



**EFFECT OF ROW RATIO AND NUTRIENT MANAGEMENT ON
PERFORMANCE OF FODDER MAIZE (*ZEA MAYS* L.) BASED LEGUME
INTERCROPPING SYSTEM**

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

By

TH. NENGPARMOI

Admn. No.: Ph-315/20 Regn. No.: Ph.D/AGR/00456

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Nagaland
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BY

Name of the Candidate - Th. Nengparmoi

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 LIVING GOD,
BELOVED FAMILY
AND
ASCENSION
EDUCATIONAL
TRUST*

Nagaland University

May, 2025

I, Th. Nengparmoi, 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.

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CERTIFICATE – I

This is to certify that the thesis entitled **“Effect of row ratio and nutrient management on performance of fodder maize (*Zea mays* L.) based legume intercropping system”** 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 Ms. Th. Nengparmoi, Registration No. PhD/AGR/00456 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.

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Place : SAS, NU, Medziphema

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CERTIFICATE – II

VIVA VOCE ON THESIS OF DOCTOR OF PHILOSOPHY IN AGRONOMY

This is to certify that the thesis entitled **“Effect of row ratio and nutrient management on performance of fodder maize (*Zea mays* L.) based legume intercropping system”** submitted by Th. Nengparmoi, Admission No. Ph-315/20, Registration No. PhD/AGR/00456, 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

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Date :

Place : SAS, NU, Medziphema

(TH. NENGPARMOI)

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LIST OF ABBREVIATIONS

%	Percentage
@	At the rate
₹	Rupees
-1 or /	Per
ai	Active ingredient
ADF	Acid detergent fibre
ATER	Area time equivalent ratio
BCR	Benefit cost ratio
CD	Critical Difference
CEC	Cation exchange capacity
CHO	Carbohydrate
CGR	Crop growth rate
cm	Centimetre
cm ²	Centimetre square
CP	Crude protein
CPY	Crude protein yield
DAS	Days after sowing
DCP	Digestible Crude Protein
df	Degree of freedom
DFY	Dry fodder yield
DM	Dry matter
DMD	Dry matter digestibility
DMI	Dry matter intake
EE	Ethel extract
EEY	Ethel extract yield
Et al	Et alia (and others/ co-authors)
F	Fodder
Fig	Figure
FYM	Farm yard manure
g	Gram
GFY	Green fodder yield
GM	Green manure
GMV	Gross monetary value
ha	Hectare
i.e.	Id est / that is
INM	Integrated nutrient management
IVDMD	In vitro dry matter digestibility
K	Crowding coefficient
kg	Kilogram

L	Carl Linnaeus
LAI	Leaf area index
LUE	Light use efficiency
LER	Land equivalent ratio
m	Metre
m ²	Metre square
MA	Monetary advantage
Max	Maximum
ME	Metabolizable energy
MFEY	Maize fodder equivalent yield
mg	Milli gram
Mj	Mega joule
Min.	Minimum
mm	Millimetre
MOP	Muriate of Potash
MSL	Minimum sea level
MSS	Mean sum squares
Mt	Million tonnes
NDF	Neutral detergent fibre
NEL	Net energy for lactation
NPK	Nitrogen Phosphorus Potassium
No.	Number
NS	Not significant
NU	Nagaland University
NUE	Nutrient use efficiency
OC	Organic carbon
p<0.05	Borderline of statistically significant
PGPR	Plant growth promoting rhizobacteria
pH	Negative log of H ion activity
PSB	Phosphate solubilising bacteria
Q	Quintal
°C	Degree Celsius
RCC	Relative crowding coefficient
RDF	Recommended Dose of Fertilizers
RGR	Relative growth rate
RYT	Relative yield total
SAS	School of Agricultural Sciences
SC	Sole cowpea
Sem±	Standard error of mean
SI No.	Serial number
SM	Sole maize

SR	Sole rice bean
ss	Sum of square
SSP	Single super phosphate
t	Tonnes
T	Treatment
TAY	Total ash yield
TDN	Total digestible Nutrients
TWD	Total dry weight
Viz.	Videlicet (Namely)

ABSTRACT

A field experiment was conducted to study the “Effect of row ratio and nutrient management on performance of fodder maize (*Zea mays* L.) based legume intercropping system” at the experimental research farm of Department of Agronomy, School of Agricultural Sciences (SAS), Nagaland University, Medziphema Campus during the *kharif* season of 2022 and 2023. The experiment was laid out in randomized block design (RBD) which comprised of nine different intercropping system (*viz.*, C₁- sole maize, C₂- sole cowpea, C₃- sole rice bean, C₄- M + C (1:1), C₅- M + R (1:1), C₆- M + C (2:1), C₇- M + R (2:1), C₈- M + C (2:2), C₉- M + R (2:2) and three nutrient levels (*viz.*, F₀- control, F₁- 50 % RDF @ 30-15-15 kg ha⁻¹, F₂- 100 % RDF @ 60-30-30 kg ha⁻¹) and replicated thrice. The varieties used were African Tall for fodder maize, Kohinoor for fodder cowpea and Bidhan rice bean-2 for fodder rice bean. The pooled results of the two years revealed that cropping system had significant effect on performance of fodder maize. The results showed that, C₁ recorded the highest plant height and number of leaves plant⁻¹ at 20 DAS (47.85 cm, 6.43), 40 DAS (173.46 cm, 8.79), 60 DAS (263.30 cm, 12.09) and 80 DAS (322.50 cm, 13.74) respectively. The treatments C₁ and C₉ recorded the largest stem girth of maize at 20 DAS (2.96 cm, 2.92 cm), 40 DAS (4.82 cm, 4.78 cm), 60 DAS (6.17 cm, 6.13 cm) and 80 DAS (7.04 cm, 7.02 cm), while the highest leaf stem ratio at 20 DAS was recorded at C₉ (3.391) and C₅ recorded the highest leaf stem ratio at 40 DAS (0.336), 60 DAS (0.453) and 80 DAS (0.333). The highest leaf area (222.74 cm², 436.23 cm², 630.84 cm² and 699.44 cm²), fresh weight (26.71 g plant⁻¹, 216.95 g plant⁻¹, 538.11 g plant⁻¹ and 808.24 g plant⁻¹) and dry weight (3.76 g plant⁻¹, 32.07 g plant⁻¹, 100.81 g plant⁻¹ and 198.38 g plant⁻¹) of maize at 20 DAS, 40 DAS, 60 DAS and 80 DAS was recorded at C₄. The highest total green fodder and dry fodder yield was recorded at C₇ (57.171 t ha⁻¹, 11.615 t ha⁻¹) and C₆ (56.588 t ha⁻¹, 11.928 t ha⁻¹). Furthermore, C₁ recorded the highest CPY (10.28 q ha⁻¹) and crude fibre (24.09 %), while C₅ (1:1) and C₇ recorded the highest ash content (8.77 %) and crude protein content (9.63 %). With respect to nutrient management, the application of nutrients at 100 % RDF (60-30-30 kg ha⁻¹) significantly recorded the highest vegetative growth, quality parameters and green and dry fodder yield of the fodder maize.

The highest CGR @ 20-40 DAS ($15.73 \text{ g m}^{-2} \text{ day}^{-1}$) and 40-60 DAS ($38.19 \text{ g m}^{-2} \text{ day}^{-1}$) was recorded at C₄. With respect to nutrient management practices, the highest CGR of fodder maize was registered F₂ at 20-40 DAS ($17.69 \text{ g m}^{-2} \text{ day}^{-1}$) and 40-60 DAS ($42.55 \text{ g m}^{-2} \text{ day}^{-1}$). The highest leaf area index @ 20 DAS (0.79) and 40 DAS (1.45) was found in C₄. The findings further revealed that treatments C₈ (M + C @ 2:2) and C₇ (M + R @ 2:1) recorded the highest LER of the system (1.263, 1.231). The treatments C₆ (M + C @ 2:1) and C₈ (M + C @ 2:2) recorded the highest RCC of the system (3.467, 3.108) and the land use efficiency was 23.3 %. The highest NAR at 20-40 DAS ($0.00233 \text{ g cm}^{-2} \text{ day}^{-1}$) and 40-60 DAS ($0.00336 \text{ g cm}^{-2} \text{ day}^{-1}$) was recorded in C₁, while treatments C₁ and C₆ (M + C @ 2:1) recorded the highest RGR @ 20-40 DAS ($0.04932 \text{ g}^{-1} \text{ g}^{-1} \text{ day}$) and 40-60 DAS ($0.02796 \text{ g}^{-1} \text{ g}^{-1} \text{ day}$). The highest aggressivity and competition ratio of the fodder maize was recorded at C₄ followed by C₅, with regard to nutrient management, the highest aggressivity and competition ratio of fodder maize was registered at F₀ (control). Intercropping of fodder maize with fodder cowpea and fodder rice bean recorded the highest maize fodder equivalent yield as compared to sole maize. Incase of nutrient management, the highest maize fodder equivalent yield was recorded at F₂ (69157 q ha^{-1}) and the lowest was obtained from F₀ (446.44 q ha^{-1}). The available N ($280.54 \text{ kg ha}^{-1}$) and P (23.69 kg ha^{-1}) was found was highest in C₃, while C₂ recorded the highest available K ($172.67 \text{ kg ha}^{-1}$) and the lowest was found in C₁. The highest content of N (1.507 %), P (0.230 %) and K (1.736 %) were recorded from C₉ (M + R @ 2:2). However, sole maize recorded the highest nutrient uptake (NPK @ $165.60 \text{ kg ha}^{-1}$, 24.88 kg ha^{-1} and $183.44 \text{ kg ha}^{-1}$) followed by C₆ (M + C @ 2:1) and C₇ (M + R @ 2:1). When it comes to expenditure, the highest cost of cultivation was recorded from C₁F₂ in both 2022 ($\text{₹ } 31551.82/\text{ha}^{-1}$) and 2023 ($\text{₹ } 32340.82/\text{ha}^{-1}$). In terms of economics, the highest gross return ($\text{₹ } 148814.00/\text{ha}^{-1}$), net return ($\text{₹ } 116973.18/\text{ha}^{-1}$) and B:C ratio (3.67) was recorded from treatment C₉F₂.

Keywords: Fodder maize, cowpea, rice bean, intercropping, nutrient management, growth, quality, yield, economics

CHAPTER - I
INTRODUCTION

INTRODUCTION

Maize (*Zea mays* L.) belongs to the tribe Maydae and family Poaceae. It was originated from Mexico and Central America and today it has become a leading crop in many temperate regions (Miedema, 1982). Globally, maize is known as “queen of cereals” due to the highest genetic yield potential among the cereals and also it is referred as “miracle crop”. Maize is one of the most important recognizable plant foods in the world today and every part (grain, leaves, stalk, tassel and cob) of the maize plant has economic value. The contribution of maize in world food recipe is of significant importance both for human and animal nutrition as well. The major portion of maize produced is used for animal consumption as it serves as a vital source of proteins and calories to billions of people in developing countries, particularly in Asia, Africa and Mesoamerica (Shiferaw *et al.*, 2011). The kernel of common maize is highly nutritive as it contains starch (71.7 %), protein (9.5 %), oil (4.3 %) and sugar (2.6 %), respectively (Watson, 2003). In addition to staple food for human being and quality feed for animals, maize serves as a basic raw ingredient material to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries, etc. (Parihar *et al.*, 2011). In India, the maize is used as human food (23 %), poultry feed (51 %), animal feed (12 %), industrial (starch) products (12 %), beverages and seed (1 % each).

At present, maize is cultivated on nearly 190 million hectares with the production of 1163 metric tonnes worldwide (Anonymous, 2024) and it is used more in developed countries than the developing countries, but the forecasts show that by the year of 2050, the demand for maize in the developing countries will double owing to the rapid growth in poultry industry, the biggest driver of growth in maize production (Rosegrant *et al.*, 2009; Prasanna, 2014). The USA continues to be largest producer of maize which contributes 31.3 % in world production, followed by China (22.9 %), Brazil (8.8 %), EU (5.9 %) and Argentina (4.5 %). India ranks seventh in the global maize production and has a modest share of 2.5 % in global maize production.

In India, maize is the third most important food crops after rice and wheat. It grows well on a wide range of climatic condition. It is mainly grown during *kharif* season which covers 78.8 % (85.79 lakh ha) of total area, with 23.08 lakh hectares grown during *rabi*. The area under maize cultivation was approximately 108.87 lakh hectares during 2023-2024, an increase from 105.24 lakh hectares in the previous year with a production of 30 million mt and it contributes nearly 10 % in the total food grain production in the country. The major *kharif* maize growing states are Madhya Pradesh (17.44 lakh ha), Karnataka (16.09 lakh ha), Rajasthan (9.44 lakh ha) and Maharashtra (9.16 lakh ha). During Rabi season, Bihar (7.92 lakh ha), Maharashtra (3.37 lakh ha) and Tamil Nadu (2.20 lakh ha) are major growers state (Anon., 2024). Apart from these states, maize is also grown in Jammu and Kashmir and North-Eastern states. According to the 3rd advance estimates for 2023-2024 by the government of India the leading states are Karnataka (54.90 lakh tonnes) followed by Bihar (46.13 lakh tonnes), Madhya Pradesh (43.29 lakh tonnes), Tamil Nadu (30.57 lakh tonnes), West Bengal (26.78 lakh tonnes), Telangana (26.68 lakh tonnes) and Maharashtra (23.98 lakh tonnes).

Maize is one the most important C₄ crop plants and is almost an ideal cereal forage crop because of its quick growing, high yielding, palatable with nutritious qualities and can be fed to the cattle at any stage of growth, as there is no problem of hydrocyanic acid or oxalic acid poisoning to cattle. Hence, it is widely known as “ready-made fodder crop” (Mishra, 2019). The green fodder of maize has also been reported to have lactogenic properties and hence, it is especially suited for milch cattle. The main aim of fodder maize production is to provide nutritious fodder in accordance with feed requirement of animal. Although maize provides high yield in terms of dry matter, it produces forage with low protein content. However, protein is needed by livestock for growth and milk production.

India is the largest country which is having 535.78 million of livestock populations in India as per the 20th Livestock Census released in 2019 (Anon., 2019). The total area under fodder crops is 8.6 m ha which constitutes about 4 % of cultivated area and is insufficient to meet the fodder requirement of existing livestock. It is constantly not viable to set aside arable land for fodder production alone, as cultivable

land is not enough for food grain production. Livestock rearing is very important part of our rural economy not only for animal products, but also for draft power, quality forage production plays an important role in dairy industry. Availability of green forage to animals is the key to success of dairy enterprises and it is hard to maintain the health and milk production of the livestock without supply of green fodder. At present, the country faces net deficit of 61.1 % green fodder and 21.9 % dry fodder. This situation indicates that green forage supply has to grow at 3.2 % to meet the deficit (Kumar and Faruqi, 2010). As a result of deficit in fodder availability, livestock suffers continuously with malnutrition for the year round in general, resulting in their production capacity at sub-optimum level.

Agriculture land is shrinking day by day as it is used for non-agricultural purposes. It is rather inevitable to accommodate fodder production in existing cropping systems. There is free interspace in widely spaced crops like maize, sorghum, bajra, hybrid cotton, red gram etc., which can be advantageously used to raise short duration pulse crops without much reduction in the main crop yields. Among the different fodder crops, maize is regarded as one of the important dual-purpose crops because it is used in human diet as well as animal feed. Maize has the potential to supply large amounts of energy-rich forage for daily animal diets and its fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid as in case of sorghum (Dahmardeh *et al.*, 2009). However, forage is poor in protein content which shows their low quality and nutritive value, the livestock needed protein for growth, milk production and also by rumen bacteria which digest the much of the feed. Thus, forage maize has become major constituent of ruminant rations in recent year.

Regarding high feed costs of protein supplementations, legumes can be used in livestock nutrition for their high protein content and thus, reducing feed cost. Intercropping of botanically diverse forage species like cereals and legumes appears to be one of the feasible approaches for increasing the fodder yield, utilization of land more efficiently improving fodder quality and providing stability to production (Tripathi, 1989). Supply of forage is inadequate in the country not only in terms of quality but also in quantity. Since the scope of area expansion under fodder cultivation is limited, the productivity of fodder crops is to be raised through best utilization of the

resources of the prevailing production systems. High quality of forage has been notified as an important aspect of forage crop production. Although cereals are widely used in livestock nutrition for their high dry matter production and low cost (Ghanbari-Bonjar, 2000), they have low nutrition value due to their low forage quality. Forage quality of legumes is high but they have low dry matter production (Ross *et al.*, 2004). Legumes are good sources of protein. Thus, legume-cereal composition is considered as a management strategy in producing both high quality and quantity forage.

Although India has very large population of livestock, the productivity of milk and other livestock product per animal is very low compared to other many countries in the world. One of the main reasons for the low productivity is malnutrition, under-nutrition or both, beside the low genetic potential of the animals. The adequate supply of nutritive fodder and feed is a crucial factor impacting the productivity and performance of the animals (Karki, 1985). The country is highly deficient in respect of availability of green fodder, dry fodder and concentrates. Future development and growth of livestock are highly associated with the scope of availability of fodder from cultivable land, forest, pastures and grazing lands. India is presently under heavy stress on account of a large-scale exploitation for fuel wood, timber and fodder, mismanagement of forest resources and frequent fires. There is acute shortage of fodder especially green nutritious fodder, which is major cause of low productivity of livestock, especially in hilly areas (Deb *et al.*, 1989). The main reasons for low productivity are insufficient and low-quality fodder and feed including grazing facilities (Deb, 1993). Therefore, it is important to put more emphasis on fodder development programmes for augmenting fodder or feed supply, while formulation of livestock development strategy.

In India, maize fodder is cultivated in various agro-climatic zones. It is evident that various factors such as composition of soil, irrigation, climatic condition, varieties, strains, manure and fertilizer effects on growth, yield and its quality in the form of chemical composition. Keeping all other factors constant, if the fertilizer application is altered considering the most economic factor, the yield and quality can be improved (Kanduri *et al.*, 2016).

Among the essential nutrients, macro-nutrients such as, nitrogen, phosphorus and potassium play a crucial role in deciding the growth and yield. Intercropping legumes results in considerable removal of nutrients in the initial stage from the soil and thus to compensate the nutrient taken by intercrops, higher levels of NPK fertilizers have to be applied (Ogutu *et al.*, 2012). Growing non-food legumes in association with cereals particularly maize increase fodder production with less effect on maize grain yield. Integration of fodder legumes and fodder cereal into maize-based cropping system through intercropping is one of the interventions for optimizing the productivity of a given land use, which can contribute towards alleviating livestock feed shortage in a mixed farming system. Fodder legume has a high protein concentration, palatability and digestibility and can be useful as a supplement to livestock feed with mature cereal crop residues that are often low in nutritive value (Hamdollah and Ghanbari, 2009). In this back drop, a study on food cum fodder system was planned to identify the agronomic practice which ensure maximum maize grain yield along with fodder.

Amongst the essential plant nutrients, N and P are often the most important determinants of plant growth and crop yield. Nitrogen is one of the critical nutrients for crop production and it promotes rapid vegetative growth and increases crop yields. The nitrogen and phosphorus, being major macronutrient, are the integral components of the chlorophyll, ATP, enzymes and nucleic acids and has vital role in metabolic activities and cellular respiration (Li *et al.*, 2011). Therefore, N and P application promotes not only growth characteristics (plant height, leaves per plant, stem diameter, leaf area, green fodder yield and dry matter percentage) but also enhance quality parameters (crude protein, crude fibre and total ash contents) (Ayub *et al.*, 2002). The green fodder yield was significantly increased with increased nitrogen levels (Ayub *et al.*, 2003).

Nitrogen is a necessary part of numerous mixes and connected with photosynthetic action. It is a fundamental part of the amino acids and related proteins (Khan *et al.*, 2014). When a lot of nitrogen is applied, abundant vegetative development happens, and the plant lodges with smallest breeze. Harvest development is deferred, and the plants are more susceptible to disease and insect pests. Insufficiency of nitrogen

results in low plant development which lessens the grain yield, leaf territory file, leaf region length and pace of photosynthesis. It confers dull green tone to plants (Pal and Kamboj, 2021).

Maize, being an exhaustive crop, requires high quantity of nutrients particularly nitrogen. The recent maize hybrids are responding to more than 240 kg N ha⁻¹. Due to high cost and rate of fertilizer, a vast majority of Indian farmers cannot afford adequate application of this crucial nutrient, hence it would be worthwhile to examine whether introducing nitrogen-fixing legume crop in maize may help to cut down the needs of fertilizer nitrogen or not (Naik *et al.*, 2017). Generally, N is applied in large quantities in the form of fertilizer to soils. However, most of the plants only utilize less than one half of applied N fertilizer, and there is a great loss of N fertilizer through leaching and volatilization. In the present days, due to concerns about environmental degradation coupled with increasing need of nitrogenous fertilizers, there is a need to out supplemental alternative sources.

Potassium, being a primary nutrient, plays many crucial roles in plants including activating enzyme, opening and closing of stomata, efficient transport of water and nutrient through xylem and finally in protein synthesis in the plant (Barker and Culman, 2020). In recent times, the intensive agricultural practices along with diversified use of cow dung has caused a broken potassium replenish leading to higher potassium mining than potassium replenishment leading to potassium deficiency in both plants and animals. As a result, there is a dire need for formulation of efficient potassium management practices for fodder crops (Pant *et al.*, 2004).

Therefore, keeping in view the above facts, the present investigation entitled **“Effect of row ratio and nutrient management on performance of fodder maize (*Zea mays* L.) based legume intercropping system”** was taken up with the following objectives:

1. To evaluate a suitable row ratio for fodder maize based legume intercropping.
2. To evaluate the NPK dose for enhancing fodder quality.
3. To analyse the economics of various treatments.

CHAPTER - II
REVIEW OF LITERATURE

REVIEW OF LITERATURE

Maize is the third most important food crops after rice and wheat in India. It's one of the most important recognizable plants foods in the world today and every part of the plant has economic value. It's important for both human and animal nutrition as well. India is the largest country which owned a million of livestock in the world. However, there is a wide gap between the supply and demand of feeding in respect of available of green fodder, dry fodder and concentrate. As the country is deficit in fodder availability, livestock suffers continuously with malnutrition for the year round, resulting in their production capacity at sub-optimum level. The rise in population leads to high demand in food production and conversion of agricultural land into urbanization, in which the agricultural land is shrinking day by day and it's inevitable to accommodate fodder production in existing cropping system. Hence, diversification of widely grown cereal-cereal cropping systems with legumes may be adopted as an effective strategy to meet or boost the fodder production in the country. The practice of nutrient management with intercropping of widely spaced crops with short duration has a wide area of study and many research has been done in India and abroad.

A comprehensive review of previous research provides good knowledge for production practices and management aspect in expressing the findings of the research. The available review of literature on different aspect related to **“Effect of row ratio and nutrient management on performance of maize (*Zea mays* L.) based legume intercropping system”** has been presented in this chapter. This chapter deals with review of studies which have a direct or indirect relevance regarding effect of row ratio and nutrient management on production potential, fodder quality and economics of fodder maize-based fodder legume intercropping system. These impacts have been reviewed in this chapters under following headings.

- 2.1 Effect of maize-based legume intercropping on growth parameters
- 2.2 Effect of maize-based legume intercropping on yield
- 2.3 Effect of maize-based legume intercropping on quality parameters
- 2.4 Effect of maize-based legume intercropping on soil status
- 2.5 Effect of maize-based legume intercropping on nutrients uptake

- 2.6 Effect of maize-based legume intercropping on economics feasibility
- 2.7 Effect of nutrient management on growth of maize-based legume intercropping
- 2.8 Effect of nutrient management on yield of maize-based legume intercropping
- 2.9 Effect of nutrient management on quality parameters of maize-based legume intercropping
- 2.10 Effect of nutrient management on nutrient uptake of maize-based legume intercropping
- 2.11 Effect of nutrient management on economics of maize-based legume intercropping

2.1 Effect of maize-based legume intercropping on growth parameters

Zaman and Malik (2000) observed that intercropping of rice bean with maize had significant effect on plant height. The higher plant height was recorded in sole maize and sole rice bean which did not differ much from maize + one row of rice bean. The minimum plant height was seen from treatment where rice bean was intercrop in three rows.

Kalia *et al.* (2001) conducted field experiment during *rabi* seasons of 1995-96, 1996-97 and 1997-98 to assess the comparative performance of forage vetch and shaftal with oat in 1:1, 1:3 and 3:1 intercropping system under sub-humid mid-hill conditions of Himachal Pradesh. Pure oat produced more plant height than pure vetch and shaftal, whereas intercropping of oat + vetch in 1:1 ratio significantly reduced the oat plant height. Among intercrops, vetch had more height than shaftal.

Iqbal *et al.* (2012) reported that legume intercrops had a significant effect on leaf area index. The highest leaf area index (1.88) was recorded for cowpea sown in alternate rows with forage maize followed by that grown in broadcast with blended seed of maize + cluster bean. Contrarily, the minimum LAI (0.66) was recorded for rice bean planted in lines with blended seed of maize + rice bean. Similar trend prevailed during the 2nd year of study with the maximum LAI (2.49) for cowpea grown in alternate rows with maize and the minimum LAI (0.84) was recorded for rice bean sown in lines with blended seed of maize + rice bean.

