across individual years and pooled means. The control (N_1) remained economically inferior. These findings underscore the value of integrated nutrient management in enhancing economic efficiency and returns.

Interaction Effect (D × N):

- The interaction between sowing date and nutrient management was non-significant for cost of cultivation, but significant for gross return, net return, and

B:C ratio. The combination of 1st July sowing with integrated nutrient management (D_3N_4) was the best-performing treatment, producing the highest gross and net returns and the maximum B:C ratio in both years and pooled analysis. In contrast, the combination of early sowing with no fertilizers (D_1N_1) resulted in the poorest economic outcomes.

Conclusion

On the basis of the results of two years of experimentations during *kharif* of 2023 and 2024 clearly demonstrated that the productivity and profitability of finger millet in rainfed conditions depend strongly on the choice of sowing time and nutrient management strategy.

- Among the sowing dates tested, sowing on 1st July (D_3) consistently produced superior results across growth attributes, yield components, grain yield, nutrient uptake, and economic benefits. This sowing date improved grain yield by 10–15%, nutrient uptake by 8–12%, and net economic return by 20–25% compared to early sowing.
- Nutrient management exerted even greater influence on crop performance. The integrated nutrient treatment (N_4: 50% inorganic + 50% FYM) emerged as the most effective and balanced approach. This treatment enhanced grain yield by 18–22%, total nutrient uptake by 20–30%, and net returns by 30–35% over the control, confirming its suitability as a sustainable and economically attractive practice for rainfed systems. While integrated nutrition maximized yield and profitability, the 100% organic treatment (N_3) produced the highest grain nutritional quality, with improvements of 10–18% in crude protein, fibre, and calcium content, indicating its potential for quality-focused production.
- The interaction between sowing dates and nutrient management (D × N) further highlighted the importance of synchronizing agronomic practices. The combination D_3N_4 resulted in the highest growth, yield, nutrient uptake, and economic efficiency—showing an overall performance improvement of 25–35% compared to less optimal combinations. For grain quality enhancement, D_3N_3 proved most suitable.

Overall, the study concludes that sowing finger millet on 1st July, coupled with an integrated nutrient supply (50% inorganic + 50% FYM), offers the most productive, profitable, and sustainable strategy for rainfed cultivation. For farmers prioritizing grain nutrition, the use of 100% FYM is recommended. These findings underline the value of combining timely sowing with balanced nutrient inputs to achieve higher yields, improved soil health, better grain quality, and enhanced economic resilience in finger millet-based farming systems.

Future line of work

Building on the outcomes of this investigation, several research directions can be pursued to further strengthen the productivity and sustainability of finger millet under rainfed conditions.

- A wider evaluation of sowing windows and nutrient combinations across diverse agro-ecological regions would help generate location-specific production guidelines.
- Incorporating micronutrients, biofertilizers, and other biological inputs alongside conventional nutrient sources may also provide a clearer understanding of how to enhance grain quality and improve the crop's tolerance to environmental stresses.
- Long-term monitoring of soil properties under various nutrient management practices is essential to assess their cumulative impact on soil fertility and overall system sustainability.
- Further opportunities lie in integrating precision nutrient management tools and water-saving techniques, which could refine input use and contribute to higher, more stable yields.
- Breeding efforts and agronomic strategies that align crop growth stages with nutrient demand may also improve both yield potential and grain nutritional value, supporting the development of climate-resilient production systems.
- Multi-location and multi-season trials will be crucial for validating these findings and ensuring the consistency of yield performance.

- Despite the promising trends observed, the present results serve as preliminary indications. Additional research is necessary to draw more definitive conclusions before firm recommendations can be offered to farmers.

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APPENDICES

APPENDIX - A

Calendar of agronomic management practices performed during the investigation period 2023 and 2024

Sl. No.	Field operations	1st sowing		2nd sowing		3rd sowing	
		2023	2024	2023	2024	2023	2024
1	Land preparation	10-5-2023	12-5-2024	20-5-2023	20-5-2024	10-6-2023	10-6-2024
a.	Primary tillage and application of FYM	15-5-2023	15-5-2024	25-5-2023	25-5-2024	15-6-2023	15-6-2024
b.	Secondary tillage	25-5-2023	25-5-2024	10-6-2023	10-6-2024	25-6-2023	25-6-2024
c.	Layout of the experiment	29-5-2023	29-5-2024	13-6-2023	13-6-2024	29-6-2023	29-6-2024
2.	Application of fertilizers	1-6-2023	1-6-2024	15-6-2023	15-6-2024	1-7-2023	1-7-2024
3	Seed treatment and sowing	1-6-2023	1-6-2024	15-6-2023	15-6-2024	1-7-2023	1-7-2024
4	Weeding and Thinning	25-6-2023	27-6-2024	12-7-2023	15-7-2024	25-7-2023	24-7-2024
5	Harvesting	8-10-2023	10-10-2024	18-10-23	20-10-2024	5-11-2023	5-11-2024

APPENDIX-B

Cost and returns of cultivation (₹ ha^{-1})