Pandey and Bhambri (2017) studied the effect of different crop arrangement and nutrient management under maize and soyabean intercropping system in Raipur. They found that intercropping had utilised the light interception more efficiently than sole crop. And also, the highest light use efficiency (LUE) was recorded at 60-80 DAS. LUE obtained from different crop arrangements were very low during first 40 DAS but at later stages a clear difference can be seen owing to better canopy development and increased leaf area index. Among the treatments, maize + soybean (2:4) crop arrangement had the highest value of LUE till harvest and followed by maize + soybean (2:2) row ratio. While, the lowest LUE throughout the crop life was observed from sole maize.

Prajapati *et al.* (2018) conducted the field study to evaluate fodder based intercropping systems for various quality traits of fodder. The treatments consisting of 10 treatments *i.e.*, single cut sorghum + cowpea, sweet sorghum + rice bean, sweet sorghum + phillipesara, sweet sorghum + cowpea, maize + rice bean, maize + phillipesara and maize + cowpea. Among the treatments, content of dry matter was significantly more in sorghum + rice bean and sorghum + cowpea, while crude protein and digestibility dry matter content were highest in fodder maize + cowpea.

Ginwal (2019) carried out the experiment to study the growth parameters of maize with cowpea under varying intercropping combinations. The experiment was laid out in randomized complete block design with seven treatments consisting of three different forage crops, *viz.*, maize, cowpea and guar sown in sole as well as in 1:1 and 2:1 intercropping combinations of forage cereal with legume crop components in three replications. They reported that all the growth parameters like plant height (221.67 cm), leaf length (93.00 cm), leaf width (6.73 cm), number of leaves plant⁻¹ (11.35), stem girth (5.95 cm) and leaf:stem ratio (0.35) were significantly higher in M + C sown at 1:1 row ratio compared to M + C at 2:1 row ratio and sole maize at the time of harvest.

Gupta, *et al.* (2019) studied the influence of maize cultivars and cowpea intercropping systems on plant growth parameters. The sole African tall recorded plant height (230.08 cm), number of leaves plant⁻¹ (14.76) and stem girth (7.72 cm). Among the intercropping treatments, the highest plant height of fodder maize (209.03 cm) was

recorded in African tall cultivar with cowpea in 2:1 seed mix, whereas the lowest plant height of maize (175.48 cm) was recorded in local variety of fodder maize with cowpea in 1:1 seed mix. Fodder maize cultivar African tall intercropped with cowpea in 2:1 row ratio and 2:1 seed mix recorded higher plant height with higher number of leaves plant⁻¹ and stem girth. This might be due to impact of competition between the two crops for the available resources in the field including space and nutrients whereas the difference in number of leaves plant⁻¹ is due to the genetic makeup of the cultivar (Islam *et al.*, 2014).

Kumar and Narmadha (2021) reported that intercropping systems had significant difference in plant height. Among various intercropping systems, taller plant (176.6 cm) was recorded under maize + pillipesara normal intercropping which was on par with maize + lucerne normal intercropping. The least plant height of maize (150.3 cm) was observed under maize + fodder cowpea paired row intercropping system. Among the intercropping systems, taller plants were observed under maize + pillipesara normal intercropping and the least plant height was recorded under sole maize. Significantly difference in leaf area index was observed with intercropping systems. Among various intercropping systems, the higher leaf area (5.56) was recorded under maize alone. The least leaf area index of 3.75 was observed under maize + fodder cowpea paired row intercropping system

2.2 Effect of maize-based legume intercropping on yield

Azim *et al.* (2000) conducted the research to examine the influence of maize (*Zea mays*) and cowpea (*Vigna unguiculata*) intercropping on fodder biomass production. The maize was cultivated alone and intercropped with cowpea at the seed ratio of 85:15 and 70:30. The data revealed the significant increase in biomass (GFY- 52 t ha⁻¹, DFY- 17.16 t ha⁻¹) and crude protein (2.48 t ha⁻¹) production of maize intercropped with cowpea at seed ratio.

Patel and Rajagopal (2001) conducted a field experiment to evaluate the production potential of maize-based legume intercropping systems. The results revealed that highest green-forage yield and dry matter yield were obtained when maize

+ cowpea was sown in planting pattern of 5:2 and this planting was statistically on par with 4:2 row ratio.

Thippeswamy and Alagundagi (2001) conducted an experiment on intercropping of legumes with sweet sorghum for higher green forage production. They observed that intercropping of sweet sorghum + field bean at 2:1 row proportion produced significantly higher mixed green forage (59.5 t ha⁻¹) followed by sorghum + cowpea and sweet sorghum + horse gram at 2:1 row ratio.

Reddy *et al.* (2004) studied fodder-based intercropping for higher biomass and quality fodder production. The results showed that intercropping of maize and cowpea at 4:1 system can be good option for higher green fodder yield. And also, they concluded that for dry matter yield and crude protein yields 2:2 and 2:1 system could be recommended for the dairy farmers for reaping higher returns.

Kumar *et al.* (2005) studied the production potential of maize and cowpea intercropping systems under rainfed condition. The research showed that intercropping of maize and cowpea in 2:2 row proportion recorded significantly higher total green fodder and dry matter yield over other row proportion.

Singh *et al.* (2005) studied the effect of intercropping on the yield of summer fodders. The results showed that intercropping of sorghum + cowpea at 2:1 row ratio gave maximum green matter yield and dry matter yield over all intercropped combination.

Patel *et al.* (2008) studied the yield and quality of forage sorghum as influenced by intercropping of cowpea and nitrogen under rainfed conditions. They observed that intercropping of forage sorghum with cowpea in the row ratio of 2:1 produced significantly higher (green and dry) over sorghum alone.

Sharma *et al.* (2008) conducted the field experiment during 2006 and 2007 at Sabour, Bihar to assess the production potential and economic viability of intercropping of forage maize with cowpea, rice bean and cluster bean under four different row proportion viz., 1:1, 1:2, 2:1, 2:2. The study revealed that intercropping

of maize + cowpea and maize + rice bean in row proportion of 2:2 record significantly higher and comparable total green fodder yield (43.2 t ha^{-1} , 41.5 t ha^{-1}), dry matter yield (9.6 t ha^{-1} , 9.1 t ha^{-1}) and crude protein yield (1.1 t ha^{-1} , 1.06 t ha^{-1}) compared with other treatments.

Eskandari and Ghanbari (2009) carried out the experiment in randomized complete block design with three replications and five treatments viz., sole maize (*Zea mays*), sole cowpea (*Vigna sinensis*), alternate-row intercrop, within-row intercrop and mixed intercrop to investigate the forage yield as well as the effect of intercropping on maize forage quality. The results showed that intercropping systems had a significant effect on forage dry weight, where dry matter yield was increased by intercropping as compared with maize and cowpea monoculture. Similarly, higher and comparable crude protein was observed in all intercropping system then sole maize and cowpea.

Sharma *et al.* (2009) carried out an experiment of fodder productivity and economics of pearl millet (*Pennisetum typhoides*) with legumes intercropping under various row proportions. They observed intercropping of pearl millet + cowpea with row proportion of 2:2 record significantly higher total green fodder yield (52.8 t ha^{-1}) and dry matter yield (13.24 t ha^{-1}) compared to all other treatments.

Surve *et al.* (2011) studied the effect of row ratio in cereal + legume fodder under intercropping system on biomass production and economics. They revealed that intercropping of sorghum + cowpea and maize + cowpea under different row proportion had significantly affected on total green fodder and dry fodder yield. However, among all treatments, maximum total green fodder yield (50.62 t ha^{-1}) and total dry fodder yield (17.41 t ha^{-1}) was recorded from maize + cowpea under 2:1 row ratio. The higher production of yield under cereal legume intercropping system may be due to better utilization of crop production resources which have increased the yield.

Eskandari (2012) investigated the effect of intercropping on forage quantity. It was found that dry matter yield of all intercropping treatments was significantly higher than sole maize. The higher yields of intercrops due to the ability of the component crops to exploit different soil layers without competing with each other.

Deore *et al.* (2013) conducted an experiment to study the production potential of forage maize + cowpea intercropping system as influenced by row ratios. In the results of their research, they observed that intercropping of maize and cowpea in 2:1 row ratio recorded significantly higher total green forage yield (422.92 q ha⁻¹) and dry matter yield (98.92 q ha⁻¹) and crude protein yield (7.73 q ha⁻¹) followed by maize and cowpea at 2:2 row ratio which recorded total green forage yield (415.97 q ha⁻¹) and dry matter yield (94.65 q ha⁻¹), respectively.

Iderawumi (2014) carried out an experiment during the raining season at the Teaching and Research Farm of Oyo State College of Education Lanlate Campus, to investigate the effect of geometric row arrangement on the growth and yield of cowpea in a maize-cowpea intercrop. There were 1:1, 1:2 and 2:1 maize + cowpea row arrangement with a sole crop of cowpea as control. He reported that no significant difference among the growth parameter (plant height, number of leaves and number of branches plant⁻¹) intercropped and the sole cowpea plants ($p < 0.05$). However, cowpea intercropped with maize at 1:1 row arrangement recorded highest grain yield plant⁻¹ and consequently hectare⁻¹ than those of 1:2 and 2:1 row arrangement.

Javanmard *et al.* (2014) studied the effect of intercropping of barley with forage legume at different seeding ratios. The research results revealed that intercropping system significantly affected dry matter yield of barley, legumes and total dry matter yield. They reported that intercropping of barley-grass pea sown at 25:75 seeding ratios recorded the highest total dry matter yield (5.44 t ha⁻¹).

Dhonde *et al.* (2016) studied the effect of intercropping of maize (*Zea mays* L.) + cowpea (*Vigna unguiculata*) on production of green fodder. They reported that green-forage yield and dry matter yield were significantly affected by intercropping of maize and cowpea under different row ratio. Among the intercropping treatments, maize + cowpea (2:2) row ratio recorded significantly the highest green fodder yield of maize and cowpea (526.12 q ha⁻¹ and 73.52 q ha⁻¹) and dry matter yield (36.13 q ha⁻¹ and 3.39 q ha⁻¹) respectively over rest of other treatments. However, maize + cowpea (3:1) row ratio and maize + cowpea (4:1) row ratio was statistically on par with maize + cowpea (2:2) row proportion.

Kumar *et al.* (2018) studied the effect of different levels of nitrogen on yield parameters of fodder maize. Among the treatments, T₃ (150 kg ha⁻¹) recorded the highest forage yield and dry weight which was followed by T₂ (100 kg ha⁻¹).

Ganvit *et al.* (2018) reported the highest green fodder yield (991.14 q ha⁻¹) of oat and lucerne as well as significantly higher dry fodder yield (114.12 q ha⁻¹) of oat were recorded when oat + lucerne was sown in 2:1 ratio.

Mishra (2019) carried out front line demonstration at Ganjam District under East and south eastern coastal plain zone of Odhisa, during *kharif* season to promote the intercropping of maize + cowpea as fodder in 1:1 row ratio. From the frontline demonstration, the higher fresh forage yield (504.5 q ha⁻¹) was recorded from 1:1 row ratio, where sole maize and sole cowpea recorded 487.6 q ha⁻¹ and 230.3 q ha⁻¹ respectively.

Gupta *et al.* (2019) carried out the experiment to study the influence of maize cultivars and cowpea intercropping systems on green fodder and dry matter yield. The results revealed that among the intercropping treatments, African tall intercropped with cowpea in 2:1 ratio recorded significantly highest green biomass yield (293.48 q ha⁻¹) which was found at par with African tall intercropped with cowpea in 2:1 seed mix and J-1006 intercropped with cowpea in 2:1 ratio. Similarly, dry matter yield (71.81 q ha⁻¹) was also found to be significantly maximum with African tall intercropped with cowpea in 2:1 row ratio which was at par with same intercropping system in 1:1 row ratio.

Ginwal *et al.* (2019) evaluated the effect of fodder productivity of fodder maize with cowpea under different intercropping treatment combinations. The results showed that the total green fodder yield was significantly influenced by the intercropping ratios. The highest total green fodder yield (449.00 q ha⁻¹) was recorded in row combination of maize + cowpea @ 2:1 row ratio, followed by maize + guar (2:1). It may be attributed to the fact that 2:1 intercropping ratio have more plant population of cereals/millet plant as compared to other planting ratios. In forage maize sole crop as well as its intercropping with cowpea/guar 2:1 row ratio, the total green

fodder yield was increased in the tune of 2.77 %, 1.11 % over total green fodder yield of sole maize crop. The higher total green forage yields in intercropping combination of maize with cowpea in 2:1 row ratio might be attributed to complementary effect of cowpea, that supplemented nitrogen to maize and the better utilization of solar radiation, space and nutrients from the soil by maize + cowpea intercropping system.

Mishra (2019) carried out an experiment to promote the intercropping of maize and cowpea as fodder in 1:1 row ratio. The higher values of fresh forage yield (504.5 q ha⁻¹) were recorded in intercropping of maize + cowpea in 1:1 ratio. Whereas, in sole maize and cowpea it was 487.6 q ha⁻¹ and 230.3 q ha⁻¹, respectively.

Tamta *et al.* (2019) carried out the research to evaluate the effect of different intercropping ratios on productivity of fodder maize (*Zea mays* L.) and Cowpea (*Vigna unguiculata* L.). They reported that various intercropping ratios had a significantly effect on green fodder yield of the fodder maize and cowpea. The highest total green fodder yield (581.15 q ha⁻¹) as well as green fodder yield (490.79 q ha⁻¹) of maize were recorded under 2:1 row ratio followed by 1:1 and minimum were under 1:2 ratio. However, the cowpea planted under 1:2 row ratio registered highest green fodder yield (162.44 q ha⁻¹) while under 2:1 recorded the minimum green fodder yield (90.36 q ha⁻¹). The highest total green fodder yield, green fodder yield of maize and cowpea under 2:1 and 1:2 intercropping ratio may be attributed due to higher proportion of maize and cowpea in respective treatments. The increase in total green fodder yield in intercropping system might be owing to better utilization of resources such as space and light interception along with nutrient contribution of leguminous fodder to maize.

Uher *et al.* (2019) conducted the study on maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L.) intercropped in different sowing densities with objective to determine the best intercropping system on forage yield and quality. The treatments consist of maize alone 75000 plants ha⁻¹ (SM) and intercropped with cowpea as follows: 75000 plants ha⁻¹ of maize and 37500 plants ha⁻¹ of cowpea (MC₁), 75000 plants ha⁻¹ of maize and 50000 plants ha⁻¹ of cowpea (MC₂) and 75000 plants ha⁻¹ of maize and 75000 plants ha⁻¹ of cowpea (MC₃) in rows alternating with maize. The highest fresh forage yield (65.8 t ha⁻¹), dry matter yield (20.6 t ha⁻¹), crude protein yield (2.47 t ha⁻¹) was

produced by MC₃. The lowest fresh forage yield (51.3 t ha⁻¹), dry matter yield (19.3 t ha⁻¹), crude protein yield (1.47 t ha⁻¹) and the highest content of dry matter (376 g kg⁻¹) of maize was recorded from sole maize (SM).

Choudhary *et al.* (2020) conducted a field experiment to find out the appropriate row ratio of cereal and legume intercrop for better quality and maximum production at research farm Bihar agricultural university during *kharif* 2019. They reported that among the different row ratios of intercropping, the total green fodder yield (491.0 q ha⁻¹) and total dry fodder yield (103.3 q ha⁻¹) was found significantly higher in intercropping of 2:1 row ratio sorghum + cowpea which was followed by 1:1 (455.41 q ha⁻¹; 98.67 q ha⁻¹) and 2:2 (451.1 q ha⁻¹; 96.32 q ha⁻¹) row ratio of sorghum + cowpea. Whereas, the total crude protein yield (5.52 q ha⁻¹) was found significantly higher with 2:1 row ratio of sorghum + cowpea followed by 1:1 and 1:2 row ratio.

Kumar and Narmadha (2021) studied the influence of legume fodder intercropping system on green fodder yield of fodder cowpea. The green fodder yield was higher (16890 kg ha⁻¹) under IM + 1C row ratio and the least was recorded under 2 + 2 intercropping ratio of maize + lucerne (1928 kg ha⁻¹). This might be due to quicker grown cowpea used all the resources like light, nutrient, water etc, and produced huge biomass than other intercrops grown.

Yadav *et al.* (2022a) studied the effect of planting ratios on green fodder yield and crude protein yield of fodder maize and fodder cowpea. The results showed that different planting ratios had significant effect on green fodder and crude protein yield. Among planting ratios, sole cropped maize recorded higher green fodder yield (507 q ha⁻¹) followed by 2M + 1C (478 q ha⁻¹) and sole cropped cowpea recorded the lowest green fodder yield (288 q ha⁻¹). The higher crude protein yield was recorded from 1M + 1C (12.74 q ha⁻¹) and 2M + 1C (11.95 q ha⁻¹).

2.3 Effect of maize-based legume intercropping on quality parameters

Azim *et al.* (2000) investigated the effect of maize-based cowpea intercropping on fodder quality. The highest quality parameters like dry matter (34.5 % DM) crude protein (8.32 % DM) crude fibre (2.9 % DM), ether extract (2.23 % DM)

and ash (6.21 % DM) respectively.

Thippeswamy and Alagundagi (2001) observed that sweet sorghum + field bean intercropping system at 2:1 row proportion produced significantly higher crude protein (812 kg ha⁻¹), crude fibre (3820 kg ha⁻¹), ether extract (259 kg ha⁻¹) and total ash (804 kg ha⁻¹) followed by sorghum + cowpea and sweet sorghum + horsegram intercropping system at 2:1 row proportion ratio.

Kumar *et al.* (2005) reported that intercropping of maize + cowpea with row ratio of 2:2 recorded significantly higher crude protein yield (10.3 q ha⁻¹). Verma *et al.* (2005) observed that treatment maize + cowpea cross sowing recorded significantly enhanced the crude protein, fat, fibre and mineral matter *i.e.*, 8.84, 2.64, 31.93 and 16.61 q ha⁻¹ respectively.

Liu *et al.* (2006) reported that in intercropping system, crude protein of plants was increased by 30.8 % and 99.4 % as compared with those for monocropping maize. Other important characteristics for forage quality are the concentration of NDF, ADF and Ash.

Patel *et al.* (2008) observed that sorghum + cowpea with row ratio of 1:2 produced significantly higher crude protein (7.84 %) which was at par with sorghum + cowpea (1:1) while crude fibre (%) was significantly higher in sorghum + cowpea (3:1).

Sharma *et al.* (2008) observed that maize + cowpea (2:2) intercropping systems recorded significantly higher total crude protein yield (1.10 t ha⁻¹) which is at par with maize + rice bean (2:2). Similarly, Sharma *et al.* (2009) observed that intercropping of pearl millet + cowpea with row ratio of 2:2 recorded significantly higher total crude protein yield (1.36 t ha⁻¹).

Dahmardeh *et al.* (2009) reported that maximum ADF (31.85 %) was recorded by sowing maize alone while increasing the proportion of cowpea seeds to 50 % in intercropping with maize resulted in the lowest ADF (25-89 %).

Eskandari and Ghanbari (2009) reported that intercropping of maize with cowpea improved the forage quality in term of crude protein. It was found that

intercropping of maize + cowpea under different planting record higher crude protein content ranging from 100.2 g kg⁻¹ to 102.4 g kg⁻¹ dry matter compared to sole maize which content 76 g kg⁻¹ dry matter.

Eskandari *et al.* (2009) found that forage quality of cow pea was significantly affected by cropping systems. In terms of crude protein content (g kg⁻¹ dry matter) cow pea sole crop had higher crude protein content than intercropped cow pea. Thus, the forage quality of cow pea was decreased by intercropping. It was related to reduction of biological nitrogen fixation induced by low PAR and phosphorus availability for cow pea in intercropping.

Eskandari (2012) carried out an experiment to investigate the effect of intercropping on forage quality and quantity. The results showed that intercropping systems had a significant effect in quantity and quality of forage. The crude protein yield and dry matter of produced forage increased by intercropping as compared with the maize monoculture. Intercropping of legumes with maize significantly increased forage digestibility by reduced NDF and ADF content, however, forage quality of cow pea and mungbean in terms of crude protein was decreased in intercropping compared to their sole crops.

Deore *et al.* (2013) observed that intercropping of maize + cowpea with row ratio of 1:2 recorded the maximum crude protein content of maize (5.44 %) and it was noticed that this treatment was at par with some of the other treatments. Cowpea, as an intercrop, helped to enhance crude protein content and total crude protein yield of intercropping system. The higher and comparable total crude protein yield was recorded with the row ratio of 1:2 and 2:1.

Zhang *et al.* (2015) reported that intercropping system of alfalfa and corn-rye provided higher forage production performance with 34.81 % in dry matter yield, 42.13 % and 16.74 % in crude protein (CP) yield, 25.94 % and 69.99 % in degradable dry matter yield, and 16.96 % and 5.50 % in degradable crude protein yield than rotation and alfalfa sole cropping systems, respectively.

Ganvit *et al.* (2018) reported that various intercropping system with different row ratio significantly influenced the crude protein content in oat. Crude protein content and crude fibre content in oat were significantly influenced by different row ratio. However, no significant difference was observed in lucerne crop. Oat and lucerne in 2:1 row ratio recorded significantly higher crude protein and crude fibre content over rest of the treatments at first and second cut.

Gupta *et al.* (2019) study the intercropping effect on quality parameter of fodder maize and cowpea. They observed that sole maize var. African tall and sole cowpea var. CL-367 recorded the highest crude protein yield of fodder maize (283.76 kg ha⁻¹) and fodder cowpea (949.60 kg ha⁻¹). Among the intercropping system, African tall with cowpea in 1:1 ratio revealed the highest crude protein yield (751.10 kg ha⁻¹) followed by African tall with cowpea in 1:1 ratio and 1:1 mix. The highest crude fibre (2277.32 kg ha⁻¹), NDF (4488.00 kg ha⁻¹) and ADF (2373.00 kg ha⁻¹) yields were recorded in local variety intercropped with cowpea in 2:1 mix.

Tamta *et al.* (2019) studied the effect of intercropping ratio on forage quality parameters (crude protein, ether extract and ash content) of maize was found significant. The highest CP (9.88 %), EE (1.98 %) and ash content (8.72 %) of maize were found under 1:2 row ratio, respectively. However, in case of cowpea the intercropping ratios were found significant for CP (%) only in which highest CP (17.19 %) reported in 1:2 intercropping ratio. The higher content of aforesaid forage quality parameters under the treatment which contain higher proportion of cowpea (1:2 and 1:1) over 2:1 intercropping ratio might be due the fact that a legume has the ability to fix atmospheric N and recycle the soil P for the component crop. Besides, better soil health with higher proportion of legume in intercropping may enhance uptake of macro and micro nutrient thus nutrients play a critical role in enhancement of forage quality.

Tamta *et al.* (2019) found the nutrient yields of fodder maize and cowpea were influenced significantly by row ratios. The highest CP, EE and ash yield of maize and cowpea were reported under 2:1 and 1:2 row ratio, respectively. However, the total CP (14.98 q ha⁻¹) and ash yield (11.53 q ha⁻¹) were reported with 2:1 row ratio and EE (2.73 q ha⁻¹) under 1:2. The highest nutrient yields of maize and cowpea under 2:1 and

1:2 row ratio may be attributed due to higher proportion of maize and cowpea in respective treatments.

Chaudhary *et al.* (2020) laid out an experiment in randomized block design with eleven treatments *i.e.*, sole sorghum, sole pearl millet, sole cowpea, sorghum + cowpea, pearl millet + cowpea intercropping each with 1:1, 1:2, 2:1 and 2:2 row ratio with replication. They reported that quality parameter of cereal fodder was influenced by intercropping of cowpea because it is able to fix the atmospheric nitrogen, some part of which might have become available to cereal crop. The average crude protein (18.16 %) and ash content (15.89 %) were found significantly higher with minimum crude fibre content in sole cowpea. However, among the intercropping combination with different row ratio, intercropped of sorghum + cowpea and pearl millet + cowpea sown at 1:2 registered higher and comparable weighted average crude protein (12.37 %, 12.63 %) and weighted ash content (13.04 %, 13.19 %). While, 2:1 row ratio recorded the higher weighted fibre content (27.84 %, 27.64 %).

2.4 Effect of maize-based legume intercropping on soil status

Arya and Niranjana (1995) investigated the productivity of sorghum (*Sorghum bicolor*) as affected by legumes intercropping under different fertility system, they found that restoration of available N and K in the soil was more in the plot receiving FYM @ 12 t ha⁻¹ in a sorghum + legume intercropping system.

Geiler (2001) reported that symbiosis alone accounts for more than 20 % of global biological nitrogen fixation and has been calculated to contribute 45-50 mt of fixed N to agriculture each year.

Vesterager *et al.* (2008) studied the effects of cropping history and phosphorus source on yield and nitrogen fixation in sole and intercropped cowpea-maize systems. The results showed that intercropping maize and cowpea was beneficial on nitrogen poor soil.

Kumar and Faruqi (2009) conducted a field experiment to evaluate the production potential and economic of food-forage based cropping system. Apart from yield, they observed that groundnut + berseem + maize (F) + cowpea (F) intercropping

system recorded higher values of organic carbon (%), available nutrients like N, P (kg ha⁻¹) compared to initial value.

Dahmardeh *et al.* (2010) examined the effect of intercropping maize with cowpea on green forage yield and quality evaluation. In their research, they found that maize-cowpea intercropping increases the amount of nitrogen, phosphorus, and potassium contents associated to monocrop of maize.

Adeleke and Haruna (2012) mentioned that pulses intercropped with cereals and advance land productivity over soil amelioration. In the result of their findings revealed increase in total nitrogen after cropping any of the four legumes (soybean, cowpea, lablab and groundnut) and when the land was left fallow. And also revealed that higher cation exchange capacity (CEC) which plots that were previously cropped to legumes and had compared with the previous maize plot and fallow plots could be attributed to the leaf litter droppings which more or less serve as mulch and later decomposed to add nutrients to the soil.

Amos *et al.* (2012) reported that degraded and infertile soils are realized as a result of continuous monocropping and insufficient organic matter reprocessing coupled with occurrence of rainfall variability marked by common dry spells account for low crop yield. It was further noted that the understanding of the fact that maintenance and improvement of soil fertility cannot be exclusively through the use of predictable fertilizers. As a trait in legumes as cover crops, conservation involves minimum soil disturbance, permanent soil cover with living or dead plant resources, and diversified crop rotation and associated by legumes crops.

Ram (2015) found that guinea grass + *Stylosanthes seabrana* recorded significantly higher organic carbon (0.48 %) and available nitrogen (228 kg ha⁻¹) than other treatment with significantly higher available nutrient like P and K. However, available nitrogen, phosphorus and potash also significantly increased in hand weeding plots than weedy check.

2.5 Effect of maize-based legume intercropping on nutrients uptake

Kanakeri (1991) showed uptake of nitrogen with green gram (284 kg ha^{-1}) was significantly developed than with cowpea (239 kg ha^{-1}) and soybean (247 kg ha^{-1}) as intercrops, the nitrogen uptake was maximum in 1:1 row ratio (274 kg ha^{-1}) compared to 1:2 row ratio (251 kg ha^{-1}). Further, among different intercrops, cowpea noted maximum uptake of nitrogen (68 kg ha^{-1}), phosphorus (12 kg ha^{-1}) and potassium (18 kg ha^{-1}) followed by soybean with 60, 12 and 18 kg ha^{-1} NPK, respectively.

Li *et al.* (2001) reported that nitrogen acceptance by maize in an intercrop is greater as compared to sole cropping. And also, phosphorus achievement by soybean was significantly amplified by P application under intercropping and by intercropping below P application. The greater N acquisition by a non-legume crop intercropped with a legume is often reported in literature (Francis, 1986; Vandermeer, 1989; Stern, 1993). This may probably be due to the effect of competition. However, nitrogen attainment by soybeans was not significantly affected by intercropping.

Fusuo and Li (2003) showed that when peanut and maize raise together, phytosiderphore released from maize roots may mobilize Fe (III) and profit the iron nutrition of peanut plant. Hongchun *et al.* (2013) reported intercropping of peanut + maize is known to progress Fe nutrition in all peanut tissues. In peanut + maize intercropping, the secretion of phytosiderophores from maize in the intercrop arrangement may contribute to the improvement of Fe nutrition of the peanut. Enhancement in the Fe nutrition of peanut intercropped with maize was mainly caused by rhizosphere collaboration between peanut and maize (Zuo *et al.*, 2000).

Askegaard and Eriksen (2008) reported that legumes as a catch crop can reduce nitrate and K leaching and act not only as a N_2 fixing crop but also as a catch crop by taking up additional soil minerals N, P and K. These findings make legumes an important tool in the cropping systems where N and K are the major yield limiting factors.

Rusinamhodzi *et al.* (2012) reported that deficiencies of micro nutrients such as zinc, molybdenum and boron in the field may bound legume growth as well as

limit nitrogen fixation. The uptake of nitrogen, phosphorus, potassium by maize was found to reduced significantly due to intercropping (263, 13 and 138 NPK kg ha⁻¹) as against sole cropping (305, 16 and 188 NPK kg ha⁻¹).

Yadav (2022a) reported that different planting ratios had significant impact on macro nutrients (N, P and K) content of fodder maize. However, macro nutrients content of cowpea fodder did not vary significantly among the planting ratios. Maize planted under 1M + 1C intercropping ratios noted higher N (10.2 %), P (7.7 %) and K (5.9 %) compared with sole maize. However, maize and cowpea grown under 2M + 1C row ratio recorded statistically similar content of N and K with that of intercropped in 1M + 1C ratio.

Yadav (2022a) study the nutrient uptake of fodder maize and cowpea as influenced by different planting ratios. They found that sole maize recorded the highest uptake of N (169.3 kg ha⁻¹), P (27.23 kg ha⁻¹) and K (147.1 kg ha⁻¹), then in M + C @ 2:1 row ratio (N- 136.5 kg ha⁻¹, P- 21.26 kg ha⁻¹ and K- 114.0 kg ha⁻¹). However, the sole cowpea recorded the highest uptake of N (169.1 kg ha⁻¹), P (21.21 kg ha⁻¹) and K (61.5 kg ha⁻¹) and it was followed by M + C planted under 1:1 row ratio. Among the planting ratios, 1M + 1C row ratio recorded the highest total uptake of nitrogen (203.7 kg ha⁻¹) and phosphorus (29.37). While, sole maize recorded the highest K uptake (133.5 kg ha⁻¹) compared to sole crop, 1M + 1C and 2M + 1C ratios respectively.

2.6 Effect of maize-based legume intercropping on economic feasibility

Allen and Obura (1983) said that LER indicates the efficiency of using land area, but time factor is not considered for which the crop occupies the land area. To rectify the limitation of the LER, the concept of area time equivalent ratio (ATER) has been developed considering the occupancy of land by the crops for certain periods. In maize + cowpea or soybean intercropping system, the yield advantages ranged from 22 to 32 % based on LER method 19 to 25 % based on ATER method over sole crops and thus LER productivity estimates were greater than that of ATER.

Gardner and Kisakye (1990) reported that the higher ATER (1.38) was observed in the maize-*Phaseolus vulgaris* in 1:2 row ratio than *Phaseolus vulgaris* and maize grown as sole crops.

Halikatti and Banarasilal (2011) conducted an experiment to investigate the production potentiality of maize as influenced by planting geometry, mulching and grain legume intercropping. Among the intercropping systems, one row of black gram followed by two rows of black gram between maize pairs recorded higher ATER value (1.18) compared to all other intercrop.

Pandita *et al.* (2000) reported that maize and *Phaseolus vulgaris* at 1:2 row ratio gave the maximum ATER (1.48) with highest maize equivalent yield (78.8 q ha⁻¹). Mohan (2003) recorded higher ATER value (1.65) with two rows of rice bean between maize spaced at 90 cm followed by two rows of soybean (1.63) and french bean (1.51) compared to other cropping systems.

Zaman and Malik (2000) reported that various intercropping systems had lower yield of both the component crops than sole crops but the income ha⁻¹ was increased due to intercropping. Maximum monetary benefits (B:C ratio 3.03) were obtained from maize intercropped with rows of rice bean in 1:2 followed by 1:1 over sole cropping.

Patel and Rajagopal (2001) observed that maize + cowpea with row ratio of 5:2 recorded significantly higher green forage yield and net return during both the year and this treatment was remained at par with maize + cowpea (4:2). Gross return and LER higher value were in maize + cowpea with row ratio of 4:2 and maize + cluster bean with row ratio of 3:3.

Kumar *et al.* (2005) observed that maize + cowpea (2:2) recorded significantly higher green fodder yield, gross and net income with higher values of B:C ratio, LER and monetary advantage. Singh *et al.* (2005) observed that sorghum + cowpea (2:1) registered significantly higher per day productivity, net profit, per day return with higher value in B:C ratio.

Verma *et al.* (2005) reported that intercropping of cereals with legume appears to be feasible approaches for increasing the herbage yield utilization of land efficiently and providing stability to production. In their research, they found that intercropping of fodder sorghum in narrow row space of pigeon pea with a row ratio of 1:2 recorded the highest pigeon pea equivalent yield (34.36 q ha^{-1}), net returns ($\text{₹ } 30179/\text{ha}^{-1}$), benefit: cost ratio (4.96), aggressivity index (0.533), area time equivalent ratio (1.21), land ratio (1.583) and relative crowding coefficient (15.07).

Sharma (2008) observed that pearl millet + cluster bean (2:2) resulted into significantly higher green fodder yield (t ha^{-1}) with higher values of net return, B:C ratio and LER.

Sharma *et al.* 2008 reported that intercropping of maize with legumes at all proportions give more advantageous than monoculture. They recorded the highest net returns, B:C ratio and LER from maize + cowpea at 2:2 row proportion followed by maize + rice bean (2:2) compared with others treatment. Similarly, the highest land equivalent ratio and relative crowding co-efficient was observed in maize + cowpea followed by maize + rice bean at 2:2 rows proportion. The association maize with cluster bean gave lower net return than others. And also, maize + cluster bean row proportion of 1:1 recorded the lowest profitability, land equivalent ratio and relative crowding coefficient. Among the component crops, maize was more competitive and aggressive than legumes intercrop. However, intercropping of maize with cowpea and rice bean at 2:1 row proportion was found to be compatible intercropping system which recorded lower values of competition ratio and aggressivity.

Kumar and Faruqui (2009) reported that groundnut + berseem + maize (F) + cowpea (F) produced significantly higher forage equivalent yield ($\text{t ha}^{-1} \text{ year}^{-1}$) with higher values of net return and B:C ratio.

Jakhar *et al.* (2009) reported that treatment lucerne + chicory (1:2 row ratio) at 15 cm spacing recorded significantly higher green forage yield with higher values of gross return, net return and B:C ratio.

Surve *et al.* (2011) showed the significantly effect of cereal + legume intercropping on gross returns, net returns, B:C ratio and LER of sorghum + cowpea and maize + cowpea under different row ratio. They reported that sorghum + cowpea under 2:1 row ratio recorded maximum land equivalent ratio (1.51), gross (₹ 60744/- ha⁻¹) and net return (₹ 50031/- ha⁻¹) along with higher benefit:cost ratio (5.67) followed by sorghum + cowpea at 1:1 and 1:2 row ratio which record higher and comparable gross returns, net returns and B:C ratio than the remaining treatments.

Eskandari (2012) showed that intercropping systems had a significant effect on environmental resources consumption, where intercropping systems had more light interception and water and nutrient uptake and compared to sole crops suggesting the complimentary effect of intercropping components in resources consumption. They observed that LER was higher than one in all of the mixtures which indicated a yield advantage over sole crops. The highest LER values were obtained from intercrops of maize with cowpea and mungbean in additive designs.

Deore *et al.* (2013) investigated the production potential of forage maize and cowpea intercropping under different row ratio. They observed that maize + cowpea (2:1) registered higher value of net return (₹ 31599/- ha⁻¹) and B:C ratio (3.3) followed by 1:1 and 1:2 row ratio. While the lowest net return (₹ 14142/- ha⁻¹) and B:C ratio (2.1) was recorded from sole cowpea followed by sole maize.

Ram and Meena (2014) observed that intercropping of pearl millet with mungbean in 1:7, followed by 2:6 and 1:3 row ratio produced maximum pearl millet equivalent yield (PMEY), land equivalent ratio (LER), aggressivity, net returns, benefit cost (B:C) ratio and also better nutrient uptake by these treatments compared to sole and other intercropping treatments. Aggressivity values showed that inter crop mungbean did not offer any competition to pearl millet in different row ratio, while relative crowding coefficient (RCC) values indicated was a yield disadvantage in mungbean in all the intercropping system except 1:7 row ratio.

Dhonde *et al.* (2016) carried out a field experiment during *Kharif* 2013 at the Agronomy Farm, College of Agriculture, Kolhapur on sandy clay loam soil with

different row ratio of maize-cowpea fodders under sole and intercropping systems. They reported that intercropping of maize with cowpea in a row ratio of 2:2 recorded maximum land equivalent ratio (1.15), gross returns (₹ 84804/- ha⁻¹), net returns (₹ 39,985/- ha⁻¹) and higher B:C ratio (1.89).

Jan *et al.* (2016) reported beneficial ATER values of 1.51 with maize-black cowpea intercropped in 2:2 row ratio. Similarly, Maize + soybean in row ratio of 2:6 recorded beneficial ATER values of 1.32 (Yogesh *et al.*, 2014). Likewise, Khoroar and Patra (2013); Choudhary (2014) observed beneficial ATER values of 1.37 and 1.47 in maize + black gram intercropped in 1:2 ratio.

Bhagat *et al.* (2017) conducted a field experiment to study the production potential and economics of fodder maize intercropping with cowpea at the Research Farm of Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu. The highest fodder maize green biomass yield (293.84 q ha⁻¹) and dry biomass yield (72.01 q ha⁻¹), net returns (₹ 37383/- ha⁻¹) and B:C (2.41) ratio was recorded with maize intercropped with cowpea in 2:1 row ratio. Fodder maize intercropped with cowpea in 2:1 row ratio was found best for increasing yield potential and economics of fodder maize in different intercropping systems.

Ganvit *et al.* (2018) reported that there was a significantly effect of oat + lucerne intercropping on forage production. Among the treatments, intercropping of oat + lucerne at 2:1 row proportion produced the maximum land equivalent ratio (1.44) gross returns (₹ 1,98,225/- ha⁻¹), net returns (₹ 1,66,341/- ha⁻¹) and B:C ratio (6.22).

Mishra (2019) observed that total Land Equivalent Ratio (LER) is found to be 1.24 which is 24 % of yield advantageous over sole crop. The maximum and minimum cost of cultivation was recorded in sole maize and sole cowpea. The highest net return (₹ 26117/- ha⁻¹) and B:C ratio (1.83) was recorded in intercropping of maize + cowpea (1:1) over sole maize and sole cowpea.

Mishra (2019) performed the frontline demonstration to promoted the intercropping of maize + cowpea as fodder in 1:1 row ratio, during *kharif* season at Ganjam District under East and south eastern coastal plain zone of Odhisa. The

intercropping of maize + cowpea in 1:1 row ratio recorded maximum cost of cultivation (₹ 42517/- ha⁻¹), net return (₹ 26117/- ha⁻¹), B:C ratio (1.83) 1.24 % and total land equivalent ratio, which is 24 % yield advantageous over sole crop. While the lowest cost of cultivation, net return and B:C ratio was recorded from Sole maize and sole cowpea.

Ginwal *et al.* (2019a) conducted a field study to evaluate the fodder productivity and economics of maize with legumes under varying intercropping combinations. Among the treatments, the highest net income (₹ 38747.27/- ha⁻¹) and B:C ratio (1.78) was recorded from maize + cowpea (2:1) followed by (₹ 37724.21/- ha⁻¹ and B:C 1.74) in maize + cowpea (1:1) intercropping combinations.

Choudhary *et al.* (2020) studied the fodder quality and economics of cereal-legumes intercropping under different row ratio. In their research, they recorded the highest gross returns (₹ 79731/- ha⁻¹), net returns (₹ 55597/- ha⁻¹) and B:C ratio (2.3) was obtained under 2:1 row ratio intercropping of sorghum + cowpea which was significantly higher than all other treatment.

Dudge *et al.* (2022) conducted a field experiment during the *rabi* season of 2019-20 at Agronomy Farm of College of Agriculture, Dapoli, district with an objective to quantify the effect of row proportion of fodder maize and fodder cowpea on growth, quality, yield and economics. The investigation revealed that intercropping of maize with cowpea at 4:2 row ratio recorded the highest land equivalent ratio (1.35), relative yield total (0.676), maize equivalent yield (346.31 q ha⁻¹), relative yield and relative crowding coefficient (4.53) over all other intercropping treatments. And 4:1 row ratio recorded highest competitive ratio (5.15) and aggressiveness index (4.51). Most of the cowpea values of aggressiveness index were negative which indicated dominance of maize. The study concluded that values of most of the intercropping indices were highest for 4:2 row proportion and hence, it will be most advantageous in terms of land utilization and net yield.

2.7 Effect of nutrient management on growth of maize-based legume intercropping

Ayub *et al.* (2002) conducted the field experiment to evaluate the effect of different level combination of nitrogen and phosphorus levels on growth parameters of fodder maize. Nitrogen and phosphorus were given at the rate of 0-0, 120-40, 120-60, 120-80, 160-40, 160-60, 160-80, 200-40, 200-60 and 200-80 kg ha⁻¹. They reported that with increase in the application of N&P fertilizers, the growth parameters were found to be significant. The highest plant height (198.8 cm), stem diameter (1.58 cm) and leaf area plant⁻¹ (4218 cm²) was recorded the treatment receiving 200-80 kg ha⁻¹N:P.

Ayub *et al.* (2003a) carried out the field trial to study the effect of 0, 80 and 120 N kg ha⁻¹ on growth of fodder maize (*Zea mays* L.). They reported that plant height, leaf area plant⁻¹, leaf number, stem diameter was increased significantly with each increment of nitrogen dose. The highest plant height (186.96 cm), leaves plant⁻¹ (12.40), leaves area (4792 cm²) and stem diameter (1.25 cm) were observed from application of N by 120 kg N ha⁻¹ and least growth parameters was observed from control.

Ali *et al.* (2012) conducted the field experiment to study the effect of different levels of nitrogen on growth of fodder maize. They observed that treatment receiving 180 kg N ha⁻¹ record the maximum stem diameter (1.43 cm), leaf area (2806 cm² and plant height (117.8 cm) than control.

Iran, Valdabadi and Farahani (2010) studied the effect of physiological growth indices in maize under nitrogenous application. They concluded that application of nitrogen substance on fodder maize had significant effect on total dry weight (TDW) and crop growth rate (CGR). The highest LAI (4.2), TDW (1910 g m⁻²), CGR (31.2 g g⁻¹ m⁻² day⁻¹) and RGR (0.08 g g⁻¹ day⁻¹) were obtained by the application of 520 kg urea ha⁻¹.

Khan *et al.* (2014) studied the response of fodder maize to various levels of nitrogen. The research results showed that plant growth parameters were significantly influenced by different levels of nitrogen. The higher value of the data indicated that higher plant height (120.8 cm), numbers of leaves plant⁻¹ (12) and leaf area plant⁻¹

(348.8 cm²) was recorded when nitrogen was applied at the rate of 180 kg N ha⁻¹ followed by 150 kg N ha⁻¹ with plant height (119.6 cm) numbers of leaves plant⁻¹ (9.8), leaf area plant⁻¹ (308.9 cm²). While, nitrogen application at 90 kg ha⁻¹ recorded the lowest plant height (78.3 cm) and number of leaves plant⁻¹ (8.5).

Amanullah *et al.* (2015) conducted a field experiment at New Developmental Research Farm of Khyber Pakhtunkhwa (KPK) to study N effect on growth, dry matter partitioning and grain yield of maize. They revealed that growth, dry matter partitioning responded positively to N fertilization, but the magnitude of response varied with level of N application. Days to tasselling, silking and physiological maturity delayed, plant height and mean single leaf area was increased with increase in N levels. Similarly, dry matter partitioning in stem, leaf, ear, and grains was increased with an increase in N levels and decreased in the control plots.

Jena *et al.* (2015) reported the higher plant height of the plant (185.95 cm) and higher leaf area index (3.17) were recorded from applying of 100 kg phosphorus ha⁻¹.

Rihab *et al.* (2015) conducted a field experiment and explained the effect of different nitrogen level (0 kg ha⁻¹, 54.7 kg ha⁻¹ and 109.5 kg ha⁻¹) on fresh weight plant⁻¹ of maize. The observation was done at 45 DAS, 60 DAS and 75 DAS. During the investigation, they observed that a treatment receiving higher dose of nitrogen (109.5 kg N ha⁻¹) recorded significantly higher fresh weight (45 DAS- 41 g plant⁻¹, 60 DAS- 75.06 g plant⁻¹ and 75 DAS- 116.16 g plant⁻¹) of fodder maize in all the three stages of observations.

Kumar *et al.* (2017) carried out an experiment to explore the possibility of cutting down the amount of nitrogen in maize under maize + urdbean intercropping system. The nitrogen was applied at 100 % recommended fertilizer dose (120 kg N ha⁻¹) and 75 % recommended fertilizer dose (90 kg N ha⁻¹). They observed that application of nitrogen doses at 100 % recommended nitrogen recorded significantly higher plant height (159.8 cm), leaf area (3157 cm² plant⁻¹), cob length (14.7 cm), number of grains row⁻¹ (34.9) and number of grains cob⁻¹ (483.5) than 75 % recommended fertilizer dose.

Kumar *et al.* (2017) reported that all the growth stages, more shoot dry matter accumulation plant⁻¹ was noted higher at 100 % recommended dose of nitrogen that was significantly superior to 75 % recommended dose. Application of 100 % recommended nitrogen dose increased shoot dry matter accumulation by 11.9, 8.6, 10.8 and 18.89 % at 30, 45, 60 DAS and at harvest stage over 75 % recommended dose, respectively.

Kumar *et al.* (2018) conducted a field experiment in the research farm faculty of Agricultural Science, Janta Mahavidyalaya Ajeetmal, Auraiya, to evaluate the effect of various levels of nitrogen on growth of fodder maize. The growth parameters were found to be increased with increasing levels of nitrogen. Among the treatments, plant height (209.66 cm), stem diameter (1.32 cm), leaf area (4207.47 cm²) and fresh weight (353.01 g plant⁻¹) was recorded from the T₃ (150 kg ha⁻¹) while numbers of leaves plant⁻¹ (13.37) were recorded from T₁ (50 kg ha⁻¹).

Pragya and Bhambri (2017) conducted a field experiment during the kharif season of 2014 and 2015 at the Indira Gandhi Krishi Vishwavidyalaya, Raipur. And their objectives were to find out the appropriate crop arrangement and nutrient management for maize and soybean intercropping system. They observed that higher fertilizer dose application showed positive results on growth and so on yield. All the growth attributing characters of maize showed increasing trend when fertilizer dose was increased from 50 % RDF to 125 % RDF.

Pragya and Bhambri (2017) studied field experiment to find out the nutrient management for maize and soybean intercropping system. They reported that a general trend of decrease in CGR followed by a plateau was observed except in case of highest fertility level (F₁). Treatment receiving 125 % RDF (F₁) recorded an increase up to flowering phase (60 DAS) and then showed a rapid decrease till harvest. The effects of nutrient levels were clear on CGR values as 125 % RDF showed the highest rate of crop growth whereas 50 % RDF showed the lowest rate.

Takele *et al.* (2017) reported the significant effect of increasing nitrogen fertilizer effect on days to physiological maturity where plants in a control treatment

matured early, while plants at the highest N rates matured lately. Their research result showed that maximum (150.3) days to reach maturity was recorded from 92 kg N ha⁻¹ whereas, the minimum (142.7) days to reach DPM was recorded for the control treatment.

Pual *et al.* (2019) conducted the field trial on fodder maize with different levels of nitrogen. They reported that nitrogen application had a significant effect on growth parameters of fodder maize. The tallest plant height (204.9 cm) and higher number of leaves plant⁻¹ (12.22) were recorded from a treatment receiving 200 kg nitrogen ha⁻¹.

Subrahmanya *et al.* (2019) conducted a field experiment to study the influence of fertility levels on growth parameters of fodder maize. The treatment consisting of five levels of nutrient *i.e.*, 0, 59, 75, 100 and 125 % RD of nitrogen and phosphorus. The recommended dose nitrogen and phosphorus were 120:60 kg ha⁻¹. They proposed that nutrient level have a significant impact on growth parameters of maize. The growth parameter was increased with increasing in nutrient levels. Among the treatments, higher plant height (280.92 cm), leaf length (118.10 cm), leaf width (9.11 cm) and number of leaves plant⁻¹ (17.13) were obtained from applying of 125 % RDF of nitrogen and phosphorus.

Shams and Lamloom (2020) studied the effect of three nitrogen levels (100, 120 and 140 kg N fed⁻¹) on maize and cowpea intercropping system at Sids Agricultural Research Station, Agricultural Research Centre (ARC), Beni-Sweif governorate Egypt. They observed that application of 140 Kg N fed⁻¹ produced the highest values of maize plant height (236 cm), leaf area index (6.28), number of ears plant⁻¹ (1.52), ear length (23.31 cm) and cowpea plant height (118.2 cm) and number of branches plant⁻¹ (3.98).

Pal and Kamboj (2021) carried out a field experiment to study the effect of three level of nitrogen (90, 120 and 150 kg ha⁻¹) on growth of maize. They reported that application of nitrogen 150 kg N ha⁻¹ produced higher plant height (120.6 cm), number of leaves plant⁻¹ (11) followed by 120 kg N ha⁻¹ and the least plant height (78.3 cm) and number of leaves plant⁻¹ (8) was recorded from application of N by 90 kg ha⁻¹.

Krishna (2022a) studied the effect of nutrient management on growth parameters of African tall fodder maize variety. The results showed that treatment receiving 100 % RDF of NKP (120:60:40) recorded the highest number of leaves plant⁻¹ (12.4), plant height (263.0 cm), leaf length (93.1 cm) and leaf width (8.0 cm).

Kumar *et al.* (2024) conducted a field experiment on fodder maize (*Zea mays*) growth as influenced by foliar application of nano urea and urea under varying levels of nitrogen at Zonal Agricultural Research Station, V.C. Farm, Mandya, Karnataka. The treatment consisting of different levels of nitrogen (50, 75 and 100 % RDF) along with foliar application of nano urea (0.2 % and 0.4 %). The growth parameters were recorded at two stages *i.e.*, 20, 40, 60 DAS and at harvest. The application of 100 % RDF N + 2 % spray recorded significantly highest growth parameters *i.e.*, leaf:stem ratio and SPAD reading at both 40 DAS and harvest and growth indices like leaf area index, absolute growth rate and crop growth rate at both 20-40 DAS and 60-harvest.