<table>
<tr><th colspan="5">A. Fixed cost</th><th colspan="2"></th></tr>
<tr><th>Sl.no</th><th colspan="2">Particulars</th><th>Input/Quantity</th><th>Rate (₹ $unit^{-1}$)</th><th colspan="2">Cost (₹ ha^{-1})</th></tr>
<tr><td>1</td><td colspan="2">Field preparation</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2">a. Primary and secondary tillage</td><td>1</td><td>3500</td><td colspan="2">3500</td></tr>
<tr><td></td><td colspan="2">b. FYM application and sowing</td><td>6 men days</td><td>400/men/day</td><td colspan="2">2400</td></tr>
<tr><td>2</td><td colspan="2">Interculture operations</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2">Thinning, hand weeding and earthing up</td><td>6 men days</td><td>400/men/day</td><td colspan="2">2400</td></tr>
<tr><td>3.</td><td colspan="2">Plant protection</td><td>4 men days</td><td>400/men/day</td><td colspan="2">1600</td></tr>
<tr><td>4.</td><td colspan="2">Harvesting, threshing and winnowing</td><td>20 men days</td><td>400/men/day</td><td colspan="2">8000</td></tr>
<tr><td>5.</td><td colspan="2">Miscellaneous</td><td>-</td><td>-</td><td colspan="2">2200</td></tr>
<tr><td></td><td colspan="2">Total</td><td></td><td></td><td colspan="2">20,200</td></tr>
<tr><th colspan="7">B. Cost of variable inputs ha^{-1}</th></tr>
<tr><td></td><td colspan="2">Seed</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>1</td><td colspan="2">VL-Mandua 352 (Finger Millet)</td><td>8kg</td><td>80</td><td>800</td><td>Cost</td></tr>
<tr><td>2.</td><td>Treatments</td><td>FYM
₹ 600/t</td><td>Nitrogen (Urea)
₹ 50/kg</td><td>Phophorus (SSP)
₹ 50/ kg</td><td>Potasium (MOP)
₹ 60/ kg</td><td>Fixed cost+Variable cost</td></tr>
<tr><td></td><td>N1</td><td></td><td></td><td></td><td></td><td>21,080</td></tr>
<tr><td></td><td>N2</td><td></td><td>40kg</td><td>30kg</td><td>20kg</td><td>32350</td></tr>
<tr><td></td><td>N3</td><td>10t</td><td></td><td></td><td></td><td>27560</td></tr>
<tr><td></td><td>N4</td><td>5t</td><td>20kg</td><td>15kg</td><td>10kg</td><td>30550</td></tr>
<tr><td></td><td colspan="2">Grand Total (A+B)</td><td>-</td><td>-</td><td colspan="2">Average=27,885</td></tr>
<tr><td></td><td colspan="6">C. Returns ha⁻</td></tr>
<tr><td>1.</td><td colspan="2">Grain</td><td>1800kg</td><td>50</td><td colspan="2">90,000</td></tr>
<tr><td>2.</td><td colspan="2">Straw</td><td>3800kg</td><td>2</td><td colspan="2">7600</td></tr>
<tr><td></td><td colspan="2">Total</td><td>-</td><td>-</td><td colspan="2">97,600</td></tr>
<tr><td></td><td colspan="2">Profit (Returns – Cost)</td><td>-</td><td>-</td><td colspan="2">69,715</td></tr>
</table>

APPENDIX-C

ANOVA 1(a): Analysis of variance of finger millet plant height (cm) at 25 DAS under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.78	0.39	0.31	0.73	S
Treatments	11	301.31	27.39	21.73	2.63	S
Factor A	2	128.70	64.35	51.05	5.44	S
Factor B	3	125.05	41.69	33.07	2.49	S
A X B	6	47.56	7.92	6.28	0.01	S
Error	22	27.74	1.27	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.38	0.20	0.26	0.78	S
Treatments	11	66.40	6.04	8.25	1.58	S
Factor A	2	5.41	2.71	3.70	0.04	S
Factor B	3	31.72	10.58	14.47	2.00	S
A X B	6	29.26	4.87	6.67	0.00	S
Error	22	16.07	0.74	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.45	0.22	0.79	0.46	S
Treatments	11	115.50	10.51	36.86	1.35	S
Factor A	2	44.56	22.28	78.21	1.00	S
Factor B	3	59.19	19.73	69.26	2.30	S
A X B	6	11.75	1.95	6.87	0.00	S
Error	22	6.27	0.29	-	-	
Total	35	-	-	-	-	

ANOVA 1(b): Analysis of variance of finger millet plant height (cm) at 50 DAS under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	6.87	3.44	4.63	0.03	S
Treatments	11	989.45	89.95	121.26	4.76	S
Factor A	2	615.80	307.90	415.08	3.39	S
Factor B	3	317.31	105.77	142.59	1.45	S
A X B	6	56.35	9.40	12.66	3.61	S
Error	22	16.31	0.75	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1.13	0.57	0.40	0.67	S
Treatments	11	332.31	30.22	21.22	3.32	S
Factor A	2	80.83	40.42	28.38	8.06	S
Factor B	3	144.61	48.20	33.86	2.02	S
A X B	6	106.90	17.82	12.51	3.96	S
Error	22	31.31	1.43	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1.18	0.58	0.51	0.61	S
Treatments	11	1144.98	104.09	91.48	9.77	S
Factor A	2	97.38	48.69	42.79	2.62	S
Factor B	3	542.51	180.84	158.93	4.66	S
A X B	6	505.12	84.18	73.99	1.85	S
Error	22	25.03	1.14	-	-	
Total	35	-	-	-	-	