2.8 Effect of nutrient management on yield of maize-based legume intercropping

Ayub *et al.* (2002) evaluated the effect of different combination of nitrogen and phosphorus on yield of fodder maize. The nitrogen and phosphorus were given at the rate of 0-0, 120-40, 120-60, 120-80, 160-40, 160-60, 160-80, 200-40, 200-60 and 200-80 kg ha⁻¹. The nutrient combination had a significant influenced on yield parameters of fodder yield. They recorded the highest green fodder yield (55.59 t ha⁻¹) and dry fodder yield (21.39 t ha⁻¹) from T₁₀ (200-80 kg ha⁻¹ N&K).

Patel and Rajagopal (2002) performed the experiment on sorghum with cowpea forage in intercropping at the Farm of the College of Veterinary Sciences, Madhya Pradesh. From the study, they revealed that intercropping of sorghum + cowpea in 4:3 row ratio with 50 + 50 kg N ha⁻¹ was found better for higher fodder yield and LER net profit.

Ayub *et al.* (2003a) conducted the field trial to study the effect of 0, 80 and 120 N kg ha⁻¹ on fodder yield of maize (*Zea mays* L.). They reported that nitrogen application had significantly increased the yield. They observed that application of N

by 120 kg N ha⁻¹ recorded the highest green fodder yield (57.52 t ha⁻¹) and dry matter (22.29 %) than control treatment.

Ali *et al.* (2012) studied the growth of rainfed fodder maize under different levels of nitrogen. In experiment maize variety Sargodha-2002 was sown in randomized complete block design (factorial) and was fertilized with four each nitrogen @ 0, 60, 120 and 180 kg ha⁻¹ doses. In their research significant increase in green fodder and dry matter yield was observed with the increased doses of nitrogen. Overall, the nitrogen application @ 180 kg ha⁻¹ recorded the maximum green fodder yield (27.96 t ha⁻¹), dry matter yield (6.65 t ha⁻¹) and dry matter content (21.65 %).

Wayasa *et al.* (2011) were conducted experiments to study the effect of nitrogen management on yield attributes and grain yield of hybrid maize. They reported that different nitrogen levels (100, 150 and 200 kg ha⁻¹) had significantly influenced the maize yield and yield components. Significantly, the highest grains weight per cob, 1000-grain weight and grain yield were recorded with 200 kg ha⁻¹ nitrogen application. Maize yield with 200 kg ha⁻¹ nitrogen application was 17 % and 8.50 % higher than 100 and 150 kg ha⁻¹ nitrogen application, respectively.

Iqbal *et al.* (2014) conducted research trial to examine the comparative efficacy of organic and inorganic sources of nitrogen fertilizers alone and in different combinations on the yield and quality contributing parameters of forage maize (*Zea mays* L.). They recorded the maximum green forage yield (47.51 t ha⁻¹), dry matter yield (10.36 t ha⁻¹) and crude protein (8.63 %) from treatment receiving 100 % recommended dose of nitrogen from urea, which were statistically at par with 75 % nitrogen from urea + 25 % nitrogen from poultry manure.

Jat *et al.* (2014) conducted the field experiments to study the effect of integrated nitrogen management (INM) and intercropping systems on yield attributes and yield of maize during *kharif* seasons of year 2009 and 2010 at KVK, Chamu, Jaipur (Rajasthan). The treatments included cropping patterns *viz.*, sole maize, maize + one row mung bean, maize + two row mung bean and sole mung bean and integrated nitrogen management *i.e.*, control, 60 kg N ha⁻¹, 60 kg N ha⁻¹ + biofertilizer (*Rhizobium*

+ *Azospirillum* + PSB), 120 kg N ha⁻¹, 120 kg N ha⁻¹ + bio-fertilizer (*Rhizobium* + *Azospirillum* + PSB) and biofertilizer (*Rhizobium* + *Azospirillum* + PSB). They reported the maximum grain and stover yield was obtained with application of 120 kg N ha⁻¹ + biofertilizers (4141 kg and 4433 kg ha⁻¹ grain and 6915 and 7166 kg ha⁻¹ stover) which was significantly higher compared to other treatments but remained at par with 120 kg N ha⁻¹ (4062 kg ha⁻¹ and 4340 kg ha⁻¹ grain and 6831 kg ha⁻¹ and 7076 kg ha⁻¹ stover) in both the year.

Jat *et al.* (2014) studied the integrated nitrogen management and intercropping systems on yield attributes and yield of maize. Their research results revealed that integrated nitrogen management significantly affected yield attributes and yield of maize in both the years of experimentation. They recorded that application of 120 kg N ha⁻¹ + biofertilizers (*Rhizobium* + *Azospirillum* + PSB) produced maximum number of cobs plants⁻¹, number of grains cobs⁻¹, cob length, 1000 grains weight.

Khan *et al.* (2014) carried the field trials at Agricultural Research Farm of Agricultural University Peshawar (Ameer Mohammad Khan Campus Mardan) during *kharif* season in 2012. The objective was to investigate the response of maize variety (Jalal) to four nitrogen rates (90, 120, 150 and 180 kg ha⁻¹) for agronomical traits. They observed that green fodder yield and dry fodder yield was increased significantly with each increment of nitrogen dose. The highest green fodder yield (23111 kg ha⁻¹) and dry fodder yield (10611 kg ha⁻¹) of maize was recorded from the application of N @ 180 kg ha⁻¹ and the lowest yield was observed from control (0 kg N ha⁻¹).

Kumari *et al.* (2014) studied the four N levels (0, 50, 100 and 125 % recommended dose of N on fodder oat. The experiment was laid down in a factorial RBD to find out the effect on green fodder yield of oats. They revealed that application of 100 % recommended dose (150 kg ha⁻¹) of N (RDN) significantly increased the yield of oats green fodder yield (90.1 t ha⁻¹) and dry matter yield (11.37 t ha⁻¹).

Amanullah *et al.* (2015) studied the effect of N level yield of maize. In their research they recorded the heaviest thousand grains weight when both N were applied at the highest rates. The highest grain yield (3122 kg ha⁻¹) and harvest index (27.8 %)

was obtained in the plots where N was applied @ 160 kg ha⁻¹, while control recorded the minimum grain yield (2039 kg ha⁻¹).

Jena *et al.* (2015) proposed that higher dry matter production (10572 kg ha⁻¹) was obtained by the application of 100 kg phosphorus ha⁻¹.

Usman *et al.* (2015) conducted field experiments at the teaching and research farm, University of Agriculture, Makurdi to determine the effect of three levels of NPK fertilizers (0, 150 and 300 kg ha⁻¹ of NPK 20:10:10) on growth parameters and yield of maize-soybean intercrop. From their results, it showed that application of fertilizer significantly ($p < 0.05$) increased the growth parameters and yield of the component crops in both seasons. Increasing the quantity of NPK fertilizer resulted in significant increase in the yield and growth parameters of maize and soybean in both years.

Asangla and Gohain (2016) studied the effect of fodder yield and quality attributes of maize (*Zea mays* L.) + cowpea (*Vigna unguiculata* L.) intercropping and different nitrogen levels. They reported that various nitrogen levels showed significant differences in the total fresh forage yield and total dry matter yield of the intercrops in both years of study. The highest total fresh yield (54.54 t ha⁻¹) and total dry matter (16.07 t ha⁻¹) was recorded from the treatment receiving 120 kg N ha⁻¹.

Hembram and Kundu (2016) conducted the experiment to study the integrated nutrient management on growth, yield and quality of rice bean-oat-moong sequence. They reported that treatment consisting of GM + 25 % N FYM + 50 % NPK inorganic resulted higher green forage yield (297.00 q ha⁻¹), dry matter weight (56.78 q ha⁻¹), crude protein (16.85 %) and crude protein yield (8.985 q ha⁻¹) in rice bean. In oat, higher green forage yield (376.00 q ha⁻¹), dry matter yield (62.125 q ha⁻¹) was recorded with the application of GM + 25 % N FYM + 50 % NPK inorganic.

Kanduri *et al.* (2016) studied the effect of different combination of nitrogen levels on the fodder yield of African tall maize fodder. Nitrogen fertilizers at the rate of 0, 100, 120 and 160 kg ha⁻¹ was applied. From the experiments they observed that green fodder yield and dry matter percentage were influenced significantly by the application

of nitrogen. Among the treatments, the maximum green fodder yield (44.97 t ha^{-1}) and dry matter percentage (22.3 %) was obtained at nitrogen level of 160 kg ha^{-1} .

Arshad (2017) studied the effect of intercropping and nitrogen dose on performance of maize-mungbean cropping systems. He reported that Grain yield of maize (7.2 t ha^{-1}) was increased successively with increasing N levels. However, effect was noticeable only when N dose was increased from 56 to 113 kg ha^{-1} . Nutritional parameters ($P \leq 0.5$) were greater for intercropping compared to sole cropping of maize. Despite a substantial reduction ($P \leq 0.5$) in growth and yield components of mungbean in intercropped situation, its contribution to overall production led to increased LER (1.9) of the intercropping system over sole cropping of maize

Kumar *et al.* (2017) carried out the experiment to study the effect of nitrogen in maize under maize + urdbean intercropping system. The nitrogen was applied at 100 % recommended fertilizer dose (120 kg ha^{-1}) and 75 % recommended fertilizer dose (90 kg ha^{-1}). From their results it was found that nutrient content *i.e.*, N:P:K in maize grain, maize stover as well as urdbean grain and urdbean straw did not differ significantly between the nitrogen application doses.

Kumar *et al.* (2017) conducted the studies of nitrogen management in maize-based legume intercropping system. They reported that application of 100 % (120 kg ha^{-1}) recommended nitrogen dose yielded significantly higher grain yield (3.72 t ha^{-1}), stover yield (6.76 t ha^{-1}) and biological yield (12.32 t ha^{-1}) than 75 % (90 kg ha^{-1}) recommended dose.

Naik *et al.* (2017) carried the field experiment that were consisted of five system treatments (sole maize at $60 \text{ cm} \times 20 \text{ cm}$ sowing, sole maize in skipped row sowing, maize in skipped row + green gram, maize in skipped row + black gram and maize in skipped row + cluster bean) and three nitrogen doses (100, 75 and 50 % recommended dose of nitrogen). They reported that yield attributes and grain yield of maize were maximum with sole maize at $60 \text{ cm} \times 20 \text{ cm}$ spacing but at par with maize + cluster bean, maize + black gram and maize + green gram intercropping system. The lowest parameters were observed with sole maize sown in skipped rows. The results

revealed that all the parameters were maximum with the application of 100 % recommended dose of nitrogen to maize, but comparable with that of 75 %. The maize equivalent yield, land equivalent ratio and benefit cost ratio were higher with maize + cluster bean intercropping as compared to other treatments. The result revealed that among the different maize intercropping systems tested, maize in skipped rows + cluster bean with 75 % recommended dose of nitrogen to maize was found economically profitable.

Naik *et al.* (2017) conducted the field experiment to find out the response of optimum nitrogen rate in maize with legume intercropping system. Their experiment results revealed that application of recommended dose of nitrogen (100 per cent) to maize resulted in highest grain (3838 kg ha⁻¹) and stover yield (5809 kg ha⁻¹) which was comparable with that of 75 % recommended dose of nitrogen application. Significantly lowest yield of grain (3055 kg ha⁻¹) and stover (4984 kg ha⁻¹) was recorded when 50 % recommended dose of nitrogen applied to maize.

Naik *et al.* (2017) reported that yield attributes and yield of three intercrops viz., green gram, black gram and cluster bean were highest with respective sole crops maize followed by application of 100, 75 and 50 % recommended dose of nitrogen to maize in the order of descent. However, when the nitrogen level to maize was gradually decreased the yield attributes and yield of intercropped legumes was also found decreased. Green gram, black gram and cluster bean suffered yield reduction to the extent of 4.0, 4.2, 7.3 and 8.1, 5.3, 8.8 % with the application of 75 and 50 % nitrogen recommended dose to maize. This shows that legumes are capable to extend their positive effect at low fertility levels in association with non-legumes.

Malunga *et al.* (2017) conducted the field experiments to study the effect of mineral nitrogen and legume intercrops on maize (*Zea mays* L.) nitrogen uptake, nutrient use efficiency and yields at Chitedze Agricultural Research Station in Lilongwe and Makoka Agricultural Research Station in Zomba during the 2016-17 growing season. The treatment consists of main plots *i.e.*, sole maize, sole bean, sole cowpea, bean-maize and cowpea-maize intercrop systems and sub plots were N fertilizer rates (0, 52.5, 78.75 and 105 kg N ha⁻¹), applied as urea. The research results showed that

application of N increased maize N uptake and grain yield. However, NUE decreased with increasing N fertilizer rate. They recorded the highest maize grain yield (6.25 mt ha⁻¹) in maize + cowpea intercropping system which received 105 kg N ha⁻¹. While the highest NUE (48.63 %) was observed from sole maize with 78.75 kg N ha⁻¹.

Malunga *et al.* (2017) studied the effect of mineral nitrogen and legume intercrops on maize (*Zea mays*). In the research, they revealed that increase in nitrogen dose increases the yield of maize. Intercropping of maize + cowpea receiving 105 kg N ha⁻¹ recorded the highest maize grain yield (6.71 mt ha⁻¹). While treatment N₀ (0 kg N ha⁻¹) recorded the lowest yield (1.27 mt ha⁻¹).

Kumar *et al.* (2018) reported that nitrogen has a significant effect on quality parameters of fodder maize. The quality data was increased with increasing the nitrogen level. The highest crude protein (9.14 %) and crude fibre (30.997 %) were recorded from treatment T₅ (150 kg ha⁻¹) and followed by T₂ (100 kg ha⁻¹).

Subrahmanya, *et al.* (2019) conducted the field experiment to evaluate the influence of fertility levels on yield of fodder maize. The treatment consisting of five levels of nutrient *i.e.*, 0, 59, 75, 100 and 125 % RD of nitrogen and phosphorus. The plot was treated with nitrogen and phosphorus at the rate of 0 kg ha⁻¹, 60:30 kg ha⁻¹, 90:45 kg ha⁻¹, 120:60 kg ha⁻¹ and 150:75 kg ha⁻¹. The highest green fodder yield (637.00 q ha⁻¹), dry matter yield (140.98 q ha⁻¹), B:C ratio (1.68), net return (₹ 59453.1/- ha⁻¹) and cost of cultivation (₹ 35285.00/- ha⁻¹) was obtained from a plot treated with 150:75 kg NP ha⁻¹.

Tamta *et al.* (2019) were observed significantly higher total green fodder yield (622.51 q ha⁻¹) and green fodder yield (485.86 q ha⁻¹) of maize with application of 120 kg N ha⁻¹, then at 90 kg N ha⁻¹ and the minimum were obtained in control. However, in case of cowpea, application of N up to 30 kg ha⁻¹ significantly increased the green fodder yield and further increase in dose of nitrogen were produced statistically similar fodder yield. The higher availability of N resulted into greater plant growth which may attribute to higher green fodder yield under higher level of N over

control. Our results of higher green fodder yield with enhanced level of N are in close agreement with the outcome of Ayub *et al.* 2002.

Pual *et al.* (2019) conduct the field trial to studied the effect of different levels of nitrogen on yield fodder maize. They reported that yield of fodder crop was significantly affected by nitrogen application. The higher forage yield (70.389 t ha^{-1}) of fodder maize was recorded in applying of $200 \text{ kg nitrogen ha}^{-1}$.

Youssef (2019) aimed to investigate the effect of different levels of nitrogen fertilization on forage yields and quality of hairy vetch (*Vicia villosa*, roth) - triticale (*Xtritcosecale*, witmack) mixtures. Nitrogen application induced an increase in dry matter yield from 7.6 to 9 t DM ha^{-1} obtained with 30 kg N ha^{-1} . This rate corresponds to the most efficient nitrogen rate as expressed by kg DM kg^{-1} of added N. It reached a mean value of $47 \text{ kg DM kg}^{-1} \text{ N}$. Moreover, application of increasing nitrogen rate caused an increase in LER (Land Equivalent Ratio) of the mixture over the unit ($\text{LER}=1.58$ at 30 kg N ha^{-1}). Crude protein content has been increased by two points from zero nitrogen application to other rates. However, no evident variation in fibres and metabolizable energy (ME) content was detected along with nitrogen application, but, mean values of 18% of CP content, 34% of NDF content and $9.7 \text{ MJ kg}^{-1} \text{ DM}$ of ME were denoted as high forage nutritional values compared to other most Tunisian conventional forages.

Shams and Lamlom (2020) carried out field trial at Sids Agricultural Research Station, Agricultural Research Centre (ARC), Beni-Sweif governorate Egypt, during 2017 and 2018 summer seasons to study the effect of three nitrogen levels (100 , 120 and $140 \text{ kg N fed}^{-1}$) on maize and cowpea intercropping system. They observed that application of $140 \text{ kg N fed}^{-1}$ produced the highest values of maize grain yield (22.22 t fed^{-1}) and cowpea fresh forage yield (15.35 t fed^{-1}) in both the season.

Pal and Kamboj (2021) studied the effect of three level of nitrogen ($90, 120, 150 \text{ kg ha}^{-1}$) on fodder maize. The research resulted showed that higher dry weight (727.8 kg ha^{-1}) was recorded when nitrogen was applied at the pace of 150 kg N ha^{-1} followed by 120 kg N ha^{-1} with dry weight (548.9 kg ha^{-1}) and 90 kg N ha^{-1}

with dry weight (538.9 kg ha⁻¹). While lower nitrogen rate (90 kg ha⁻¹) came about most minimal dry weight.

Krishna *et al.* (2022) study the effect of forage yield and yield components of African tall fodder maize variety in response to nutrient management. The results showed that treatment receiving 100 % RDF of NKP (12:60:40 kg ha⁻¹) recorded green fodder yield (36.5 t ha⁻¹) and dry matter yield (7.5 t ha⁻¹) and the lowest yield and yield components was recorded from treatment control (no fertilizers application). The significant increase in fodder yield with increase in fertility levels could be attributed to conducive effect on root and shoot growth of plant which in turn accrued from increased morphological parameters.

Kumar *et al.* (2022) carried out experiments in kharif 2018 and 2019 at ICAR- National Dairy Research Institute, Karnal, with four nutrient management strategies (N₀: Control; N₁: 100 % RDF; N₂: 75 % RDF + PGPR + Panchagavya spray; N₃: 50 % RDF + 25 % FYM + PGPR + Panchagavya spray) using split plot design. They reported that application of 75 % RDF + PGPR + Panchagavya spray (N₂) recorded significantly high dry fodder yield (12.24 t ha⁻¹), CPY (12.68 %), EEY (2.62 %) and TAY (9.77 %) yields.

Yadahalli *et al.* (2022) conducted the field experiment to studied the effect of different level of nitrogen with vermicompost practices on quality parameters of fodder maize intercropped with cowpea. The treatments were N₁- control, N₂- 100 % of recommended dose of Nitrogen (RDN), N₃- 75 % RDN + 25 % N through vermicompost, N₄- 50 % RDN + 50 % N through vermicompost and N₅- 25 % RDN + 75 % N through vermicompost. The research was carried out during the both year of 2021 and 2022. During the research, highest data of green fodder yield (456.77 q ha⁻¹), dry fodder yield (114.28 q ha⁻¹), crude protein yield (9.92 q ha⁻¹) and crude fibre yield (31.38 q ha⁻¹) was recorded from treatment N₃, while the lowest yield was obtained control plot in both years.

Kumar *et al.* (2024) studied the effect of fodder maize (*Zea mays*) on yield as influenced by foliar application of nano urea and urea under varying levels of

nitrogen at Zonal Agricultural Research Station, V.C. Farm, Mandya, Karnataka. The treatment comprised of different levels of nitrogen (50, 75 and 100 % RDF) along with foliar application of nano urea (0.2 % and 0.4 %). The treatment receiving 100 % RDF N with 2 % spray recorded the highest green fodder yield (427.70 q ha⁻¹) and dry matter yield (91.64 q ha⁻¹) respectively.

2.9 Effect of nutrient management on quality of maize-based legume intercropping

Ayub *et al.* (2002) studied the effect of different combination of nitrogen and phosphorus on fodder maize quality. The fertilizers were given at the rate of 0-0, 120-40, 120-60, 120-80, 160-40, 160-60, 160-80, 200-40, 200-60 and 200-80 kg ha⁻¹. Among the treatments, T₁₀ recorded the highest dry matter content (21.39), crude protein (10.21 %), crude fibre (35.5 %) and total ash (10.17 %) respectively

Ayub *et al.* (2003a) studied the field trial of different levels of nitrogen (0, 80 and 120 kg ha⁻¹) on quality of fodder maize (*Zea mays* L.). The research findings showed the significant increase in quality parameters of maize with increase in nitrogen doses. In this research they recorded the maximum crude protein (9.23 %), crude fibre (31.72 %) and total ash (9.29 %) from the application of nitrogen by 120 kg ha⁻¹ than 0 kg ha⁻¹ (control). However, increase in application of nitrogen doses lead to decrease the ether extractable fat of maize. The higher ether extractable fat (1.25 %) was recorded from treatment control (0 kg N ha⁻¹) while the lowest was observed from application of nitrogen by 120 kg N ha⁻¹.

Rashid and Iqbal (2012) proposed that fodder maize yield increased by applying with a higher rate of phosphorus till 53 kg phosphorus ha⁻¹ at side it also increased the quality parameters of fodder maize crop and showed the non-significant effects of acid detergent fibre (ADF) and neutral detergent fibre (NDF).

Kumari *et al.* (2014) carried out the field experiment to study the effect of our N levels (0, 50, 100 and 125 % recommended dose of N) on fodder quality of oat. They reported that N application had a significantly effect on quality parameters of oat. The higher crude protein (12.5 %), EE (2.32 %) and total ash (9.8 %) was observed

from the treatment receiving 125 % RDN. And also, they reported that increased in levels of N application leads to decrease in some quality parameters like total carbohydrates, organic matter, NDF. However, N application did not significantly affect hemicellulose, neutral detergent at 2nd cut and acid detergent fibre at 1st cut.

Hembram and Kundu (2016) conducted the experiment to study the integrated nutrient management on growth, yield and quality of rice bean-oat-moong sequence. They reported that treatment consisting of GM + 25 % N FYM + 50 % NPK inorganic resulted higher green forage yield (297.00 q ha⁻¹), dry matter weight (56.78 q ha⁻¹), crude protein (16.85 %) and crude protein yield reclean (8.985 q ha⁻¹) in rice bean. In oat, higher green forage yield (376.00 q ha⁻¹), dry matter yield (62.125 q ha⁻¹) was recorded with the application of GM + 25 % N FYM + 50 % NPK inorganic.

Ijaz *et al.* (2014) studied the effect of different level of potassium on maize. They reported that application of several doses of potassium fertilizers significantly contributed in the improvement, quality and yield of maize plant. They also revealed that with application of 175 kg potash ha⁻¹ to crop gave higher plant height (273.72 cm).

Iqbal and Amanullah, (2015) conducted the experiment to study the impact of potassium levels on maize. They proposed that different growth and yield parameters were observed in applying of various levels of potassium fertilizer (30, 60 and 90 kg ha⁻¹), the higher plant height, maximum number of leaves plant⁻¹ and maximum leaf area was obtained from the treatment receiving of 90 kg potassium ha⁻¹.

Kanduri *et al.* (2016) conducted the field experiment to study the effect of different combination of nitrogen levels on the fodder quality of African tall maize fodder. They reported that quality parameters such as crude protein, crude fibre, ether extract, total ash, calcium and phosphorus contents were influenced significantly by the application of nitrogen fertilizers. The treatment receiving 160 kg N ha⁻¹ produced highest crude protein (10.83 %), crude fibre (27.55 %), ether extract (1.85 %), total ash (10.02 %), calcium (0.74 %) and phosphorus (0.31 %) contents over control.

Kumar *et al.* (2017) carried out the experiment to studies the effect of nitrogen in maize under maize + urdbean intercropping system. The nitrogen was

applied at 100 % recommended fertilizer dose (120 kg ha^{-1}) and 75 % recommended fertilizer dose (90 kg ha^{-1}). They reported that Protein content of maize and urdbean did not differ significantly between the nitrogen doses applied in maize crop.

Asangla and Gohain (2016) conducted the field experiment to study the effect of fodder quality of maize (*Zea mays* L.) + cowpea (*Vigna unguiculata* L.) under different nitrogen levels. The research data showed that different nitrogen levels affected per cent crude protein total ash content and IVDMD significantly, however the increase in levels of nitrogen lowered the crude fibre content. The maximum crude protein (12.59 %), total ash content (7.79 %) and IVDMD (64.08 %) was recorded with treatment receiving 120 kg N ha^{-1} in both seasons. Incase of crude fibre content significantly higher content was recorded in treatment where nitrogen was not applied and the lowest was in treatment where nitrogen was applied @ 120 kg ha^{-1} in the analysis of two years data.