ANOVA 1(d): Analysis of variance of finger millet plant height (cm) at harvest under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	4.10	2.05	1.07	0.36	S
Treatments	11	632.19	57.47	29.75	1.18	S
Factor A	2	97.58	48.78	25.25	2.00	S
Factor B	3	250.74	83.59	43.26	2.13	S
A X B	6	283.86	47.32	24.50	1.11	S
Error	22	42.49	1.94	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.55	0.27	0.12	0.89	S
Treatments	11	1033.89	94.00	39.68	6.31	S
Factor A	2	18.69	9.35	3.94	0.03	S
Factor B	3	818.47	272.82	115.17	1.34	S
A X B	6	196.74	32.80	13.85	1.73	
Error	22	52.11	2.37	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1.81	0.90	0.78	0.46	S
Treatments	11	685.44	62.31	54.26	2.45	S
Factor A	2	41.11	20.55	17.90	2.44	S
Factor B	3	472.21	157.41	137.04	2.19	S
A X B	6	172.12	28.68	24.98	9.19	S
Error	22	25.27	1.15	-	-	
Total	35	-	-	-	-	

ANOVA 2(a): Analysis of variance of finger millet plant population (m^{-2}) at 25 DAS under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.17	0.08	0.09	0.91	S
Treatments	11	48.67	4.42	4.59	0.00	S
Factor A	2	4.67	2.33	2.42	0.12	NS
Factor B	3	22.22	7.40	7.69	0.00	S
A X B	6	21.78	3.63	3.78	0.01	S
Error	22	21.17	0.96	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	2.06	1.03	0.92	0.42	S
Treatments	11	211.56	19.23	17.20	2.49	S
Factor A	2	73.56	36.78	32.88	2.45	S
Factor B	3	118.44	39.48	35.30	1.38	S
A X B	6	19.56	3.25	2.91	0.03	S
Error	22	24.61	1.12	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.27	0.14	0.23	0.80	S
Treatments	11	88.22	8.02	14.42	1.28	S
Factor A	2	21.56	10.78	19.38	1.40	S
Factor B	3	55.50	18.50	33.26	2.37	NS
A X B	6	11.17	1.86	3.34	0.02	S
Error	22	12.23	0.55	-	-	
Total	35	-	-	-	-	

ANOVA 2(b): Analysis of variance of finger millet plant population (m^{-2}) at 50 DAS under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1.06	0.53	0.46	0.64	S
Treatments	11	34.89	3.18	2.79	0.01	S
Factor A	2	1.39	0.69	0.61	0.56	S
Factor B	3	13.56	4.52	3.98	0.03	S
A X B	6	19.94	3.32	2.94	0.03	S
Error	22	24.94	1.14	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1.56	0.78	0.89	0.43	S
Treatments	11	173.64	15.78	18.18	1.48	S
Factor A	2	54.89	27.44	31.59	3.41	S
Factor B	3	103.19	34.39	39.60	4.86	S
A X B	6	15.56	2.60	2.98	0.02	S
Error	22	19.11	0.87	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1.02	0.51	0.86	0.43	NS
Treatments	11	70.41	6.41	10.85	1.63	S
Factor A	2	13.52	6.76	11.44	0.00	S
Factor B	3	45.53	15.18	25.71	2.23	S
A X B	6	11.38	1.90	3.22	0.02	S
Error	22	12.98	0.59	-	-	
Total	35	-	-	-	-	

ANOVA 3(a): Analysis of variance of finger millet on number of tillers $plant^{-1}$ under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.39	0.20	3.75	0.04	S
Treatments	11	6.05	0.55	10.32	2.48	S
Factor A	2	0.83	0.41	7.80	0.01	S
Factor B	3	4.41	1.48	27.60	1.21	S
A X B	6	0.81	0.14	2.53	0.05	NS
Error	22	1.17	0.05	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.04	0.02	0.37	0.69	S
Treatments	11	5.97	0.54	8.97	8.02	S
Factor A	2	1.80	0.91	14.97	7.86	S
Factor B	3	2.71	0.91	14.96	1.57	S
A X B	6	1.45	0.25	3.98	0.00	S
Error	22	1.32	0.06	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.11	0.05	1.35	0.28	S
Treatments	11	5.54	0.50	13.59	2.20	NS
Factor A	2	1.25	0.63	16.96	3.49	S
Factor B	3	3.36	1.13	30.31	5.39	NS
A X B	6	0.91	0.16	4.09	0.01	
Error	22	0.81	0.03	-	-	
Total	35	-	-	-	-	

ANOVA 3(b): Analysis of variance of finger millet on number of tillers m^{-2} at flowering under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	2.39	1.19	0.23	0.81	S
Treatments	11	938.56	85.32	16.05	4.74	S
Factor A	2	7.06	3.53	0.67	0.53	NS
Factor B	3	893.44	297.82	56.03	1.82	S
A X B	6	38.06	6.35	1.19	0.34	NS
Error	22	116.94	5.32	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	3.17	1.58	0.65	0.53	S
Treatments	11	1861.33	169.21	69.59	1.79	S
Factor A	2	26.00	13.00	5.35	0.02	S
Factor B	3	1792.89	597.63	245.75	4.61	S
A X B	6	42.44	7.07	2.91	0.03	S
Error	22	53.50	2.44	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	2.72	1.36	0.68	0.52	S
TSreatments	11	1309.81	119.07	58.94	1.03	S
Factor A	2	14.84	7.43	3.68	0.05	S
Factor B	3	1280.81	426.93	211.34	2.30	NS
A X B	6	14.16	2.36	1.17	0.36	S
Error	22	44.44	2.02	-	-	
Total	35	-	-	-	-	