Meena *et al.* (2019) studied the effect of nitrogen level on quality parameters of fodder maize. They reported that quality parameters of fodder maize were to be increased with increasing in nitrogen level. The highest crude protein content (7.04 %), crude fibre content (25.21 %), crude protein yield (866 kg ha^{-1}), crude fibre yield (3143 kg ha^{-1}) and nitrogen content (1.17 %) was obtained in the treatment receiving 120 g N ha^{-1} and the lowest quality was recorded from control plot.

Tamta *et al.* (2019) revealed that nitrogen fertilization showed significant effect on the chemical composition of the fodder maize and cowpea. Maximum CP (12.26 %, 4.77 %), EE (1.70 %, 3.03 %) and ash content (8.79 %, 11.39 %) of maize and cowpea were found with the application of 120 kg N ha^{-1} and lowest under control. The higher CP % could be attributed due to fact that optimum levels of nitrogen in plants are known to enhanced nitrogen uptake which might improves protein synthesis. Significant improvement of ash and ether content in fodder might be due to fact the higher availability of nitrogen promotes the growth and dry matter accumulating capacity of the plants and synergistic effect of nitrogen on the availability of macro and micro nutrient further add in the enhancement of these quality parameters.

Tamta *et al.* (2019) studied the effect of different level of nitrogen fertilization on nutrient yield of fodder maize and cowpea. They found that nitrogen fertilization had significant effect on nutrient yields. The application of N @ 120 kg ha⁻¹ recorded the highest CPY (7.03 qha⁻¹), EEY (2.75 q ha⁻¹) and ash yield (13.23 q ha⁻¹), which were accountable for 42.51, 21.01, 14.62 and 8.58 % higher CP, 42.78, 19.29, 12.43 and 5.78 % higher EE and 40.82, 18.03, 11.81 and 5.12 % higher ash yields of forage maize over 0, 30, 60 and 90 kg N ha⁻¹, respectively. However, the cowpea responded significantly to the N application up to 60 kg N ha⁻¹ only. Further increase in N application rates were produced similar nutrient yields of cowpea (CP, EE and ash yield). The application of N @ 120 kg ha⁻¹ were accountable for 40.39, 17.67, 10.71 and 6.25 % higher total CP (maize + cowpea), 44.30, 17.03, 9.54 and 4.30 % higher.

Ali *et al.* (2020) studied the role of potassium in enhancing the quality of maize. They observed that a higher content of crude protein (7.66 %) and crude oil (3.66 %) were recorded from applying of potassium @ 16 kg ha⁻¹.

Kumar *et al.* (2022) conducted the field experiments to evaluate the effect of four nutrient management strategies (N₀: Control; N₁: 100 % RDF; N₂: 75 % RDF + PGPR + Panchagavya spray; N₃: 50 % RDF + 25 % FYM + PGPR + Panchagavya spray) on quality properties of fodder maize. They reported that treatment N₂ (75 % RDF + PGPR + Panchagavya spray) produced the higher DCP (5.63 %), DMI (1.89 %), DMD (59.74 %) TDN (53.02 %) and NEL (5.52 %) which was on par with treatment N₃ (50 % RDF + 25 % FYM + PGPR + Panchagavya spray).

Yadahalli *et al.* (2022) conducted the field experiment to studied the effect of different level of nitrogen with vermicompost practices on quality parameters of fodder maize intercropped with cowpea. The treatments were N₁- control, N₂- 100 % of recommended dose of Nitrogen (RDN), N₃- 75 % RDN + 25 % N through vermicompost, N₄- 50 % RDN + 50 % N through vermicompost and N₅- 25 % RDN + 75 % N through vermicompost. The research was carried out during the both year of 2021 and 2022. During the research, highest data of green fodder yield (456.77 q ha⁻¹), dry fodder yield (114.28 q ha⁻¹), crude protein yield (9.92 q ha⁻¹) and crude fibre yield

(31.38 q ha⁻¹) was recorded from treatment N₃, while the lowest yield was obtained control plot in both years.

Yadahalli *et al.* (2022) studied the effect of integrated nutrient management on fodder quality of maize. Among the treatments, N₃ (75 % + 25 vermicompost) record the highest crude protein (8.47 %), ash content (11.61 %) and acid insoluble ash (2.81 %). While, highest crude fibre (29.89 %) was recorded from N₄ (50 % RDN + 50 % N through vermicompost).

Kumar *et al.* (2024) evaluated the influence of foliar application of nano urea (0.2 % and 0.4 %) and urea under varying levels of nitrogen (50, 75 and 100 % RDF) on quality parameters of fodder maize. The highest crude protein yield (8.64 q ha⁻¹), TDCPY (8.64 q ha⁻¹), total CHO yield (74.6 q ha⁻¹) and dry matter content (21.4 %).

2.10 Effect of nutrient management on nutrient uptake of maize-based legume intercropping

Naik *et al.* (2017) reported that sole maize at 60 cm x 20 cm and application of 100 % recommended dose of nitrogen to maize resulted in highest uptake of nitrogen followed by maize + green gram, maize + black gram and maize + cluster bean. Lowest nitrogen uptake was estimated with sole maize sown in skipped rows and with 50 % recommended dose of nitrogen to maize. The net gain of post-harvest soil available nitrogen was higher with maize + green gram, with the application of 100 % recommended dose of nitrogen to maize and the net loss of soil available nitrogen was with sole maize sown in skipped rows at 50 % recommended dose of nitrogen.

Kumar *et al.* (2017) studied the nitrogen management in maize-urbean intercropping system. The data of their results showed that N, P and K uptake by maize grain was not affected significantly. However, higher values were found at 100 per cent recommended dose than that of 75 % recommended dose. A trend of reduction in N, P and K uptake by stover was observed with decreasing nitrogen fertilization dose but such reduction in uptake was not significant. However, higher N, P and K uptake by stover was noted under 100 % recommended nitrogen dose. In case of urdbean N uptake

by grain, straw and total uptake was found significant with variable doses of nitrogen affected in maize where 75 % recommended dose resulted in more N uptake by grain than that 100 %. Higher values of P and K uptake were also found fewer than 75 % recommended dose but the difference did not reach to the level of significance. An increase in N, P, K and total uptake by intercropped urdbean was noticed with reduction in nitrogen dose in base maize crop from 100 to 75 %.

Malunga *et al.* (2017) studied the effect of mineral nitrogen and legume intercrops on maize (*Zea mays* L.). In their research, they observed the highest nitrogen uptake (198.15 mg N plant⁻¹) in treatment N₃ (105 kg N ha⁻¹) nitrogen level, followed by N₂ (78.75 kg N ha⁻¹). The lowest amounts of nitrogen uptake (56.05 mg N ha⁻¹) were recorded in N₀ (0 kg N ha⁻¹) and N₁ (52.5 kg N ha⁻¹) nitrogen levels.

Malunga *et al.* (2017) conducted the field experiments to study the effect of mineral nitrogen and legume intercrops on maize (*Zea mays*). The treatment consists of main plots i.e., sole maize, sole bean, sole cowpea, bean + maize and cowpea + maize intercrop systems and sub plots were N fertilizer rates (0, 52.5, 78.75 and 105 kg N ha⁻¹), applied as urea. They reported that treatment sole maize with 105 kg N ha⁻¹ reported the highest nitrogen uptake (219.57 mg N ha⁻¹) than the remaining treatments. While the lowest nitrogen uptake was recorded from maize + bean with 0 kg N ha⁻¹ (49.66 mg N ha⁻¹) followed by sole maize with 0 kg N ha⁻¹ (53.07 mg N ha⁻¹).

Ginwal *et al.* (2019a) conducted the study in summer (*kharif*) 2017 to evaluate the fodder productivity and economics of maize with legumes under varying intercropping combinations. This experiment was laid out in randomized complete block design with 7 treatments consisting of 3 different forage crops, viz., maize, cowpea and guar sown in sole as well as in 1:1 and 2:1 intercropping combinations of forage cereal with legume crop components in three replications. They reported that total uptake of nitrogen and phosphorus was highest with maize + cowpea and maize + guar (2:1) intercropping combinations.

Subrahmanya *et al.* (2019) conducted the field experiment to study the influence of fertility levels on fodder maize. The treatment consisting of five levels of

nitrogen and phosphorus fertilizers i.e., T₁- 0 kg ha⁻¹, T₂- 60:30 kg ha⁻¹, T₃- 90:45 kg ha⁻¹, T₄- 120:60 kg ha⁻¹ and T₅- 150:75 kg ha⁻¹. They find out highest uptake of nitrogen (89.99 kg ha⁻¹) and phosphorus (39.85 kg ha⁻¹) by plant from treatment T₅ (150:75 kg N:P ha⁻¹).

Subrahmanya *et al.* (2019) studied the influence of fertility levels on fodder maize performance. The treatment consisting of five levels of nitrogen and phosphorus fertilizers i.e., T₁- 0 kg ha⁻¹, T₂- 60:30 kg ha⁻¹, T₃- 90:45 kg ha⁻¹, T₄- 120:60 kg ha⁻¹ and T₅- 150:75 kg ha⁻¹. After harvesting of the crop, they analysis the nutrient status of the soil. Among the different levels of nutrient, the highest available soil nitrogen (192.24 kg ha⁻¹) and available phosphorus (16.22 kg ha⁻¹) was obtained in a plot receiving 150:75 kg ha⁻¹ of nitrogen and phosphorus.

Porte *et al.* (2019) studied the effect of different levels of nitrogen application on uptake of nitrogen by fodder maize. The treatments consisting of four levels of nitrogen i.e., N₁- 0 kg ha⁻¹ (control), N₂- 80 kg ha⁻¹, N₃- 120 kg ha⁻¹ and N₄- 160 kg ha⁻¹. The highest nitrogen uptake (172.8 kg ha⁻¹) by fodder maize was obtained from treatment N₄ (160 kg ha⁻¹ N).

2.11 Effect of nutrient management on economics of maize-based legume intercropping

Naik *et al.* (2017) reported that with regards to nitrogen management to maize showed that application of 100 % recommended dose of nitrogen to maize significant superiority of maize equivalent yield (5663 kg ha⁻¹), land equivalent ratio (1.916), gross returns (₹ 51113/- ha⁻¹) and net returns (₹ 32871/- ha⁻¹). However, application of 100 % recommended dose of nitrogen to maize resulted in higher benefit cost ratio (2.80) but at par with application of 75 % recommended dose of nitrogen to maize. As regards the nitrogen management, graded decrease in recommended dose of nitrogen to maize gradually decreased the gross and net returns with significant disparity between 100 %, 75 % and 50 % recommended dose of nitrogen.

Takele *et al.* (2017) carried out a field experiment to determine the effect of intercropping of legumes and rates of nitrogen fertilizer on yield and yield components

of maize (*Zea mays* L.). Among the intercropping system, they reported that the total LER, was significantly affected by the cropping system. The maximum (2.2) total LER was recorded from maize + common bean-mung bean. Intercropping three cropping species was greater by 40 % compared to intercropping of two crop species. Intercropping maize + common bean with mung bean also gave significantly higher gross monetary value (GMV) of 87,191.0 Birr ha⁻¹ and monetary advantage (MA) of 47,068.2 Birr ha⁻¹ when compared to maize + common bean cropping system. While, the maximum net return of 55,2140 Birr ha⁻¹ was obtained when maize intercropped with common bean.

Ginwal *et al.* (2019b) carried out a study to evaluate the fodder productivity and economics of maize with legume intercropping combinations. In terms of economics of different treatments, they recorded highest net income (₹ 38747.27/- ha⁻¹) and B:C ratio (1.78) with maize + cowpea (2:1) followed by (₹ 37724.21/- ha⁻¹ and B:C 1.74) in maize + cowpea (1:1) intercropping combination.

Porte *et al.* (2019) conducted a field experiment to study the response of agronomic, agro-physiological, apparent recovery, economic nitrogen use efficiency, nitrogen increment efficiency of African tall fodder maize to different levels of nitrogen. They report that, among all the treatment combinations, apparent recovery efficiencies decreased to 56.1 % with each increase in nitrogen levels from control to 160 kg N ha⁻¹, and the agro-physiological, economic nitrogen use efficiency, nitrogen increment efficiency was increased as 21.6 kg ₹⁻¹ and 0.73 kg ₹⁻¹ respectively. However, agronomical nitrogen use efficiency increased with increase N levels up to 120 kg ha⁻¹ and tends to decrease with more increase in N levels up to 160 kg N ha⁻¹.

Shams and Lamloom (2020) conducted a field experiment to study the effect of three nitrogen levels (100, 120 and 140 kg N fed⁻¹) on maize and cowpea intercropping system at Agricultural Research Center (ARC), Beni-Sweif governorate Egypt. They observed the gradual increases in LER with increasing N fertilization rate. They recorded the maximum values of LER (1.6), income of maize (LE 1104/- Fed⁻¹), cowpea (LE 4677/- fed⁻¹), gross income (LE 16,598) and net return of (LE 8,301) respectively. However, found that gradual decreases in aggressivity with increasing N

fertilization rate. The highest aggressivity value of maize (1.01) recorded from the treatment received 140 kg N fed⁻¹. The aggressivity value of maize was positive for all treatments indicating that maize was dominant component whereas the aggressivity value of cowpea was negative for all treatments indicating that cowpea was dominated component in their study.

CHAPTER - III
MATERIALS AND METHODS

MATERIALS AND METHODS

The field experiment entitled “**Effect of row ratio and nutrient management on performance of maize (*Zea mays* L.) based legume intercropping system**” was conducted at the experimental farm of Department of Agronomy, School of Agricultural Sciences, Medziphema, Nagaland University, Campus: Medziphema, Nagaland, during the *kharif* season of 2022 and 2023. This chapters deals with the details of the materials used and methodology employed for carrying out the experiments and recording the observation during the course of research investigation.

3.1 Experimental site

The experiment was carried out at the experimental farm of School of Agricultural Sciences (SAS), Nagaland University, Medziphema during the *kharif* season of 2022 and 2023. The farm is situated at the foot hill of Nagaland at an altitude of 310 meters above the mean sea level with the geographical location at 25° 45' 43" North latitude and 95° 53' 04" East longitude in the sub-tropical zone.

3.2 Climatic condition

The climatic condition of the experimental site is sub-humid tropical climatic zone with high relative humidity, moderate cold and hot situations. May and June are the hottest months with means temperature ranging from 21°C to 30°C during summer and rarely goes below 8°C in winter due to high atmospheric pressure. The average annual rainfall of the experimental sites was between 1800 mm to 2500 mm, of which the major portion was received during the monsoon season (May to October) and the rest during winter and spring seasons. The relative humidity increases from June to September with means or average ranging from 70 - 90 %. The average weekly meteorological data for standard weeks during the cropping season of 2022-2023 and 2023-2024 was recorded at the meteorological observatory of the ICAR-Regional Research Centre, Jharnapani, Nagaland is presented in Table 1 & 2 and Figure 1 & 2.

Table 1. Mean meteorological data during the period of investigation - 2022

Standard Week No.	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Windspeed (km hr ⁻¹)	Bight Sunshine hours
	Max	Min	Max	Min			
20	29.1	21.9	93	81	110.6	0.989	2.2
21	30.8	22.3	93	72	10.9	1.116	3.4
22	33.3	23.3	93	65	22.5	1.214	4.8
23	33.0	24.0	94	74	51.1	1.196	2.9
24	30.3	23.3	95	74	46.7	0.872	1.3
25	31.2	23.4	95	75	34.8	0.824	1.8
26	33.3	24.9	93	68	9.9	1.313	4.5
27	34.2	24.7	91	66	77.1	1.569	7.2
28	34.1	24.5	90	69	22.9	1.464	6.9
29	33.9	24.5	92	75	135.3	1.357	3.4
30	31.8	23.2	96	70	135.3	1.024	3.6
31	33.6	23.9	93	68	48.8	1.259	3.1
32	33.3	23.9	96	71	114.7	1.205	5.1
33	33.6	24.2	91	72	27.5	1.286	6.1
34	34.1	24.5	94	68	64.2	1.039	4.1
35	32.7	24.3	93	68	9.0	0.945	4.6
36	33.4	24.4	89	67	21.7	1.423	4.9
37	31.9	23.5	91	72	42.8	1.042	4.1
38	33.5	24.0	91	65	15.3	0.964	5.6
39	32.8	23.2	91	70	81.2	1.024	6.3
40	31.9	23.5	95	74	31.0	0.672	4.4
41	31.8	22.7	91	71	2.9	0.810	5.0
42	30.9	20.6	94	65	19.7	1.010	5.9
43	28.1	19.9	95	71	41.0	1.127	4.7
44	29.8	17.1	96	60	0.0	0.963	8.0
45	29.3	16.7	96	57	0.0	0.867	8.2
46	27.9	14.6	98	56	0.0	0.971	8.2
47	27.7	12.8	96	52	0.0	0.913	8.0
48	27.8	14.3	96	67	0.0	0.932	7.4
49	27.6	12.0	95	49	0.0	0.944	8.0
50	26.4	11.3	96	50	0.0	0.843	7.0
51	25.7	11.0	96	51	0.2	0.704	6.4

Source: ICAR NEHR Jharnapani, Nagaland Centre

Table 2. Mean meteorological data during the period of investigation - 2023

Standard Week No.	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Windspeed (km hr ⁻¹)	Bright Sunshine hours
	Max.	Min.	Max.	Min.			
20	30.4	20.8	92	63	24.5	0.271	3.6
21	33.4	21.8	80	58	35.2	0.976	5.0
22	35.8	22.8	85	49	2.5	0.392	9.2
23	36.9	24.1	84	61	77.1	0.561	5.1
24	30.2	23.6	93	80	107.2	0.276	0.8
25	30.2	23.6	92	77	63.2	0.161	2.5
26	34.1	25.1	91	75	25.0	0.434	4.0
27	34.0	24.9	90	65	59.6	0.656	4.6
28	33.0	25.1	92	73	4.4	0.622	1.7
29	33.4	25.1	94	72	41.5	0.731	4.6
30	34.0	25.0	93	70	123.6	0.642	4.1
31	34.2	25.1	92	74	112.3	0.474	3.2
32	32.3	25.1	91	76	73.2	0.526	1.4
33	33.0	25.3	92	74	41.9	0.282	2.9
34	31.5	24.6	93	81	70.6	0.563	2.1
35	32.6	24.5	93	67	16.2	0.322	7.2
36	35.3	25.1	92	68	21.3	0.342	6.8
37	33.4	24.9	93	70	18.2	0.429	6.3
38	32.3	24.3	94	75	48.4	0.279	4.3
39	33.5	24.1	92	70	70.9	0.418	7.1
40	31.5	24.1	93	76	23.8	0.296	3.6
41	31.0	22.7	92	67	1.2	0.244	5.8
42	30.8	20.3	94	62	0.0	0.281	8.1
43	29.2	21.0	94	70	1.4	0.044	4.8
44	30.5	18.0	93	59	0.0	0.186	8.3
45	28.7	16.6	95	62	0.0	0.058	7.5
46	27.7	17.7	95	67	29.1	0.183	5.2
47	27.0	15.5	95	60	0.1	0.092	6.8
48	27.1	12.9	95	55	0.0	0.062	6.9
49	24.7	15.6	96	74	35.2	0.055	2.3
50	23.6	13.0	95	66	0.0	0.086	5.5
51	24.4	9.4	96	52	0.0	0.044	6.0

Source: ICAR NEHR Jharnapani, Nagaland Centre

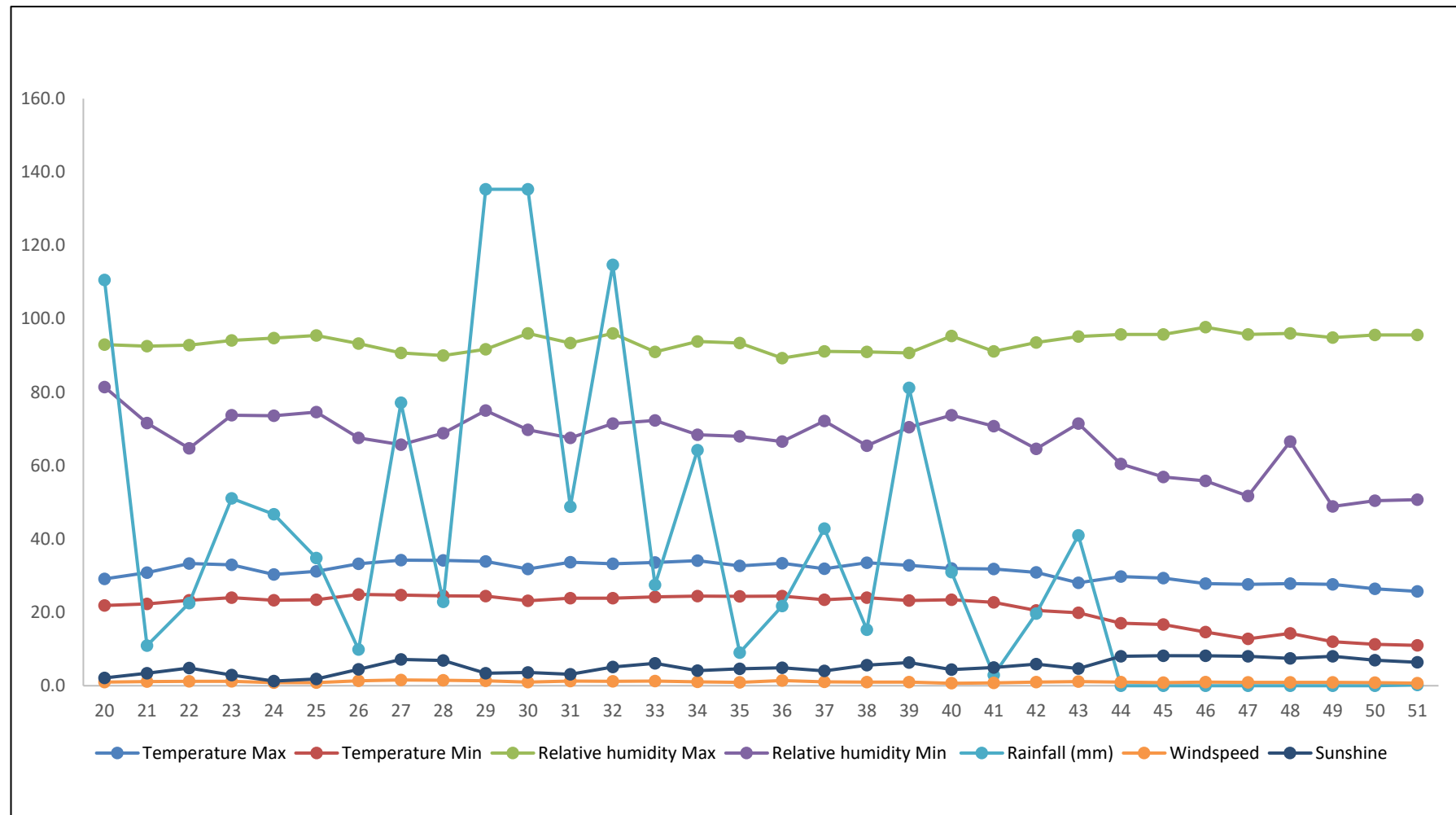


Fig.1. Weekly mean meteorological data during the period of investigation - 2022

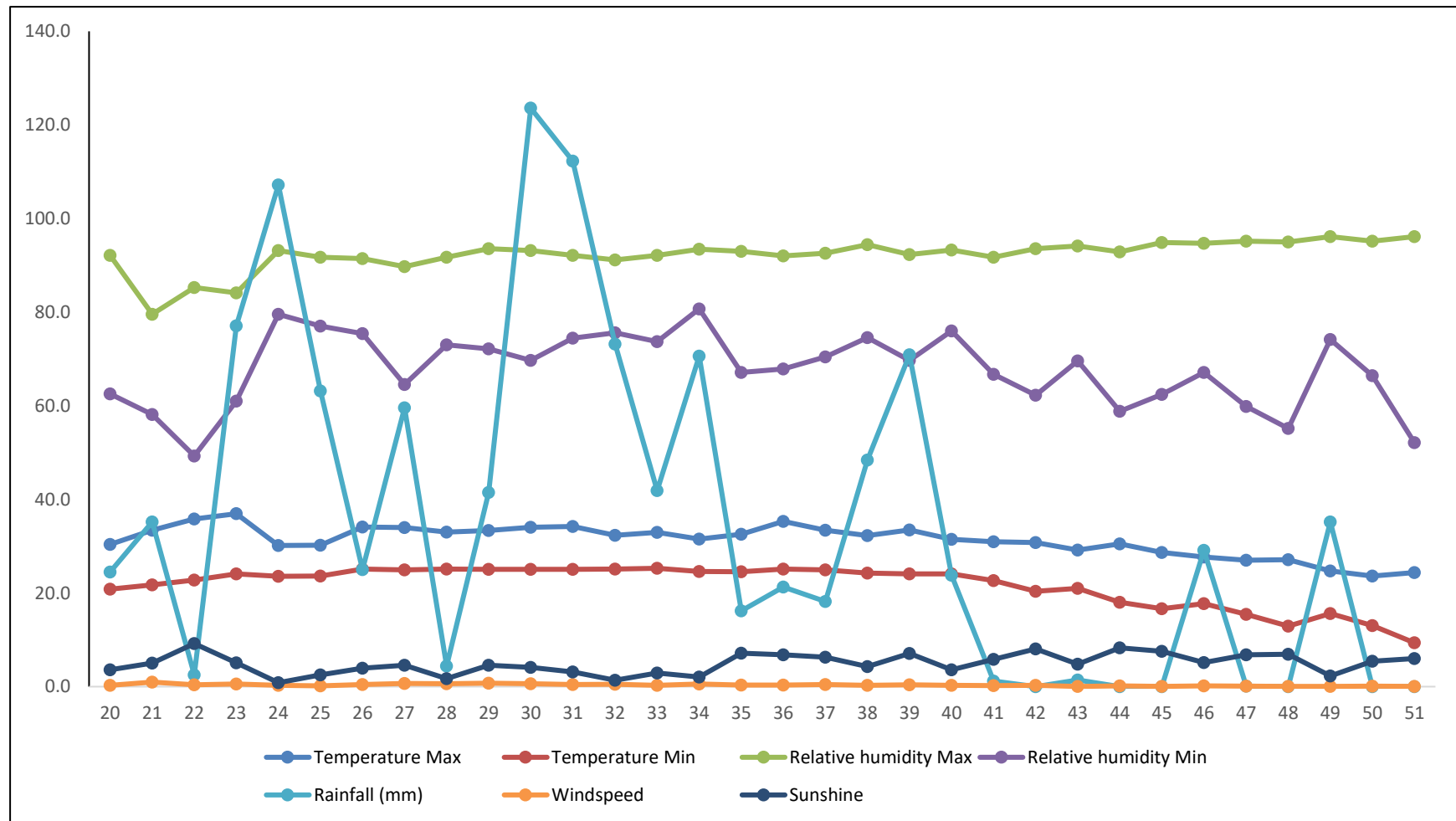


Fig.2. Weekly mean meteorological data during the period of investigation - 2023

3.3 Initial status of the experimental soil

Before the experiment was laid out, soil sample drawn from the depth of 0-15 cm from randomly selected spot from the experimental field with the help of soil auger. The collected homogenous composite soil samples were then air dried, properly grinded, sieved processed and analysed for physio-chemical properties and the results were presented in Table 3.