ANOVA 4(a): Analysis of variance of finger millet on crop growth rate CGR (g m^{-2} day^{-1}) at 25-50 DAS under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.69	0.35	3.09	0.07	NS
Treatments	11	1.77	0.17	1.45	0.23	NS
Factor A	2	0.59	0.29	2.66	0.09	NS
Factor B	3	0.90	0.30	2.69	0.08	NS
A X B	6	0.27	0.05	0.41	0.87	NS
Error	22	2.45	0.11	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.20	0.11	0.52	0.61	NS
Treatments	11	2.33	0.21	1.05	0.43	NS
Factor A	2	0.74	0.37	1.85	0.19	NS
Factor B	3	0.11	0.04	0.17	0.91	NS
A X B	6	1.48	0.25	1.24	0.32	NS
Error	22	4.43	0.20	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.11	0.05	0.70	0.50	NS
Treatments	11	1.39	0.12	1.52	0.19	NS
Factor A	2	0.60	0.30	3.56	0.05	NS
Factor B	3	0.33	0.11	1.33	0.28	NS
A X B	6	0.46	0.08	0.93	0.49	NS
Error	22	1.84	0.08	-	-	
Total	35	-	-	-	-	

ANOVA 4(b): Analysis of variance of finger millet on crop growth rate CGR (g m^{-2} day^{-1}) at 50-75 DAS under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	2.01	1.00	1.48	0.25	NS
Treatments	11	5.38	0.49	0.72	0.70	NS
Factor A	2	3.07	1.54	2.26	0.12	NS
Factor B	3	0.49	0.17	0.25	0.86	NS
A X B	6	1.81	0.31	0.44	0.84	NS
Error	22	14.92	0.68	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	4.83	2.41	4.46	0.03	NS
Treatments	11	12.53	1.14	2.10	0.07	NS
Factor A	2	5.74	2.87	5.28	0.01	NS
Factor B	3	2.31	0.76	1.41	0.26	NS
A X B	6	4.48	0.74	1.38	0.26	NS
Error	22	11.94	0.55	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	3.97	1.98	10.74	0.01	NS
Treatments	11	5.18	0.48	2.54	0.03	NS
Factor A	2	1.94	0.97	5.24	0.02	NS
Factor B	3	0.80	0.26	1.46	0.25	NS
A X B	6	2.44	0.40	2.20	0.09	NS
Error	22	4.07	0.18	-	-	
Total	35	-	-	-	-	

ANOVA 5(a): Analysis of variance of finger millet on regulative growth rate RGR (g g^{-1} day^{-1}) at 25-50 DAS under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	5.00	2.50	1.94	0.16	NS
Treatments	11	0.01	5.16	4.00	0.01	NS
Factor A	2	0.00	7.50	5.83	0.00	NS
Factor B	3	0.00	7.03	5.46	0.01	NS
A X B	6	0.00	3.43	2.66	0.05	NS
Error	22	0.00	1.29	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	7.22	3.61	2.01	0.15	NS
Treatments	11	0.00	2.70	1.50	0.20	NS
Factor A	2	0.00	0.00	5.73	0.01	NS
Factor B	3	3.06	1.02	0.56	0.65	NS
A X B	6	6.11	1.02	0.56	0.75	NS
Error	22	0.00	1.80	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.01	0.01	1.03	0.37	NS
Treatments	11	0.07	0.00	0.99	0.49	NS
Factor A	2	0.01	0.00	0.97	0.39	NS
Factor B	3	0.01	0.00	1.02	0.41	NS
A X B	6	0.03	0.00	0.99	0.45	NS
Error	22	0.13	0.00	-	-	
Total	35	-	-	-	-	

ANOVA 5(b): Analysis of variance of finger millet on regulative growth rate RGR (g g^{-1} day^{-1}) at 50-75 DAS under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	2.32	1.15	1.50	0.24	S
Treatments	11	0.00	1.30	1.70	0.15	S
Factor A	2	0.00	5.30	6.91	0.01	S
Factor B	3	3.08	1.03	1.34	0.29	NS
A X B	6	6.06	1.00	0.14	1.00	NS
Error	22	0.00	7.67	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.00	5.14	4.13	0.03	NS
Treatments	11	0.00	2.74	2.20	0.06	NS
Factor A	2	0.00	6.08	4.88	0.02	S
Factor B	3	6.20	2.07	1.66	0.20	NS
A X B	6	0.00	1.97	1.57	0.21	NS
Error	22	0.00	1.24	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1.85	9.25	2.08	0.15	NS
Treatments	11	0.00	1.66	3.73	0.00	NS
Factor A	2	0.00	5.65	12.77	0.00	NS
Factor B	3	3.04	1.02	2.29	0.10	NS
A X B	6	3.84	6.39	1.45	0.24	NS
Error	22	9.75	4.44	-	-	
Total	35	-	-	-	-	

ANOVA 6(a): Analysis of variance of finger millet on days to 50% flowering under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	30.17	15.08	3.23	0.06	S
Treatments	11	485.33	44.12	9.47	5.15	S
Factor A	2	43.17	21.58	4.64	0.03	S
Factor B	3	146.89	48.97	10.50	0.00	S
A X B	6	295.28	49.22	10.57	1.51	S
Error	22	102.50	4.65	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	16.67	8.33	2.14	0.15	S
Treatments	11	274.75	24.97	6.43	0.00	S
Factor A	2	0.50	0.25	0.06	0.94	S
Factor B	3	135.64	45.22	11.65	8.86	S
A X B	6	138.61	23.11	5.96	0.01	S
Error	22	85.33	3.88	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	19.63	9.82	3.49	0.05	S
Treatments	11	283.35	25.75	9.19	6.65	S
Factor A	2	13.05	6.53	2.33	0.12	S
Factor B	3	97.07	32.36	11.53	9.48	S
A X B	6	173.23	28.88	10.30	1.84	S
Error	22	61.70	2.81	-	-	
Total	35	-	-	-	-	

ANOVA 7(a): Analysis of variance of finger millet on days to maturity flowering under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	10.72	5.36	1.04	0.37	NS
Treatments	11	782.97	71.17	13.83	1.87	NS
Factor A	2	698.72	349.36	67.85	3.90	S
Factor B	3	1.86	0.62	0.12	0.94	NS
A X B	6	82.39	13.73	2.67	0.04	NS
Error	22	113.28	5.15	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	10.06	5.03	0.32	0.74	NS
Treatments	11	386.31	35.12	2.19	0.06	NS
Factor A	2	280.72	140.36	8.75	0.01	S
Factor B	3	15.42	5.14	0.33	0.81	NS
A X B	6	90.17	15.03	0.94	0.48	NS
Error	22	352.61	16.03	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	6.17	3.08	0.52	0.61	NS
Treatments	11	531.83	48.34	8.16	1.77	NS
Factor A	2	454.88	227.43	38.35	6.76	S
Factor B	3	5.17	1.72	0.29	0.84	NS
A X B	6	71.80	11.96	2.01	0.10	NS
Error	22	130.50	5.94	-	-	
Total	35	-	-	-	-	

ANOVA 8: Analysis of variance of finger millet on number of panicles m^{-2} flowering under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	5108.67	2554.33	5.60	0.02	NS
Treatments	11	45168.08	4106.18	9.02	7.76	S
Factor A	2	379.17	189.58	0.41	0.67	NS
Factor B	3	43888.08	14629.36	32.12	3.22	S
A X B	6	900.83	150.14	0.33	0.91	NS
Error	22	10020.00	455.46	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	793.56	396.78	0.87	0.44	NS
Treatments	11	43844.31	3985.85	8.65	1.09	S
Factor A	2	7020.72	3510.36	7.61	0.00	S
Factor B	3	30480.75	10160.25	22.05	7.97	S
A X B	6	6342.83	1057.14	2.29	0.08	NS
Error	22	10141.11	460.96	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	2482.06	1241.03	4.56	0.03	NS
Treatments	11	37988.56	3453.50	12.72	4.00	S
Factor A	2	2008.52	1004.26	3.69	0.04	S
Factor B	3	34931.72	11643.90	42.87	2.33	NS
A X B	6	1048.31	174.72	0.64	0.70	NS
Error	22	5975.44	271.61	-	-	
Total	35	-	-	-	-	

ANOVA 9: Analysis of variance of finger millet on number of fingers ear^{-1} flowering under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	5.05	2.53	5.37	0.02	NS
Treatments	11	43.68	3.97	8.45	1.33	S
Factor A	2	0.32	0.17	0.35	0.71	NS
Factor B	3	41.36	13.79	29.31	7.22	S
A X B	6	2.01	0.34	0.71	0.64	S
Error	22	10.34	0.47	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.39	0.19	0.28	0.76	S
Treatments	11	28.97	2.64	3.87	0.00	S
Factor A	2	2.39	1.19	1.75	0.20	NS
Factor B	3	20.75	6.92	10.18	0.00	S
A X B	6	5.83	0.97	1.43	0.25	NS
Error	22	14.94	0.67	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	2.04	1.02	2.89	0.08	S
Treatments	11	30.68	2.78	7.86	2.35	S
Factor A	2	1.03	0.52	1.44	0.25	S
Factor B	3	28.43	9.47	26.74	1.60	S
A X B	6	1.22	0.21	0.56	0.75	NS
Error	22	7.80	0.36	-	-	
Total	35	-	-	-	-	

ANOVA 10: Analysis of variance of finger millet on number of grains finger^{-1} under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	96.99	48.50	0.80	0.47	S
Treatments	11	29250.40	2659.13	44.04	2.14	S
Factor A	2	590.66	295.34	4.89	0.01	S
Factor B	3	28254.64	9418.21	156.01	5.66	S
A X B	6	405.10	67.52	1.11	0.39	S
Error	22	1328.13	60.37	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	137.41	68.71	0.86	0.44	S
Treatments	11	30503.69	2773.07	34.36	2.73	S
Factor A	2	8627.59	4313.80	53.47	3.58	S
Factor B	3	16870.34	5623.45	69.70	2.16	S
A X B	6	5005.76	834.30	10.34	1.78	S
Error	22	1775.16	80.68	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	74.23	37.12	0.91	0.41	S
Treatments	11	26538.57	2412.59	58.82	1.05	S
Factor A	2	3184.61	1592.31	38.83	6.08	S
Factor B	3	21613.15	7204.39	175.65	1.63	S
A X B	6	1740.83	290.13	7.08	0.00	S
Error	22	902.36	41.02	-	-	
Total	35	-	-	-	-	