The soil of experimental field was found to be well drained and sandy loam in texture. The soil was high in organic carbon, low in available nitrogen and phosphorus and high content of available potassium and had a pH of 5.2. Similarly, treatments wise soil samplings were collected at the end of the crop season in both years. The composited soil sample obtained were air dried, processed and were analysed for different physio-chemical properties of the soil.

Table 3. Initial status of the experimental field

Soil parameters	Methods followed	Content	Rating
Soil texture	International pipette method (Piper, 1966)	Sand: 54.6 % Silt: 27 % Clay: 17 %	Sandy loam
Soil pH	Digital pH meter (Jackson, 1973)	5.20	Acidic
Organic carbon (%)	Rapid titrimetric method (Walkley and Black, 1934)	0.90	High
Available N (kg ha ⁻¹)	Alkaline potassium method (Subbiah and Asijah, 1956)	256.40	Medium
Available P (kg ha ⁻¹)	Bray's No.1 method (Bray and Kurtz, 1945)	22.09	Medium
Available K (kg ha ⁻¹)	Flame photometer (Hanway, 1952)	144.92	Medium

3.4 Cropping history of the experiment field

The details of cropping history of the experimental field for last two years experimentation were given in the Table 4.

Table 4. Previous cropping history of the experimental field

Year	Crops grown
2019-2020	Maize
2020-2021	Sunflower

3.5 Experimental details

3.5.1 Experimental design

The experiment was carried out in Randomized Block Design (RBD) with three replications. It comprised of 27 treatment combinations with 9 cropping system of fodder maize with fodder cowpea and fodder rice bean *viz.*, sole maize, sole cowpea, sole rice bean, fodder maize + fodder cowpea (1:1), fodder maize + fodder rice bean (1:1), fodder maize + fodder cowpea (2:1), fodder maize + fodder rice bean (2:1), fodder maize + fodder cowpea (2:2), fodder maize + fodder rice bean (2:2) and three levels of nutrient management practices *i.e.*, control (no fertilizers application), 50 % RDF (30-15-15 NPK kg ha⁻¹) and 100 % RDF (60-30-30 NPK kg ha⁻¹). The allocations of the various treatment were done randomization using Fishers and Yates random number tables. The detailed information of experimental field layout is presented in Figure 3.

3.5.2 Details description of intercropping system treatments

As per the experimental layout, cropping system and spacing details are presented in Figure 4 and 5. The main crop fodder maize was grown with fodder cowpea and fodder rice bean as intercrop at different row ratio *i.e.*, sole, 1:1, 2:1 and 2:2 with a spacing of 30 cm x 10 cm. At 1:1 row ratio, after one row of main crop, next main crop row was removed and replace by one row of intercrop, and for 2:1 row ratio,

after every two row of main crop, one row of intercrop was inserted. The row ratio at 2:2, after every two rows of main crop, the two row of main was replaced with intercrop fodder cowpea or rice bean.

3.5.3 Details of crops and varieties

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

3.5.3.1 Fodder maize variety African Tall

The fodder maize variety African Tall is a promising composite variety obtained from Indian Grassland and Fodder Research Institute (IGFRI), Jhansi, Uttar Pradesh. This maize variety can be grown in all maize growing areas in the country throughout the year. The variety are tall plant (9 to 11 feet), vigorous, sturdy with leafier and wells developed stalks roots. Stem thick light green and soft, long leaves blade (30-150 cm), leaf width (5-15 cm) and dark green (Mishra, 2019). Resistant to major foliar diseases and insect-pests, specifically resistant to stem borer, rust, leaf blight and Downey mildew.

3.5.3.2 Fodder cowpea variety Kohinoor

Fodder cowpea variety Kohinoor (S-450) is forage type variety released from Indian Grassland and Fodder Research Institute, Jhansi - 284003 (U.P.). It grows well in all cowpea growing areas in the country. The variety is decumbent type in growth habit and tolerant to semi-looper, flee beetle and leaf hopper, susceptible to grain pests during storage.

3.5.3.3 Fodder rice bean variety Bidhan Rice bean-2

Fodder rice bean variety Bidhan Rice bean-2 is developed by Bidhan Chandra Krishi Viswavidyalaya, West Bengal. The plant is erect in early stage of growth, later on viny, twinning, indeterminate type and luxuriant, tall growing with profuse branching. Abundance of lush green, trifoliate broad leaf. This variety can be grown and well adoption only in North-Eastern region of the country. And the special attributes of this variety are too tolerant to drought.

3.5.4 Details description of nutrient management treatments

The recommended doses of nitrogen, phosphorus and potassium for fodder maize in the north eastern region is 60:30:30 kg ha⁻¹. The nutrient management was maintained at three level *i.e.*, control, 50 % RDF and 100 % RDF, respectively which applied through urea (46 % N), single super phosphate (16 % P₂O₅) and muriate of potash (60 % K₂O). The treatments were maize with cowpea and rice bean grown at 50 % RDF and 100 % RDF of NPK were received 65:93:25 kg ha⁻¹ and 130:186:50 kg ha⁻¹ in the form of urea, SSP and MOP respectively.

3.5.5 Details of the experimental techniques

1. Experimental Design	: Randomized Block Design
2. Number of treatments combinations	: 27
3. Number of replications	: 3
4. Total number of plots	: 81
5. Net plot area	: 5.4 m x 4.6 m (24.84 m ²)
6. Block border	: 1 m
7. Plot border	: 0.5 m
8. Variety	: Maize - African tall : Cowpea - Kohinoor : Rice bean - Bidhan Rice bean-2
9. Spacing	: 30 cm x 10 cm
10. Growing season	: <i>Kharif</i> season of 2022 and 2023
11. Harvesting	: Maize - 50 % silking stage : Cowpea - 50 % flowering stage : Rice bean - 50 % flowering stage

3.5.6 Treatment details

The experiment was carried out with two factors *i.e.*, cropping system and nutrient management. The combinations of different row ratio and nutrient levels of the present investigation are given below:

1. Cropping system

C ₁	: Sole maize
C ₂	: Sole cowpea
C ₃	: Sole rice bean
C ₄	: Maize + Cowpea (1:1)
C ₅	: Maize + Rice bean (1:1)
C ₆	: Maize + Cowpea (2:1)
C ₇	: Maize + Rice bean (2:1)
C ₈	: Maize + Cowpea (2:2)
C ₉	: Maize + Rice bean (2:2)

2. Nutrient levels (NPK @ kg ha⁻¹)

F ₀	: 0 kg ha ⁻¹
F ₁	: 30-15-15 kg ha ⁻¹
F ₂	: 60-30-30 kg ha ⁻¹

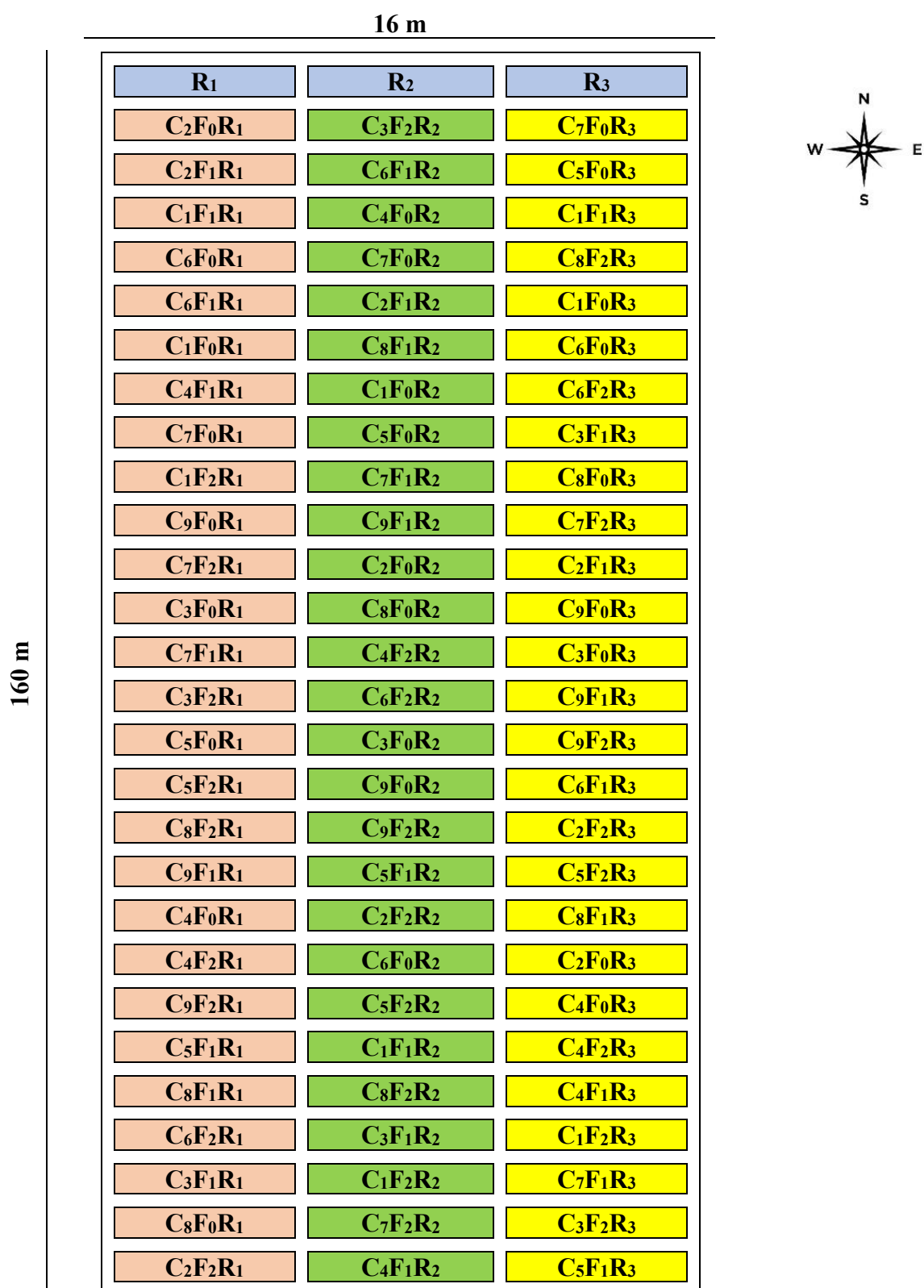


Fig.3. Layout of the experimental field

S = Sole

M = Sole Maize

C = Sole Cowpea

R = Sole Rice bean

Row Ratio = 1:1, 2:1 and 2:2

SM	M	M	M	M	M	M	M	M	M	M	M	M	M	M
SC	C	C	C	C	C	C	C	C	C	C	C	C	C	C
SR	R	R	R	R	R	R	R	R	R	R	R	R	R	R
1:1	M	C	M	C	M	C	M	C	M	C	M	C	M	C
1:1	M	R	M	R	M	R	M	R	M	R	M	R	M	R
2:1	M	M	C	M	M	C	M	M	C	M	M	C	M	M
2:1	M	M	R	M	M	R	M	M	R	M	M	R	M	M
2:2	M	M	C	C	M	M	C	C	M	M	C	C	M	M
2:2	M	M	R	R	M	M	R	R	M	M	R	R	M	M

Fig.4. Layout out of cropping system

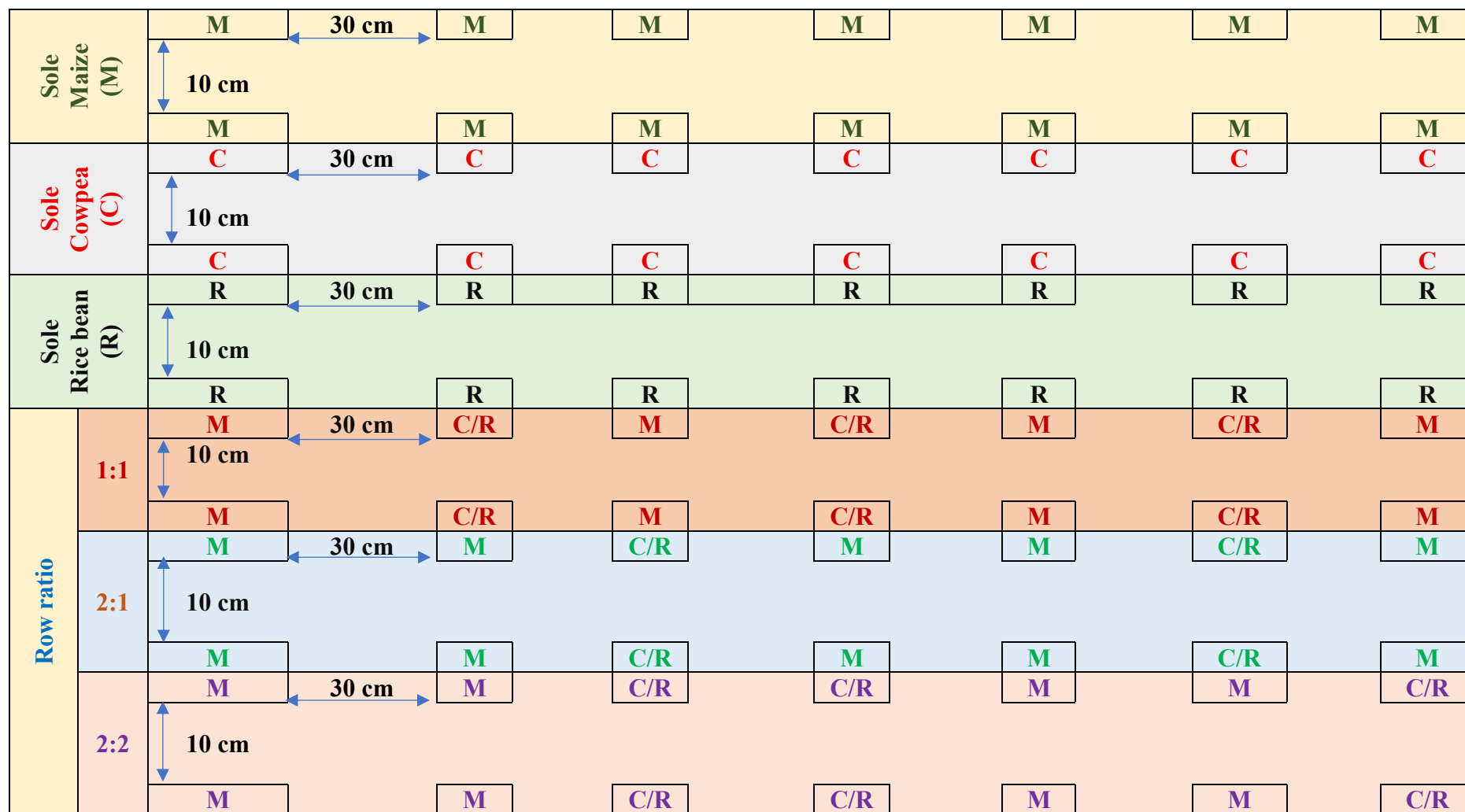


Fig.5. Layout out of spacing details

3.6 Details of field operation

The agronomic or cultural practices carried out for cultivation of fodder maize with fodder legumes are given below.

3.6.1 Selection and Preparation of land

A well-drained and fertile plot was selected for carrying out the research work in the experimental farm of Agronomy Department, SAS, NU, Medziphema, Nagaland. The field was thoroughly ploughed by tractor drawn disc plough during the last week of May followed by single pass of tractor drawn rotavator to break the hard pan to bring the soil into properly tilth soil subsequently harrowing was done to crush the clods and to uproot and remove the weeds, all the stubbles and debris from the field. Finally, the field was levelled with the help of wooden planker and then plot was laid out as per the treatment details in the experimental layout plan.

3.6.2 Application of fertilizers

As per the treatment details, the fertilizers were applied at different levels *i.e.*, 0 % RDF @ 0 NPK kg ha⁻¹, 50 % RDF @ 30-15-15 NPK kg ha⁻¹ and 100 % RDF @ 60-30-30 NPK kg ha⁻¹. The fertilizers were applied in the form of Urea, SSP and MOP respectively. Urea was applied in two split doses. One split dose urea whereas full dose of SSP and MOP were applied as basal at a day before sowing and the remaining split dose of urea was applied after 20 DAS. Likewise, the same operation was followed in fodder cowpea and fodder rice bean.

3.6.3 Seed rate

The healthy and clean seeds were selected for sowing. The recommended seed rate used during the field experiment for fodder maize, fodder cowpea and fodder rice bean were 40 kg ha⁻¹, 30 kg ha⁻¹ and 20 kg ha⁻¹. The seed rate for fodder maize, fodder cowpea and fodder rice bean at 1:1, 2:1 and 2:2 row ratio was 20-15-10 kg ha⁻¹, 26.7-10-6.7 kg ha⁻¹ and 20-15-10 kg ha⁻¹ and the seeds were sown in replacement series.

3.6.4 Sowing of seeds

The seeds were sown at the depth of about 5 cm deep. Both main crop and intercrop was sown at 2nd week June in both of investigation (2022 and 2023). The seed were sown in a furrow line by dibbing two or three seeds hill⁻¹ at the spacing of 30 cm row to row and 10 cm plant to plant and then planking was done to cover the seeds.

3.6.5 Intercultural operations

After 10 days of seed germination, gap filling and thinning was done where it was needed as to maintain optimum plant population. Three manual hand weeding was done with the help of *khurpi* and hand hoe at 10 DAS, 20 DAS and 45 DAS to control the weeds in the field and then followed up by earthing up.

3.6.6 Plant protection measures

The seed of the fodder maize, cowpea and rice bean were treated with Saaf @ 2 g kg⁻¹ seed to control the seed borne fungal diseases. To control the infestation of pests like termites, Chlorpyrifos 50 % + Cypermethrin 5 % EC @ 2.5 ml L⁻¹ was applied to the field. The crop was spray with neem oil 0.03 %, Minchu @ 2.5 ml L⁻¹ and Emamectin Benzoate 5 % SG @ 1 scoop 15 L⁻¹ for controlling of cut worm and fall army worms.

3.6.7 Harvesting and samples collection

Both the main crop and companion crop were harvested manually at 50 % tasselling and 50 % flowing from both experimental years. First, the plant from border were harvested and removed from the field. Thereafter, the plant was harvested at about 10 cm from the ground levels of the net plot. The harvested green fodder was weighted in kg plot⁻¹ and converted into tonnes ha⁻¹ basis. The plant samples were collected from each of the experimental plots and then it was shade dried for two days. After shade dried, the samples were shifted to the hot air oven for drying at 70°C, thereafter the dry fodder yield was recorded. These dried samples were grinded to pass through the 40 meshed sieve and used it for plant chemical analysis.

3.7 Biometrical observations

3.7.1 Growth parameters (20 days interval)

The growth parameters observation for each crop was done at 20 days interval from the of sowing. From each plot, five numbers of plant from each crop of fodder maize, fodder cowpea and fodder rice bean were selected randomly from the net plot area and were tagged.

3.7.1.1 Maize

3.7.1.1.1 Plant height (cm)

Two rows from all sides of each plot were left and discard as border rows. The plant height of the tagged plants was measured from the ground level of the plant to the base of the fully opened top leaf by using meter scale and the average was worked out and expressed in centimetre (cm).

3.7.1.1.2 Leaf area (cm²)

From each tagged plants ten healthy leaves with different size were plucked and measured the leaf area manually with the help of graph and scale and then mean leaf area was worked out and expressed in centimetre (cm).

3.7.1.1.3 Leaf to stem ratio

The leaves of the plants were detached from the stem and then weight of the fresh leaves and stem was recorded separately, then leaf stem ratio was calculated by using the following equation.

$$\text{Leaf to Stem Ratio} = \frac{\text{Weight of leaves (g)}}{\text{Weighth of stem (g)}}$$

3.7.1.1.4 Fresh weight of plant (g plant⁻¹)

The plant was cut from the ground level and the fresh weight of the plant was recorded separately and the average weight of the plant was worked out and expressed in gram (g plant⁻¹).

3.7.1.1.5 Dry weight of plant (g plant⁻¹)

The plant was cut from the ground level and the fresh weight of the plant was recorded separately. These collected samples were put into perforated paper bags and sun dried for a few days. Thereafter, the samples were shifted into oven and dried at 65±5°C till constant weighed was obtained and the average weight of the plant was worked out and expressed in gram (g plant⁻¹).

3.7.1.1.6 Number of leaves plant⁻¹

The number of leaves of plant⁻¹ of fodder maize was recorded by counting the fully open leaves of five tagged plants. The average leaves plant⁻¹ of the five plants were worked out.

3.7.1.1.7 Stem girth of maize (cm)

The stem girth of the five tagged plants of fodder maize was measured at the height of 10 cm, 20 cm and 30 cm above the ground level at 20 days interval after sowing. The average stem girth of the plant was worked out and expressed in centimetre (cm).

3.7.1.2 Cowpea

3.7.1.2.1 Plant height (cm)

The height of the tagged plants of fodder cowpea was measured from the ground level of the plant to the tip of the vine with the help of meter scale and the average height of the plant was worked out and expressed in centimetre (cm).

3.7.1.2.2 Leaf length (cm)

The leaf length of the five tagged plants of fodder cowpea was taken by measuring the healthy leaf from 3rd and 4th of the top and recorded. The length of the leaves was measured by using ruler. The average of ten leaves was worked out and expressed in centimetre (cm).

3.7.1.2.3 Leaf width (cm)

The leaf of the five tagged plants of fodder cowpea was taken to record the leaf width of the plant. The leaf width from middle portion of the leaf blade was measured by using ruler and the average values were worked out and expressed in centimetre (cm).

3.7.1.2.4 Leaf to stem ratio

The leaves of fodder cowpea were detached from the stem. The fresh weight of leaves and the fresh weight of stem was recorded separately and then leaf stem ratio was worked out by using the following equation.

$$\text{Leaf to Stem Ratio} = \frac{\text{Weight of leaves (g)}}{\text{Weight of stem (g)}}$$

3.7.1.2.5 Stem girth (cm)

The stem girth of the five tagged plants of fodder cowpea was measured at the height of 10 cm, 20 cm and 30 cm above the ground level at 20 days interval after sowing. The average values were worked out and expressed in centimetre (cm).

3.7.1.2.6 Number of leaves plant⁻¹

The number leaves of plant⁻¹ of fodder cowpea were recorded by counting the fully open leaves of five tagged plants. The average leaves plant⁻¹ of the five plants were worked out.

3.7.1.2.7 Number of primary branches plant⁻¹

The number of primary branches plant⁻¹ from five selected plant from each plot were counted at 20, 40 and 60 days after sowing. The average number of primary branches plant⁻¹ was worked out.

3.7.1.2.8 Fresh weight of plant (g plant⁻¹)

The plant of fodder cowpea was cut from the ground level and the fresh weight of the plant was recorded separately and the average weight was worked out and expressed in gram (g plant⁻¹).

3.7.1.2.9 Dry weight of plant (g plant⁻¹)

After the completion of fresh weight observation of the plant. The collected samples were put into a perforated paper bags separately and then it was sun dried for a few days. Thereafter, the samples were shifted in oven at 65±5°C till constant weighed was obtained and the average was worked out and expressed in gram (g plant⁻¹).

3.7.1.3 Rice bean

3.7.1.3.1 Plant height (cm)

The height of the tagged plants of fodder rice bean was measured from the ground level of the plant to the tip of the vine with the help of meter scale and the average was worked out and expressed in centimetre (cm).