ANOVA 11: Analysis of variance of finger millet on number of length of finger (cm) under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1.89	0.95	1.45	0.25	NS
Treatments	11	35.02	3.18	4.88	0.01	NS
Factor A	2	0.23	0.11	0.19	0.83	NS
Factor B	3	23.20	7.73	11.86	7.88	S
A X B	6	11.59	1.93	2.96	0.02	S
Error	22	14.34	0.66	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	2.29	1.15	1.87	0.17	NS
Treatments	11	22.80	2.07	3.41	0.01	S
Factor A	2	0.67	0.33	0.54	0.58	S
Factor B	3	17.63	5.88	9.64	0.00	S
A X B	6	4.52	0.75	1.24	0.33	NS
Error	22	13.40	0.60	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	2.07	1.04	1.88	0.17	NS
Treatments	11	27.41	2.49	4.52	0.00	NS
Factor A	2	0.04	0.01	0.03	0.98	NS
Factor B	3	20.11	6.71	12.13	6.76	S
A X B	6	7.28	1.22	2.19	0.08	NS
Error	22	12.14	0.55	-	-	
Total	35	-	-	-	-	

ANOVA 12: Analysis of variance of finger millet on test weight (g) of under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.00	0.00	0.93	0.41	S
Treatments	11	0.88	0.08	677.80	3.50	S
Factor A	2	0.04	0.03	191.90	1.18	S
Factor B	3	0.75	0.25	2129.31	3.01	S
A X B	6	0.08	0.01	114.03	1.97	S
Error	22	0.01	0.00	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.00	5.28	0.58	0.57	S
Treatments	11	0.73	0.06	717.81	1.88	S
Factor A	2	0.01	0.00	25.34	1.96	S
Factor B	3	0.68	0.23	2459.70	6.19	S
A X B	6	0.05	0.00	77.70	1.11	S
Error	22	0.00	9.21	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.00	6.31	1.10	0.35	S
Treatments	11	0.77	0.07	1220.05	5.57	S
Factor A	2	0.01	0.00	142.66	2.53	S
Factor B	3	0.70	0.23	4138.78	2.04	S
A X B	6	0.04	0.01	119.82	1.16	S
Error	22	0.00	5.71	-	-	
Total	35	-	-	-	-	

ANOVA 13: Analysis of variance of finger millet on yield ha^{-1} under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	422720.79	211360.40	6.22	0.00	S
Treatments	11	7220881.40	656443.76	19.32	8.23	S
Factor A	2	16997.45	8498.73	0.25	0.79	S
Factor B	3	7161523.42	2387174.48	70.23	2.00	S
A X B	6	42360.52	7060.08	0.21	0.98	S
Error	22	747708.16	33986.74	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	59428.32	29714.16	1.08	0.35	S
Treatments	11	7098051.39	645277.40	23.56	1.19	S
Factor A	2	537165.91	268582.96	9.81	0.01	S
Factor B	3	6127052.08	2042350.70	74.60	1.10	S
A X B	6	433833.39	72305.56	2.64	0.05	S
Error	22	602310.95	27377.77	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	199125.24	99562.61	5.58	0.02	S
Treatments	11	6734537.93	612230.73	34.34	2.75	S
Factor A	2	179173.60	89586.79	5.03	0.02	S
Factor B	3	6460106.03	2153368.68	120.79	8.12	S
A X B	6	95258.31	15876.38	0.90	0.52	S
Error	22	392178.55	17826.29	-	-	
Total	35	-	-	-	-	

ANOVA 14: Analysis of variance of finger millet on straw yield ha^{-1} under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	2160321.50	1080160.75	3.16	0.07	S
Treatments	11	54446814.75	4949710.44	14.53	1.19	S
Factor A	2	18836.17	9418.08	0.03	0.98	S
Factor B	3	53857354.75	17952451.58	52.67	3.31	S
A X B	6	570623.83	95103.97	0.27	0.95	S
Error	22	7498216.50	340828.03	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	636188.39	318094.19	1.43	0.27	S
Treatments	11	50162918.31	4560265.31	20.37	4.94	S
Factor A	2	3612011.06	1806005.53	8.07	0.00	S
Factor B	3	42760044.97	14253348.32	63.66	5.26	S
A X B	6	3790862.28	631810.38	2.82	0.03	S
Error	22	4925518.94	223887.23	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1285250.94	642625.46	3.85	0.04	S
Treatments	11	48385093.14	4398644.84	26.39	3.89	S
Factor A	2	777717.56	388858.78	2.33	0.12	S
Factor B	3	46817011.81	15605670.61	93.64	1.10	S
A X B	6	790363.78	131727.29	0.79	0.58	S
Error	22	3666181.23	166644.61	-	-	
Total	35	-	-	-	-	

ANOVA 15: Analysis of variance of finger millet on harvest index (%) under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	4.18	2.09	3.01	0.07	NS
Treatments	11	12.51	1.14	1.63	0.16	NS
Factor A	2	6.96	3.47	4.98	0.01	S
Factor B	3	0.32	0.10	0.15	0.92	NS
A X B	6	5.23	0.88	1.25	0.32	NS
Error	22	15.32	0.70	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1.18	0.60	0.98	0.39	NS
Treatments	11	14.81	1.35	2.20	0.05	NS
Factor A	2	1.19	0.60	0.97	0.40	NS
Factor B	3	3.88	1.29	2.13	0.13	NS
A X B	6	9.72	1.62	2.66	0.04	NS
Error	22	13.43	0.62	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.29	0.15	0.44	0.65	NS
Treatments	11	6.07	0.56	1.71	0.14	NS
Factor A	2	3.13	1.57	4.86	0.02	NS
Factor B	3	0.91	0.30	0.95	0.43	NS
A X B	6	2.02	0.34	1.05	0.43	NS
Error	22	7.09	0.32	-	-	
Total	35	-	-	-	-	

ANOVA 16: Analysis of variance of finger millet on crude protein content (%) under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.04	0.02	0.54	0.59	S
Treatments	11	11.71	1.07	27.67	2.44	S
Factor A	2	2.07	1.04	27.01	1.20	S
Factor B	3	5.23	1.74	45.37	1.36	S
A X B	6	4.40	0.74	19.05	1.10	S
Error	22	0.84	0.03	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.20	0.10	0.99	0.39	S
Treatments	11	11.13	1.02	9.75	4.06	S
Factor A	2	1.06	0.54	5.14	0.02	S
Factor B	3	3.51	1.16	11.23	0.00	S
A X B	6	6.57	1.10	10.52	1.56	S
Error	22	2.28	0.11	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.02	0.02	0.41	0.67	S
Treatments	11	11.10	1.00	32.60	4.68	S
Factor A	2	1.53	0.77	24.78	2.31	S
Factor B	3	4.26	1.41	45.82	1.24	S
A X B	6	5.30	0.88	28.59	2.55	
Error	22	0.68	0.04	-	-	
Total	35	-	-	-	-	

ANOVA 17: Analysis of variance of finger millet on carbohydrate content (%) under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.89	0.45	0.41	0.67	S
Treatments	11	357.26	32.48	29.10	1.47	S
Factor A	2	4.27	2.14	1.92	0.18	
Factor B	3	271.54	90.51	81.09	4.74	
A X B	6	81.47	13.58	12.17	4.98	
Error	22	24.56	1.11	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1.24	0.62	0.95	0.40	S
Treatments	11	250.80	22.80	35.26	2.11	S
Factor A	2	74.44	37.22	57.56	1.81	S
Factor B	3	128.20	42.73	66.09	3.63	S
A X B	6	48.16	8.03	12.42	4.24	S
Error	22	14.22	0.65	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.98	0.50	1.05	0.37	S
Treatments	11	272.22	24.75	53.42	2.88	S
Factor A	2	28.05	14.03	30.27	4.81	S
Factor B	3	191.25	63.75	137.62	2.10	S
A X B	6	52.91	8.82	19.04	1.10	S
Error	22	10.20	0.46	-	-	
Total	35	-	-	-	-	

ANOVA 18: Analysis of variance of finger millet on crude fiber content (%) under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.01	0.01	0.15	0.86	S
Treatments	11	2.38	0.22	18.19	1.46	S
Factor A	2	0.37	0.18	15.14	7.34	S
Factor B	3	1.36	0.45	38.14	6.86	S
A X B	6	0.66	0.11	9.22	4.19	S
Error	22	0.26	0.02	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.08	0.03	2.72	0.09	S
Treatments	11	5.51	0.50	37.27	1.20	S
Factor A	2	1.34	0.67	50.00	6.56	S
Factor B	3	2.35	0.79	58.14	1.27	S
A X B	6	1.83	0.31	22.59	2.32	S
Error	22	0.30	0.01	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.01	0.01	2.08	0.15	S
Treatments	11	3.18	0.29	63.08	5.05	S
Factor A	2	0.74	0.37	80.86	7.27	S
Factor B	3	1.63	0.54	119.00	9.48	S
A X B	6	0.80	0.14	29.19	2.10	S
Error	22	0.11	0.01	-	-	
Total	35	-	-	-	-	

ANOVA 19: Analysis of variance of finger millet on calcium content (%) under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.00	0.01	0.27	0.76	S
Treatments	11	1.70	0.16	66.66	2.81	S
Factor A	2	0.81	0.40	174.71	3.15	S
Factor B	3	0.75	0.24	106.40	3.01	S
A X B	6	0.15	0.02	10.78	1.30	S
Error	22	0.05	0.00	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.02	0.01	1.12	0.34	S
Treatments	11	1.30	0.12	22.72	1.72	S
Factor A	2	0.56	0.28	54.13	3.18	S
Factor B	3	0.46	0.15	29.67	6.46	S
A X B	6	0.28	0.04	8.75	6.17	S
Error	22	0.11	0.00	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.01	0.00	1.28	0.30	S
Treatments	11	1.44	0.13	71.82	1.28	S
Factor A	2	0.68	0.34	186.02	1.64	S
Factor B	3	0.58	0.20	107.20	2.79	S
A X B	6	0.17	0.02	16.08	4.88	S
Error	22	0.04	0.01	-	-	
Total	35	-	-	-	-	