3.7.1.3.2 Leaf length (cm)

The leaf length of the five tagged plants of fodder rice bean was taken by measuring the healthy leaf from 3rd and 4th of the top and recorded separately. The length of the leaves was measured by using ruler. The average of ten leaves was worked out and expressed in centimetre (cm).

3.7.1.3.3 Leaf width (cm)

The leaf of the five tagged plants of fodder rice bean was taken to record the leaf width of the plant. The leaf width from middle portion of the leaf blade was measured by using ruler and the average values were worked out and expressed in centimetre (cm).

3.7.1.3.4 Leaf to stem ratio

The leaves of fodder rice bean were detached from the stem and then weight of the fresh leaves and stem was recorded separately and the leaf stem ratio was worked out by using the following equation.

$$\text{Leaf to Stem Ratio} = \frac{\text{Weight of leaves (g)}}{\text{Weight of stem (g)}}$$

3.7.1.3.5 Stem girth (cm)

The stem girth of the five tagged plants of fodder rice bean was measured at the height of 10 cm, 20 cm and 30 cm above the ground level at 20 days interval after sowing. The average values were worked out and expressed in centimetre (cm).

3.7.1.3.6 Number of leaves plant⁻¹

The number leaves of plant⁻¹ of fodder rice bean were recorded by counting the fully open leaves of five tagged plants. The average leaves plant⁻¹ of the five plants were worked out.

3.7.1.3.7 Number of primary branches plant⁻¹

The number of primary branches plant⁻¹ from five selected plants of fodder rice bean from each plot were counted at 20, 40 and 60 days after sowing. The average number of primary branches plant⁻¹ was worked out.

3.7.1.3.8 Fresh weight of plant (g plant⁻¹)

The plant of fodder rice bean was cut from the ground level and the fresh weight of the plant was recorded separately and the average was worked out and expressed in gram (g plant⁻¹).

3.7.1.3.9 Dry weight of plant (g plant⁻¹)

The plant was cut from the ground level and fresh weight of the plant was recorded separately. These collected samples were put into perforated paper bags and

sun dried for few days. Thereafter, the sample was shifted in oven at $65\pm 5^{\circ}\text{C}$ till constant weighed was obtained and the average weight of the plant was worked out and expressed in gram (g plant^{-1}).

3.8 Yield studies

3.8.1 Green fodder yield (t ha^{-1})

The two rows from both sides of the plot were discarded to eliminate the border effect on the treatments. The crops were harvested at 50 % silking and 50 % flowering stages. For recording the green fodder yield of fodder maize, fodder cowpea and rice bean, the green fodder yield per meter square was recorded each plot separately and the harvested green fodder was weighed in kg m^{-2} . Later, this green fodder yield was converted into tonnes ha^{-1} .

3.8.2 Dry fodder yield (t ha^{-1})

The dry fodder yield of the crops was worked out by multiplying the green fodder yield with its dry matter content. The equation is below.

$$\text{DFY (t ha}^{-1}\text{)} = \frac{\text{Dry matter content (\%)} \times \text{Green fodder yield (kg ha}^{-1}\text{)}}{1000}$$

3.9 Qualitative analysis

3.9.1 Preparation of the substrates

The plant samples of fodder maize, cowpea and rice bean were dried in oven and grounded to pass through 1 mm screen for qualitative analysis.

3.9.2 Crude protein content (%)

Crude protein in the fodder samples was estimated by Kjeldahl method. A known quantity of the representative sample (0.5 g) was transferred in the Kjeldahl flask with 20 ml concentrated H_2SO_4 and in the present of 3 g digestion mixture (K_2SO_4 + CuSO_4 in the ratio of 9:1). The flask was placed on digestion chamber and heat till the solution become clear blue. Once the digestion was completed and the contents were cooled, tube was inserted into micro-Kjeldahl apparatus and 40 ml of 40 % NaOH

solution was added to make the content alkaline. The distillation was carried in KEL PLUS[®] N analyser. The distillate was collected in a conical flask containing 10 ml of 2 % boric acid. The distillate was titrated with standard acid till the end point was reached (red colour). This gave the total nitrogen content and crude protein content of the samples was calculated by multiplying the N content with factor of 6.25 (AOAC, 2005).

$$\text{Total N (\%)} = \frac{0.014 \times 0.01 \times \text{Volume of 0.001 N H}_2\text{SO}_4 \text{ used} \times \text{Volume made ml}}{\text{Aliquat taken (ml)} \times \text{Wt. of oven dry sample (g)}} \times 100$$

$$\text{CP (\%)} = \text{Total N (\%)} \times 6.25$$

3.9.3 Crude protein yield (q ha⁻¹)

The estimation of crude protein content in the fodder samples was done by kjeldahl method, and then on crude protein yield was calculated by multiplying the crude protein content with dry fodder yield.

$$\text{CP yield (q ha}^{-1}\text{)} = \frac{\text{CP content (\%)} \times \text{Dry fodder yield (t ha}^{-1}\text{)} \times 10}{100}$$

3.9.4 Crude fibre (%)

The crude fibre consists of cellulose, variable portion of hemicellulose and highly variable proportion of lignin along with some minerals. The estimation of crude fibre content in the fodder samples was done based on treating the moisture and fat free sample successively with diluted acid and alkali. A known quantity of moisture and fat free sample (2 g) was transferred it to the 1 L spoutless beaker containing 200 ml of 1.25 % H₂SO₄, then place on hot plate and allowed to reflux for 30 minutes. After boiling for 30 minutes, the beaker was removed from hot plate and filter through a muslin cloth using suction and the residue was washed with hot water till the sample was free from acid. Then the residue was transferred to the same beaker and add 200 ml of 1.25 % NaOH solution and again reflux the content for 30 minutes, then sample was filter again with muslin cloth with the help of suction or vacuum pump and washed with hot water till it free from alkali. Once washing was done the residue was

transferred it to crucible and place it in hot air oven to allowed it to dry at 80°C to 110°C and the weight was recorded. After drying the crucible was put it in the muffle furnace and ignite it at around 550°C to 600°C for two to three hours, cool and weigh again. The loss of weight due to ignition is the weight of crude fibre.

$$\text{Crude fibre (\%)} = \frac{\text{Weight of crude fibre}}{\text{Original weight of sample}} \times 100$$

3.9.5 Ash content (%)

Ash is the inorganic or mineral component of the sample left after complete ignition of the sample at 600°C in muffle furnace. A known quantity of grounded sample (5 g) was transferred in the pre-weight crucible and ignited the sample on the heater till the smoke ends up. The crucible was transferred to a muffle furnace with the help of long tongs and keep it for two hours at 600°C. The crucible was removed and cooled it in a desiccator and weigh again to find out the ash weight of the ash (AOAC, 2005). The total ash was calculated on dry matter basis using the formula.

$$\begin{aligned} &\text{Ash content (\%)} \\ &= \frac{[(\text{Wt. of crucible} + \text{Wt. of ash after cooling}) - \text{Wt. of empty crucible}]}{\text{Wt. of oven dry sample (g)}} \times 100 \end{aligned}$$

3.10 Intercropping studies

3.10.1 Crop growth rate (g m⁻² day⁻¹)

Crop growth rate (CGR) was calculated for the time periods at 20 to 40 DAS and 40 to 60 DAS. The periodic dry weight of the five randomly selected plants from each plot were used to compute the mean crop growth rate with the help of the following formula (Radford, 1967) and it expressed g m⁻² day⁻¹.

$$\text{CGR} = \frac{(W_2 - W_1)}{(t_2 - t_1) S}$$

Where, W₁ & W₂ are dry weight (g) of the plant at time t₁ and t₂, respectively, t₂ & t₁ is the interval of time in days and S denotes the land area (m⁻²) over which the plant dry

matter was recorded.

3.10.2 Leaf area index

The five plants selected randomly from the row of the crop from each plot and were cut from the ground level. The leaf area of these plant was measured. Finally, the leaf area index was calculated by dividing the leaf area by ground area occupied by the plant.

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

3.10.3 Land equivalent ratio

Land equivalent ratio (LER) is the most commonly used index of agronomic yield advantage and it was calculated as per the formula suggested by Willey (1979).

$$LER = \frac{Y_{fx}}{Y_{ff}} + \frac{Y_{xf}}{Y_{xx}}$$

Where, Y_{fx} - Intercrop yield of fodder maize

Y_{xf} - Intercrop yield of fodder cowpea/rice bean

Y_{ff} - Sole crop yield of fodder maize

Y_{xx} - Sole crop yield of fodder cowpea/rice bean

3.10.4 Land use efficiency (%)

Land use efficiency indicates the percent land use in terms of duration. Land use is given by:

$$LUE = \frac{D_i}{365} \times 100 \%$$

Where, D_i - Number of days occupied by crop

3.10.5 Net assimilation rate (g cm⁻² day⁻¹)

Net assimilation rate (NAR) was observed for the time periods of 20 to 40 DAS and 40 to 60 DAS. For calculating NAR, dry weight of the five randomly selected plants from each plot were recorded. It indirectly indicates the rate of net photosynthesis and it is expressed g of dry matter production per day per sq. meter of leaf area (g cm⁻² day⁻¹).

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

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

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

3.10.6 Relative growth rate (g g⁻¹ day)

The relative growth rate of the crop at time instant is defined as the increase of plant material per unit weight. The observation was done from the time periods of 20 to 40 DAS and 40 to 60 DAS. The dry weight of five randomly selected plants from each plot were recorded and the average mean was work out. The relative increment in growth rate of the fodder crops was calculated by using the formula given by Radford (1967) which was expressed as g g⁻¹ day.

$$\text{RGR} = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

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

3.10.7 Relative crowding co-efficient

Relative crowding co-efficient is used in replacement series, each component has its own coefficient (k) which give a measured of whether that component has produced more or less or fewer than the expected. This was proposed by Wit in 1960. It also measured the relative dominance of one component crop over the other in an intercropping system. It is given by:

$$K_{ab} = \frac{Y_{ab} \times Z_{ba}}{(Y_{aa} - Y_{ab}) \times Z_{ab}}$$

$$K_{ba} = \frac{Y_{ba} \times Z_{ab}}{(Y_{bb} - Y_{ba}) \times Z_{ba}}$$

Where, K = RCC of the system

K_{ab} = RCC of component crop 'a' in the intercropping

K_{ba} = RCC of component crop 'b' in the intercropping

Y_{aa} = Yield of component crop 'a' as sole crop

Y_{bb} = Yield of component crop 'b' as sole crop

Y_{ab} = Yield of component crop 'a' as intercropping in combination with 'b'

Y_{ba} = Yield of component crop 'b' as intercropping in combination with 'a'

Z_{ab} = Sown proportion of component 'a' in combination with 'b'

Z_{ba} = Sown proportion of component 'b' in combination with 'a'

If a component has RCC,

>1, it means that it has produced more yield than expected yield

<1, it means that it has produced less yield than expected yield

=1, it means that it has produced equal yield than expected yield

3.10.8 Aggressivity

Aggressivity (A) was computed by using the formula proposed by McGilchrist (1965). Aggressivity show the relationship between dominant and dominated species. It measured how much the relative yield increases in species 'a' is greater than that of species 'b' in an intercropping system and it can be expressed in given formula.

$$A_{ab} = \frac{Y_{ab}}{Y_{aa} \times Z_{ab}} - \frac{Y_{ba}}{Y_{bb} \times Z_{ba}}$$

Where, A_{ab} = Aggressivity of 'a' in combination with 'b'

Y_{aa} = Yield of component crop 'a' as sole crop

Y_{bb} = Yield of component crop 'b' as sole crop

Y_{ab} = Yield of component crop 'a' as intercropping in combination with 'b'

Y_{ba} = Yield of component crop 'b' as intercropping in combination with 'a'

Z_{ab} = Sown proportion of component 'a' in combination with 'b'

Z_{ba} = Sown proportion of component 'b' in combination with 'a'

If aggressivity,

>0, component is dominant

<1, component is dominated by other

=0, component crops are equally competitive

3.10.9 Competition ratio

Competition ratio (CR) was calculated based on the formula suggested by Willey *et al.* (1980).

$$CR = \frac{Y_{ab}}{Y_{bb} \times Z_{ab}} \div \frac{Y_{ba}}{Y_{bb} \times Z_{ab}}$$

$$CR_a = \frac{LER_a}{LER_b} \times \frac{Z_{ba}}{Z_{ab}}$$

$$CR_b = \frac{LER_b}{LER_a} \times \frac{Z_{ab}}{Z_{ba}}$$

Where, CR= Competition Ratio of 'a' in the mixture over 'b'

Y_{aa} = Yield of component crop 'a' as sole crop

Y_{bb} = Yield of component crop 'b' as sole crop

Y_{ab} = Yield of component crop 'a' as intercrop in component with 'b'

Y_{ba} = Yield of component crop 'b' as intercrop in component with 'a'

Z_{ab} = Sown proportion of component 'a' in combination with 'b'

Z_{ba} = Sown proportion of component 'b' in combination with 'a'

LER_a = LER of component 'a'

LER_b = LER of component 'b'

3.10.10 Maize fodder equivalent yield ($q\ ha^{-1}$)

Maize fodder equivalent yield is a way of expressing the productivity of an intercropping system in terms of their market value. The yields of different intercrops

are converted into equivalent yield of any one crop based on price of the produce. This converted yield is called crop equivalent yield and it can be expressed in the given formula.

Maize fodder equivalent yield ($q\ ha^{-1}$)

$$= \frac{\text{Yield of base crop} + \text{Yield of intercrop} \times \text{Price of intercrop} (q^{-1})}{\text{Price of base crop} (q^{-1})}$$

3.11 Chemical analysis

3.11.1 Soil analysis

To determine the nutrient status of the soil, soil samples from 0-15 cm depths were collected separately from each plot after harvest of fodder crops in the both years. Soil pH, organic carbon, available nitrogen (N), available phosphorus (P) and available potassium (K) content were analysed.

3.11.1.1 Soil pH

The soil pH was analysed by potentiometer method. The soil and water were taken in the ratio of 1:2 and the soil suspension were stirred with a glass rode for 30 minutes. The pH of the soil suspension was determined by using digital pH meter (Richard, 1954).

3.11.1.2 Soil Organic carbon (%)

The organic carbon content of the soil was determined by rapid titration method (Walkley and Black, 1934). A known of quantity of soil (0.5 g) was taken to oxidize its organic matter by using chromic acid (10 ml of potassium dichromate + 20 ml sulphuric acid) and heat of the dilution of sulphuric acid (added 200 ml distilled water). Then, added 10 ml of phosphoric acid and 1 ml of diphenyl amine in indicator. The un-reacted dichromate was determined by back titration with ferrous ammonium sulphate till the colours changes from blue violet to green and result was expressed in percentages.

3.11.1.3 Available N (kg ha⁻¹)

The available nitrogen content in the soil was estimated by using alkaline potassium permanganate method by Subbiah and Asija (1956). A known quantity of soil sample was taken and its organic matter oxidised by using alkaline (40 ml of 40 % KMnO_4 + 40 ml of 40 % NaOH). Ammonia evolved from soil sample was hydrolysed and absorbed in excess of 20 ml of 2 % boric acid. The amount of such absorbed ammonia was calculated by titrating the boric acid with 0.01N H_2SO_4 .

3.11.1.4 Available P (kg ha⁻¹)

The available phosphorus content in the soil was determined by following Bray and Kurtz No.1 method (Bray and Kurtz, 1945). A known quantity of soil sample along with 3 scoops of activated charcoal was extracting with 50 ml of P-extracting solution. Out of this extract, 5 ml was taken out and then 5 ml of Dickman and Bray's reagent was added, neutralised with little amount of distilled water. Furthermore, 1 ml of freshly diluted stannous chloride solution was added, make up the volume with distilled water and blue colour developed after mixing properly. The phosphorus content was measured at 660 nm SU-vis spectrophotometer.

3.11.1.5 Available K (kg ha⁻¹)

The available potassium content in the soil was extracted with neutral normal ammonium acetate (pH 7.0) solution. A quantity of soil sample was taken and its potassium ions was separated by using 25 ml of 1N ammonium acetate. The concentration of such separated potassium ions in soil solution was measured by using flame photometer (Jackson, 1973).

3.11.2 Plant analysis

The plants samples of the harvest fodder crop from each plot were dried in hot air oven at 60°C. These samples oven dried was ground to pass through 40 mess sieve and used it for chemical analysis.

3.11.2.1 N content (%) and uptake by crop

The nitrogen content in fodder sample were determined by using Kjeldhal apparatus (Piper, 1966) and were expressed as percentage (%) and the nitrogen uptake by fodder crops was computed by multiplying the nitrogen content of the samples with respective dry biomass. The nitrogen uptake was expressed in kg ha^{-1} .

3.11.2.2 P content (%) and uptake by crop

The phosphorus content of the fodder crop plant sample was determined by using Vanado-molybdate-phosphoric acid yellow colour method (Jackson, 1973). The phosphorus uptake was computed by multiplying the phosphorus content of the samples with respective dry biomass and was expressed in phosphorus uptake in kg ha^{-1} .

3.11.2.3 K content (%) and uptake by crop

The potassium content of the fodder crop plant sample was determined by using the flame photometer.

3.12 Economics analysis

Economics for different treatments of the fodder crops were worked out on the basis of prevailing market prices.

3.12.1 Cost of cultivation

The cost of cultivation was calculated in hectares wise for each treatment by considering the cost of different inputs which include human labour, used of machinery, seed cost, fertilizers and pesticide cost, harvesting. However, the production cost does not include the value of land. The total costs were calculated by adding the expenditure involved in all kinds of operations as per treatment on per hectare basis in ₹ ha^{-1} .

3.12.2 Gross returns (₹ ha^{-1})

The gross return was worked out by considering the prevailing market price of fodder crops.

Gross return = Yield of the produce x Prevailing support price of output

3.12.3 Net returns (₹ ha⁻¹)

The net return for each treatment was calculated by using by the formula:

$$\text{Net return} = \text{Gross return} - \text{Total cost of cultivation}$$

3.12.4 Benefit: Cost ratio

The Benefit:Cost ratio (BCR) was calculated by dividing the net return with the cost of cultivation for different treatments.

$$\text{B: C Ratio} = \frac{\text{Net return}}{\text{Cost of cultivation}}$$

3.13 Statistical analysis

The experiment data were processed in Microsoft Excel - 2011 and analysed with the help of analysis of variance (ANOVA) for Randomized Block Design (RBD) as per the method suggested by Gomez and Gomez (1984). Wherever the F value was found significant, critical difference was worked out at five percent and one per cent probability levels.



Plate 1. Field preparation



Plate 2. Crop germination



Plate 3. Crop growth at 20 DAS



Plate 4. Crop growth at 40 DAS



Plate 5. Crop growth at 60 DAS



Plate 6. Crop growth at 80 DAS



Plate 7. Root nodules



Plate 8. Sole crop plot



Plate 9. M + L (1:1)



Plate 10. M + L (2:1)



Plate 11. M + L (2:2)



Plate 12. Spraying of insecticides



Plate 13. Hand picking of fall armyworm



Plate 14. Harvesting



Plate 15. Field visited by Supervisor



Plate 16. View of the experimental field



Plate 17. Sample collection





Plate 18. Laboratory analysis

CHAPTER - IV
RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The results of the present field experiment entitled **Effect of row ratio and nutrient management on performance of maize (*Zea mays* L.) based legume intercropping system**” was conducted during the *kharif* season of two consecutive years 2022-2023 and 2023-2024 at the research farm of department of agronomy, School of Agricultural sciences, Nagaland university. The field observations data and laboratory assessment data related to various treatments were tested for significance using standard statistical methods. The results of the investigation are interpreted and discussed in this chapter. The recorded data have been represented in tables and graphically depicted for more understanding and better insight of important trend.

4.1 Growth parameters (20 days interval)

4.1.1 Maize

4.1.1.1 Plant height (cm)

The data on plant height of fodder maize during 2022 and 2023 are presented in Table 5a and it was recorded at 20, 40, 60 and 80 DAS. The results revealed that intercropping system and nutrient management have a significant effect on plant height of fodder maize and the plant height was range from 30.40 cm to 322.50 cm. During the two years of investigation, the second year performed better than the first year. Among the treatments, sole maize (C₁) significantly maintained the highest plant height of fodder maize (47.85 cm, 173.46 cm, 263.30 cm and 322.50 cm at 20, 40, 60 and 80 DAS) in all the stages of observations, the second highest plant height at 20 DAS and 40 DAS was recorded from C₉ (45.89 cm and 168.44 cm) followed by C₇ (43.71 cm) at 20 DAS and C₄ (159.12 cm) at 40 DAS. However, at 60 DAS it was recorded from C₉ (250.86 cm) which was on par with C₄ (250.56 cm) and 80 DAS it was recorded from C₄ (300.96 cm) followed by C₉ (299.62 cm). The lowest plant height at 20, 40, 60 and 80 DAS was obtained at C₈ (37.33 cm, 130.36 cm, 218.40 cm and 265.61 cm) respectively

The height of fodder maize was significantly more in sole crop as compared to intercropping system. The more plant height in sole fodder maize was probably due to faster plant growth under free competition habit. These findings were also in accordance with Zaman and Malik (2000), Eskandari and Ghanbari (2009) who reported that higher plant height was recorded in sole maize as compared to plant when grown in intercropping system. The higher in plant height is due to faster growing and more extensive root system for extracting available nutrient resources in the soil. Gupta *et al.* (2019) also stated that the height of fodder maize var. African Tall recorded the highest plant under pure sole stand than growing under intercropping system. Among the various intercropping system, more plant height of fodder maize was observed under 1:1 and 2:2 row ratio. These findings were also in confirmatory with Ginwal *et al.* (2018). This might be due to impact of competition between the two crops and the nutrients contributed by the legume crops.

Among the nutrient management options, the plant height of fodder maize was significantly increased with increasing in nutrient levels (Table 5a). The fodder maize fertilized with 100 % RDF (F_2 - 60-30-30 kg ha⁻¹) produced the highest plant height of maize (47.36 cm, 165.82 cm, 272.62 cm and 312.19 cm) in all the stages of observation, which was followed by 50 % RDF (F_1 - 30-15-15 kg ha⁻¹) and the lowest plant height at 20, 40, 60 and 80 DAS (37.64 cm, 133.32 cm, 212.27 cm and 259.46 cm) was recorded in control plot (F_0 - 0-0-0 kg ha⁻¹), respectively. Many authored also claimed that plant height of fodder maize was significantly increased with each increment of nutrients application. Many researchers like Ayub *et al.* (2003a); Ali *et al.* (2012); Khan *et al.* (2014); Amanullah *et al.* (2015); Kumar *et al.* (2017); Rihab *et al.* (2015); Pual *et al.* (2019); Shams and Lamloom (2020); Pal and Kamboj (2021) also reported the increased in nitrogen dose promoted the plant height of fodder maize. They even proved that application of nitrogen at 200 kg ha⁻¹ produced the higher plant than those receiving lower dose of nitrogen. Likewise, Ayub *et al.* (2002); Jena *et al.* (2015); Pragya and Bhambri (2017); Subrahmanya *et al.* (2019); Krishna *et al.* (2022a) and Kumar *et al.* (2024) also proved that plant height of fodder maize was increase with increase in NPK doses. The higher in plant was mainly due to more availability of nutrient to the plant.

The interaction between cropping system and nutrient management was found to be statistically significant (Table 5b). The combined results revealed that crop receiving higher doses *i.e.*, 100 % recommended doses of NPK recorded the highest plant height, while control or zero application of nutrients recorded the lowest plant height of fodder maize. Among the treatment combinations, C₁F₂ recorded the highest plant height of fodder maize at 20, 40, 60 and 80 DAS (54.83 cm, 188.80 cm, 296.26 cm and 343.63 cm) and the lowest was obtained at C₈F₀. The increase in plant height at sole crop receiving 100 % RDF (F₂- 60-30-30 kg ha⁻¹) was mainly due to more obtainable nutrient and competition for light and space within them. Similarly, Asangla (2015) reported the higher plant height at 1:1 and 2:1 row ratio which received higher doses of nutrient.

4.1.1.2 Leaf area (cm²)

The result showed that combination of cropping system and nutrient management caused a significant impact on leaf area of fodder maize (Table 6a). Growing of crop together at different row ratio has positive effect on leaf area of fodder maize, the treatment C₄ recorded the highest leaf area of fodder maize at 20, 40, 60 and 80 DAS (222.74 cm², 436.23 cm², 630.84 cm² and 699.44 cm²) followed by C₅ (217.82 cm², 421.61 cm², 614.54 cm² and 688.70 cm²) respectively. At 20 DAS, the lowest value of leaf area was recorded at C₇ (205.11 cm²) which was on par with C₆ (207.65 cm²) and C₁ (209.70 cm²) respectively. However, at 40, 60 and 80 DAS, the lowest data of leaf area of fodder maize was observed at C₁ (367.45 cm², 562.22 cm², 662.88 cm²) followed by C₆ (378.65 cm², 567.72 cm², 666.72 cm²) and C₇ (379.52 cm², 577.95 cm², 664.51 cm²) respectively. The higher leaf area of fodder maize grown at 1:1 followed and 2:1 row ratio was mostly due to higher leaf length and leaf width and the least was observed at sole plot. This finding was in collateral with findings reported by Ginwal *et al.* (2019a) and Yadav *et al.* (2022a).