ANOVA 20: Analysis of variance of finger millet on cost of cultivation under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	15.72				NS
Factor A	2	1.72	0.86	0.33	0.72	S
Factor B	3	661001365.67	220333788.56	85124080.85		S
Intraction A X B	6	7.83	1.31	0.50	0.80	S
Error	22	56.94	2.59			S
Total	35	661001447.89				

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	32.72				NS
Factor A	2	5.06	2.53	0.72	0.50	S
Factor B	3	660941599.64	220313866.55	62720550.60	< 0.001	S
Intraction A X B	6	36.28	6.05	1.72	0.16	S
Error	22	77.28	3.51			S
Total	35	660941750.97				

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.39				S
Factor A	2	0.39	0.19	0.16	0.85	NS
Factor B	3	661104400.67	220368133.56	184494218.61	< 0.001	S
Intraction A X B	6	1.17	0.19	0.16	0.98	NS
Error	22	26.28	1.19			S
Total	35	661104428.89				

ANOVA 21: Analysis of variance of finger millet on gross return under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1521782695.28	760891347.64	6.22	0.00	NS
Treatments	11	25995184306.40	2363198573.31	19.32	8.24	NS
Factor A	2	61194349.64	30597174.81	0.25	0.79	S
Factor B	3	25781492505.60	8593830835.19	70.24	1.99	NS
A X B	6	152497451.21	25416241.86	0.21	0.98	S
Error	22	2691731956.83	122351452.58	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	213947036.67	106973518.34	1.08	0.35	NS
Treatments	11	25553065519.70	2323005956.33	23.57	1.19	S
Factor A	2	1933814557.60	966907278.80	9.81	0.01	S
Factor B	3	22057454417.50	7352484805.83	74.59	1.10	S
A X B	6	1561796544.60	260299424.10	2.64	0.05	S
Error	22	2168313971.70	98559725.98	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	716851437.67	358425718.83	5.58	0.02	S
Treatments	11	24244342211.00	2204031110.09	34.34	2.75	S
Factor A	2	645023884.98	322511942.49	5.03	0.02	S
Factor B	3	23256388516.20	7752129505.38	120.79	8.12	S
A X B	6	342929809.90	57154968.31	0.90	0.52	S
Error	22	1411843276.85	64174694.41	-	-	
Total	35	-	-	-	-	

ANOVA 22: Analysis of variance of finger millet on net return under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1521782695.28	760891347.64	6.22	0.00	NS
Treatments	11	19733847923.50	1793986174.86	14.67	1.09	NS
Factor A	2	61194349.64	30597174.81	0.25	0.79	NS
Factor B	3	19520156122.70	6506718707.56	53.19	3.02	S
A X B	6	152497451.20	25416241.86	0.21	0.98	NS
Error	22	2691731956.83	122351452.58	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	213947036.67	106973518.34	1.08	0.35	S
Treatments	11	19730622956.40	1793692996.03	18.19	1.46	S
Factor A	2	1933814557.60	966907278.80	9.81	0.01	S
Factor B	3	16235011854.20	5411670618.06	54.91	2.21	S
A X B	6	1561796544.60	260299424.10	2.64	0.05	S
Error	22	2168313971.70	98559725.98	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	716851651.03	358425825.52	5.58	0.02	S
Treatments	11	18202453121.10	1654768465.56	25.78	4.92	S
Factor A	2	645023908.19	322511954.10	5.03	0.02	S
Factor B	3	17214499399.00	5738166466.35	89.42	1.78	S
A X B	6	342929813.87	57154968.97	0.90	0.52	S
Error	22	1411843252.34	64174693.28	-	-	
Total	35	-	-	-	-	

ANOVA 23: Analysis of variance of finger millet on B:C ratio under different sowing dates and nutrient management

ANOVA Table of first year (2023)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	1.72	0.86	5.54	0.01	NS
Treatments	11	14.04	1.28	8.22	1.65	S
Factor A	2	0.09	0.05	0.32	0.74	S
Factor B	3	13.68	4.56	29.36	7.10	S
A X B	6	0.26	0.05	0.29	0.94	NS
Error	22	3.41	0.15	-	-	
Total	35	-	-	-	-	

ANOVA Table of second year (2024)						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.25	0.12	1.01	0.38	S
Treatments	11	18.75	1.71	13.71	2.03	S
Factor A	2	2.45	1.23	9.85	0.01	S
Factor B	3	14.40	4.80	38.61	6.11	S
A X B	6	1.90	0.31	2.54	0.05	S
Error	22	2.73	0.12	-	-	
Total	35	-	-	-	-	

ANOVA Table of Pooled Final						
Source of Variance	**df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**	**S/NS**
Replications	2	0.81	0.40	5.04	0.02	S
Treatments	11	14.58	1.33	16.64	3.39	S
Factor A	2	0.87	0.43	5.47	0.02	S
Factor B	3	13.25	4.41	55.44	2.02	S
A X B	6	0.46	0.08	0.95	0.48	S
Error	22	1.76	0.08	-	-	
Total	35	-	-	-	-	