The nutrient management result brought a significant variation on leaf area of fodder maize (Table 6a). Among the different nutrient levels, the treatment F₂ (60-30-30 kg ha⁻¹) showed significantly the highest leaf area (250.88 cm², 481.50 cm², 689.69 cm² and 754.20 cm² at 20, 40, 60 and 80 DAS) of fodder maize in all the stages

of the observation when compared to F₀ and F₁. The lowest leaf area at 20 DAS (169.86 cm²), 40 DAS (326.30 cm²), 60 DAS (492.23 cm²) and 80 DAS (596.56 cm²) was obtained in F₀ in all the stages of observation. The higher leaf area in treatment F₂ was attributable to sufficient available of nutrients in soil which promote the vegetative growth of the plant. Similarly, this finding is in accordance with the results finds by Alie *et al.* (2012): Khan *et al.* (2014): Kumar *et al.* (2017): Subrahmanya *et al.* (2019): Krishna *et al.* (2022a).

The different nutrient levels had a significant impact at cropping system (Table 6b). The result showed that nutrient management has a various effect on leaf area of fodder maize. In all the treatment combinations, it was found that, treatments receiving higher doses of NPK *i.e.*, 100 % RDF recorded comparatively higher leaf area of fodder maize and while the lowest leaf area was obtained from treatments receiving zero nutrients application (control). The treatment combination of C₄F₂ (264.03 cm², 523.90 cm², 732.44 cm², 810.33 cm²) significantly managed the highest leaf area in all the stages of observation and followed by C₅F₂ (253.50 cm², 518.77 cm², 698.05 cm² and 777.27 cm²) at 20, 40 and 60 DAS. The lowest leaf area was recorded from C₁F₀ (159.83 cm², 295.67 cm², 446.76 cm² and 579.39 cm²) and then followed by C₆F₀ and C₇F₀ at 20, 40 60 and 80 DAS. The higher observation of leaf area of fodder maize in fodder maize intercropped with fodder cowpea and fodder rice bean along with 100 % RDF was may be due their competition for resources and adequate availability of nutrients in the soil.

4.1.1.3 Leaf to stem ratio

The leaf stem ratio of the plant was found significant under row ratio of fodder maize intercropped with fodder legume crops and results data are presented in Table 7a. The ratio was observed at 20 days interval of after sowing. At 20 DAS, the leaf stem ratio was range from 2.745 to 3.391 and the higher ratio was recorded from C₉ (3.391), while the lowest was obtained from C₇ (2.745) and which were statistically on par with C₁, C₄ and C₆. During at this stage the leaf stem ratio data recorded was high, due to more weight or growth of leaf portion than stem. However, at 40 DAS onward the data become low and ranged from 0.262 to 0.336. Among the different row

ratios, C₅ recorded the comparatively higher leaf stem ratio at 40 DAS (0.336), 60 DAS (0.453), 80 DAS (0.333) and followed by C₉ at 40 DAS (0.326), 60 DAS (0.429) and 80 DAS (0.329). The lowest leaf stem ratio was revealed from C₁ at 40 DAS (0.262), 60 DAS (0.403) and 80 DAS (0.301). The higher leaf:stem ratio was due to more leafy growth than stem. The higher leaf stem ratio of fodder maize with fodder cowpea and fodder rice bean was recorded at 1:1 and 2:2 row ratios. The higher ratio was mainly due to more leafy growth of the plant. Similarly, in 2019, Ginwal and his co-worker reported that higher leaf stem ratio of fodder maize in 1:1 row ratio.

Incase of nutrient management practices (Table 7a), it was found that the nutrient management had huge impact on leaf stem ratio of the plant and ranged from 2.613 to 2.884 at 20 DAS, but 40 DAS to 80 DAS onward, the leaf stem ratio was ranging from 0.233 to 0.536. The leaf stem ratio was increased from 40 DAS to 60 DAS, however, it was found to be decreased at 80 DAS. During investigations, F₂ (100 % NPK) recorded the highest leaf stem ratio at 20 DAS (2.884), 40 DAS (0.352), 60 DAS (0.536) and 80 DAS (0.329), while the lowest ratio of the plant obtained from F₀ (control) in all the stages of the observation *i.e.*, 20 DAS (2.613), 40 DAS (0.233), 60 DAS (0.333) and 80 DAS (0.271). The higher obtained of leaf stem ratio was mainly due to higher availability of nutrients which improved the vegetative growth of the crop. Kumar *et al.* (2016) observed also reported the higher ratio of maize plant with increased in nutrient doses. Similarly, increase in application of nutrients doses lead to produced higher leaf stem ratio (Kumar *et al.*, 2024).

The interaction effect of cropping system and nutrient management on leaf stem ratio of the plant was found statistically significant (Table 7b). The leaf stem ratio was found to be high at 20 DAS, due to higher growth of leaf more than stem part. However, from 40 days onward the leaf stem ratio was found below one and then it was increased from 40 to 60 DAS and thereon the decreased in leaf stem ratio was observed as plant grow toward maturity. At 20 DAS, the leaf stem ratio was ranging from 2.393 to 3.977, the highest and the lowest ratio among the treatments were obtained at C₉F₂ (3.977) and C₈F₀ (2.393). The leaf stem ratio at 40, 60 and 80 DAS were ranged from 0.191 to 3.94, 0.321 to 0.599 and 0.261 to 0.390. The highest leaf stem ratio was at 40 and 80 DAS was found at C₁F₂ followed by C₄F₂ and C₉F₂. Where at 60 DAS, the higher

leaf stem ratio was recorded at C₉F₂ followed by C₁F₂. The lower and comparable leaf stem ratio was observed at C₇F₀ and C₇F₀ at 40 DAS (0.207) and 80 DAS (0.261), while C₇F₀ recorded at 60 DAS (0.321) respectively. The results revealed that nutrient management had a significant impact on plant growth. In all the treatment combinations, the higher leaf stem ratio of the plant was observed from the treatments receiving full doses of NPK which improved plant growth, while control or zero application of nutrient significantly produced the lowest leaf stem ratio of the plant in compared to a treatment receiving nutrients.

4.1.1.4 Fresh weight of plant (g plant⁻¹)

The result revealed that combinations of cropping system with nutrient management on fodder maize intercrop with fodder legume had significant impact on fresh weight of the plant (Table 8a). The wide variation in fresh weight of the plant was observed during the period of observations. At 20 DAS, the fresh weight of the plant was around 20.6 g plant⁻¹ to 26.16 g plant⁻¹, the highest fresh weight was recorded at C₄ (26.16 g plant⁻¹), followed by C₅ (23.22 g plant⁻¹) and the lowest was obtained at C₁ (20.60 g plant⁻¹), which was statistically on par with C₆ (20.89 g plant⁻¹) and C₇ (20.95 g plant⁻¹). However, from 40 DAS onward, there was a drastic increased in fresh weight of the plant as the plant grow toward physiological maturity. At 40 DAS, the highest fresh weight was observed in C₄ (216.95 g plant⁻¹) and C₅ (204.96 g plant⁻¹), while the lowest fresh weight was recorded in C₁ (175.55 g plant) and C₆ (180.16 g plant⁻¹) respectively. The C₄ maintained the highest fresh weight of the plant at 60 DAS (538.11 g plant⁻¹) and 80 DAS (808.24 g plant⁻¹) and followed by C₅ (527.22 g plant⁻¹, 782.79 g plant⁻¹) and C₇ (510.24 g plant⁻¹, 771.02 g plant⁻¹). The lowest fresh weight of the plant at 60 DAS was observed in C₁ (500.27 g plant⁻¹) followed by C₈ (502.27 g plant⁻¹), C₆ (503.80 g plant⁻¹), C₉ (505.27 g plant⁻¹) and for 80 DAS, it was recorded at C₈ (741.45 g plant⁻¹) and C₉ (744.30 g plant⁻¹). Among the different row ratio, the higher fresh was observed in 1:1 and 2:2 row ratio as compared to sole crop. This was probably due to more suitable companion between the two crops.

The fresh weight of the plant was ranged from 14.14 g plant⁻¹ to 818.26 g plant⁻¹ (Table 8a). Among the nutrient management, F₂ (100 % RDF *i.e.*, NPK) recorded

significantly the highest fresh weight of the plant at 20 DAS (25.71 g plant⁻¹), 40 DAS (237.83 g plant⁻¹), 60 DAS (620.50 g plant⁻¹) and 80 DAS (818.26 g plant⁻¹) in comparison with the treatments receiving 50 % RDF of NPK and control. The lowest fresh among the different levels of nutrient management was recorded in F₀ in all the stages of the observation *i.e.*, 20 DAS (14.14 g plant⁻¹), 40 DAS (133.41 g plant⁻¹), 60 DAS (373.67 g plant⁻¹) and 80 DAS (551.53 g plant⁻¹) respectively. The obtained of higher fresh weight plant⁻¹ in F₂ (100 % RDF) treatment was due to sufficient supply of nutrients for their vegetative growth and this finding was in compliance with Bhaumik *et al.* (2023). Rihab *et al.* (2015) also reported that application of nutrient at higher doses significantly registered higher fresh weight plant⁻¹ in all the stages of the observations. The studied on different level of NP on growth parameters of maize registered higher dry weight of maize in the application of nutrient at 150-60 kg ha⁻¹ than 130-50, 110-40 and 90-30 kg ha⁻¹ (Panwar *et al.*, 2020).

The interaction of the treatments was statistically significant in all the stages of the observation (Table 8b). The interaction results showed that nutrients have a significant role in plant growth and development. From the results it was observed that intercropping of fodder maize with fodder legume grown under fertilizers application produced better growth and development of the plant than the plant growth under control. Comparison of all the treatment combinations between intercropping of fodder maize + fodder legume with nutrient management, the highest fresh weight of the plant was recorded in C₄F₂ (37.12 g plant⁻¹) and C₅F₂ (30.17 g plant⁻¹), C₈F₂ (28.92 g plant⁻¹), while the lowest fresh weight was seen in C₁F₀ (14.99 g plant⁻¹) and C₆F₀ (15.09 g plant⁻¹) at 20 DAS. From 40 DAS (271.91 g plant⁻¹), 60 DAS (654.45 g plant⁻¹) and 80 DAS, the treatment C₄F₂ (959.34 g plant⁻¹) recorded the highest fresh weight of the plant and which was followed by C₅F₂ at 40 DAS (255.14 g plant⁻¹), 60 DAS (648.91 g plant⁻¹) and 80 DAS (929.55 g plant⁻¹). The lowest fresh weight of the plant at 40 DAS (141.29 g plant⁻¹, 144.52 g plant⁻¹) was recorded at C₁F₀ and C₈F₀, while C₆F₀ and C₁F₀ registered the lowest fresh weight at 60 DAS (410.96 g plant⁻¹, 413.88 g plant⁻¹) and then at 80 DAS it was obtained from C₈F₀ (595.13 g plant⁻¹) and C₉F₀ (602.75 g plant⁻¹), respectively.

4.1.1.5 Dry weight of plant (g plant⁻¹)

The result (Table 9a) of intercropping of fodder maize with fodder legume at different row ratio showed significant impact on dry weight of the plant. Among the different row ratio, C₄ (3.76 g plant⁻¹) and C₅ (3.41 g plant⁻¹) showed the highest dry weight of the plant at 20 DAS, while C₁, C₆, and C₇ recorded the lowest dry weight of the plant. The treatment C₄ recorded the highest dry weight (32.07 g plant⁻¹, 100.81 g plant⁻¹, 198.38 g plant⁻¹) at 40 DAS, 60 DAS and 80 DAS, then it was followed by C₅ (30.18 g plant⁻¹, 97.80 g plant⁻¹, 188.24 g plant⁻¹). The lowest dry weight was recorded from C₁ at 40 DAS (25.63 g plant⁻¹), 60 DAS (90.31 g plant⁻¹) and 80 DAS (174.49 g plant⁻¹) and followed by C₈ at 40 DAS (26.06 g plant⁻¹), 60 DAS (90.83 g plant⁻¹) and 80 DAS (176.32 g plant⁻¹). The higher dry weight of the fodder maize was likely due to higher fresh weight of plant.

Among the nutrient management, the dry weight of the plant in each treatment were statistically differed from each. The result (Table 9a) revealed that treatment receiving higher doses of NPK produced significantly the higher dry weight of the plant. During investigation period, the second year of observation performed much better than first in all the stages of the observation. During the different stages of observation, the highest dry weight of the plant was recorded from F₂ at 20 DAS (4.01 g plant⁻¹), 40 DAS (35.85 g plant⁻¹), 60 DAS (112.44 g plant⁻¹), 80 DAS (248.39 g plant⁻¹) and while the lowest dry weight was observed from F₀ in all the stages of observation *i.e.*, 20 DAS (2.69 g plant⁻¹), 40 DAS (19.05 g plant⁻¹), 60 DAS (80.77 g plant⁻¹) and 80 DAS (127.87 g plant⁻¹) respectively. Application of nutrient at 100 % RDF improve the growth and development of the plant, which lead to accumulation of higher dry weight as compared to 50 % RDF and 0 % RDF. In the same way, Kumar *et al.* (2017) observed the higher shoot dry matter accumulation plant⁻¹ at 100 % RDF of nitrogen than at 70 % RDF. Kumar *et al.* (2018) reported the higher dry weight of the plant⁻¹ at 125 kg ha⁻¹ N than 0, 75 and 100 kg ha⁻¹ N. Panwar *et al.* (2020) studied the different levels of NP on growth parameters of maize and found that application of nutrient at 150:60 kg ha⁻¹ produced higher dry weight than 130-50, 110-40 and 90-30 kg ha⁻¹.

The result of the interaction displayed that intercropping of fodder maize with fodder legume had a significant effect on dry weight production of the plant (Table 9b). At 20 DAS, the treatment C₄F₂ (4.63 g plant⁻¹) recorded the highest dry weight of plant followed by C₅F₂ (4.25 g plant⁻¹), from then on the higher dry weight was maintained by C₄F₂ and C₅F₂ at 40 DAS (40.66 g plant⁻¹, 39.31 g plant⁻¹), 60 DAS (126.16 g plant⁻¹, 122.78 g plant⁻¹), 80 DAS (273.60 g plant⁻¹, 251.34 g plant⁻¹) and then which was followed by C₉F₂, C₈F₂ and C₆F₂ respectively. The lowest dry weight of the plant was recorded in C₁F₀ (2.52 g plant⁻¹), C₆F₀ (2.53 g plant⁻¹) and C₉F₀ (2.55 g plant⁻¹) at 20 DAS. At 40 DAS, the lowest dry weight was recorded from C₁F₀ (20.20 g plant⁻¹) followed by C₇F₀ (20.27 g plant⁻¹), C₆F₀ (20.59 g plant⁻¹), C₈F₀ (20.73 g plant⁻¹), thereafter the lowest dry weight at 60 DAS was recorded from C₆F₀ (70.63 g plant⁻¹), C₁F₀ (76.21 g plant⁻¹) and C₈F₀ (76.42 g plant⁻¹), while C₁F₀ (116.72 g plant⁻¹) and C₈F₀ (119.72 g plant⁻¹) maintained the lowest dry weight of the plant at 80 DAS, respectively.

4.1.1.6 Number of leaves plant⁻¹

The result (Table 10a) showed that significantly the higher number of leaves plant⁻¹ was counted from C₁ at 20 DAS (6.43), 40 DAS (8.79), 60 DAS (12.09) and 80 DAS (13.74) respectively and which was followed by C₉ and C₄ at 20 DAS (6.39, 6.38) and 40 DAS, it was observed at C₄ (8.74) and C₅ (8.61). At 60 and 80 DAS, it was recorded from C₅ (12.00, 13.35) and C₄ (11.75, 13.30). The lowest number of leaves plant⁻¹ were counted at C₅ (6.21) and C₈ (6.22) at 20 DAS, while C₈ (8.54) and C₉ (8.52) at 40 DAS. At 60 DAS and 80 DAS, the lowest number of leaves plant⁻¹ was observed at C₈ (11.53, 13.22) and C₇ (11.63, 13.26). Among the different row ratio, intercropping of fodder maize with fodder legume at 1:1 and 2:2 produced higher number of leaves plant⁻¹. Similarly, more numbers of leaves plant⁻¹ in sole crop were reported by Gupta *et al.* (2019). Ginwal *et al.* (2019b) claimed the higher number of leaves plant⁻¹ of fodder maize was registered when it was grown with legume crop at 1:1 row ratio as compared to 2:1 row ratio.

The nutrient management result showed that nutrient application had a significant impact on number of leaves plant⁻¹ (Table 10a) and also revealed that treatments receiving higher doses of NPK performed better than control. Among the

nutrient management, F₂ recorded the highest number of leaves plant⁻¹ in all the stages of observation (*i.e.*, 6.88, 9.96, 13.27 and 14.54 at 20, 40, 60 and 80 DAS) and the lowest number of leaves plant⁻¹ (5.67, 7.34, 10.16 and 12.05) in all the stages of the observation was found in F₀ (control). The more numbers of leaves plant⁻¹ was mostly due to adequate amount on nutrient availability in soil which contributed to higher number of leaves formation of the plant. Hnamte *et al.* (2016) studied the effect of different doses of NPK on growth parameters of maize and found that application of NPK @ 120-60-40 kg ha⁻¹ counted the highest numbers of leaves plant⁻¹. This finding was in collateral with Pual *et al.* (2019) Subrahmanya *et al.* (2019) and Pal and Kamboj (2021), who reported that higher application of nutrients produced higher number of leaves plant⁻¹. Kumar *et al.* (2022) studied the effect of nutrient management on growth parameters of African Tall maize variety and found that application of NPK @ 120:60:40 kg ha⁻¹ recorded the highest numbers of leaves plant⁻¹.

The interaction of both factors was also counted significantly (Table 9b). The highest number of leaves plant⁻¹ was counted at C₄F₂ (7.17), C₁F₂ (7.05) and C₉F₂ (7.02) and the lowest was recorded at C₄F₀ (5.40), C₅F₀ (5.55) and C₈F₀ (5.69) at 20 DAS. Treatment C₁F₂ produced the highest number of leaves plant⁻¹ at 40 DAS (10.22), 60 DAS (13.71) and 80 DAS (14.73), which was followed by C₄F₂ (10.08) and C₅F₂ (9.97) at 40 DAS and 60 DAS at C₅F₂ (13.56) and C₄F₂ (13.40), while C₉F₂ (14.60) and C₅F₂ (14.58) recorded the highest at 80 DAS. The lowest number of leaves plant⁻¹ at 40 DAS was recorded at C₈F₀ (7.23), C₉F₀ (7.24) and C₆F₀ (7.27). Furthermore, the lowest of number leaves plant⁻¹ at 60 DAS and 80 DAS was counted at C₇F₀ (9.93, 11.88), C₆F₀ (10.12, 11.92), C₄F₀ (10.12, 11.95) and C₈F₀ (10.20, 11.93) respectively. Application of nutrient at 100 % RDF in 1:1 and 2:2 row ratio gave the best combination interaction results. The higher number of leaves plant⁻¹ was primarily owing to positive interaction between the two crops and sufficient available nutrient to the plant. This finding was in accordance with Asangla (2015).

4.1.1.7 Stem girth of maize (cm)

The stem girth of the plant was found statistically significant (Table 11a) and the girth ranged from 2.69 cm to 7.04 cm from 20 DAS onward to 80 DAS. The

largest stem girth of the plant was observed in C₁ and C₉ at 20 DAS (2.96 cm, 2.92 cm), 40 DAS (4.82 cm, 4.78 cm), 60 DAS (6.17 cm, 6.13 cm) and 80 DAS (7.04 cm, 7.02 cm) which was followed by C₆ (2.82 cm) at 20 DAS, from then C₄ and C₈ at 60 DAS, while C₄ and C₆ at 40 DAS and 80 DAS respectively. The statistically comparable and smaller girth of the plant at 20 DAS was recorded in C₅ (2.69 cm), C₆ (6.00 cm) at 60 DAS, while C₈ (4.65 cm, 6.83 cm) recorded at 40 and 80 DAS. Correspondingly, Gupta *et al.* (2019) reported the larger stem girth at sole crop. However, between different row ratios, the larger stem girth was observed at 1:1 and 2:1 row ratio. Likewise, Ginwal *et al.* (2019a) reported the larger stem of fodder maize at 1:1 row ratio.

The stem girth of the plant differed with different level of nutrient management (Table 11a). The nutrient applied at 100 % RDF of NPK recorded the largest stem girth (2.92 cm, 5.39 cm, 6.92 cm and 7.29 cm) among the treatment as more availability of nutrient to the plant. While F₀ (control) recorded the smallest stem girth (2.27 cm, 3.59 cm, 5.13 cm and 6.51 cm) of the plant in all stages (20, 40, 60 and 80 DAS) of the observation due to insufficient supply of nutrient for their growth. Similar finding of larger stem girth of maize which higher doses of nutrients was also reported Panwar *et al.* (2020): Kumar *et al.* (2019) claimed that higher application of nutrients at 150 % RDF produced larger stem of the fodder maize. Law-ogbomo *et al.* (2009) carried out the field trial to estimate the effect of NPK on maize. They found that application of NPK @ 60.00-27.16-49.80 kg ha⁻¹ produced larger stem girth of the plant.

The results (Table 11b) in interaction showed that both the factor *i.e.*, different row ratio and nutrient management had significant effect on stem girth of the plant. In interaction it was found that nutrient application produced comparatively larger stem girth than control treatments. The stem girth ranged from 2.12 cm to 3.38 cm at 20 DAS, 3.9 cm to 5.53 cm at 40 DAS, 4.95 cm to 6.95 cm at 60 DAS and 6.35 cm to 7.4 cm 80 DAS. Among all the treatment combinations, C₁F₁ recorded the largest stem girth at 20 DAS (3.38 cm), 40 DAS (5.53 cm) and 80 DAS (7.40 cm), which were on par with C₆F₂ at 20 and C₄F₂ at 40 DAS and 80 DAS. However, at 60 DAS, the largest stem girth was recorded at C₆F₂ (6.95 cm) and it was on par with C₄F₂ (6.93 cm) and C₉F₂ (6.93 cm). The smallest stem girth was observed at different treatments at

different stages of the growth. The smaller stem girth of the plant was obtained at C₈F₀ (2.12 cm), C₅F₀ (2.25 cm) and C₆F₀ (2.25 cm) at 20 DAS, C₅F₀ (3.9 cm), C₄F₀ (4.03 cm), C₇F₀ (4.03 cm) and C₈F₀ (4.05 cm) at 40 DAS. At 60 DAS, it was recorded at C₈F₀ (4.95 cm), C₆F₀ (5.00 cm) and C₄F₀ (5.08 cm) and for at 80 DAS, it was recorded at C₈F₀ (6.35 cm), C₆F₀ (6.55 cm) and C₅F₀ (6.43 cm), respectively.

Table 5a. Effect of row ratio and nutrient management on plant height of maize

Treatments	Plant height (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system (C)												
C ₁ - Sole Maize (M)	44.22	51.48	47.85	170.82	176.09	173.46	247.22	279.38	263.30	309.68	335.33	322.50
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	40.89	42.26	41.57	162.73	155.50	159.12	235.31	265.80	250.56	279.82	322.10	300.96
C ₅ - M + R (1:1)	32.77	46.79	39.78	131.49	142.49	136.99	223.99	258.99	241.49	278.22	289.49	283.86
C ₆ - M + C (2:1)	40.09	42.81	41.45	133.19	134.28	133.73	214.06	255.34	234.70	228.02	304.61	266.32
C ₇ - M + R (2:1)	38.93	48.49	43.71	136.32	146.01	141.16	226.71	258.69	242.70	244.76	295.26	270.01
C ₈ - M + C (2:2)	30.48	44.18	37.33	121.80	138.92	130.36	194.36	242.43	218.40	242.66	288.56	265.61
C ₉ - M + R (2:2)	44.11	47.66	45.89	167.69	169.18	168.44	233.07	268.66	250.86	278.81	320.43	299.62
SEm±	0.26	0.38	0.23	1.23	1.21	0.86	2.26	2.09	1.54	2.02	1.77	1.34
CD (P=0.05)	0.73	1.07	0.64	3.49	3.44	2.42	6.41	5.93	4.31	5.73	5.01	3.76
2. Nutrient management (F)												
F ₀ - Control	34.30	40.98	37.64	127.77	138.87	133.32	195.39	229.14	212.27	239.62	279.30	259.46
F ₁ - 50 % NPK	38.69	46.39	42.54	146.60	149.32	147.96	229.30	259.79	244.55	267.36	311.23	289.29
F ₂ - 100 % NPK	43.36	51.35	47.36	164.50	167.15	165.82	250.18	295.05	272.62	291.00	333.37	312.19
SEm±	0.15	0.22	0.13	0.71	0.70	0.50	1.30	1.21	0.89	1.17	1.02	0.77
CD (P=0.05)	0.42	0.62	0.37	2.02	1.98	1.40	3.70	3.42	2.49	3.31	2.89	2.17

Table 5b. Interaction effect of row ratio and nutrient management on plant height of maize

Interaction (C x F)	Plant height (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	38.73	41.71	40.22	147.00	151.03	149.01	190.73	259.77	225.25	274.66	305.33	290.00
C ₁ F ₁	43.80	53.20	48.50	182.40	182.72	182.56	265.33	271.45	268.39	322.70	338.39	330.54
C ₁ F ₂	50.13	59.53	54.83	183.07	194.54	188.80	285.60	306.93	296.26	331.67	362.27	346.97
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	36.97	37.53	37.25	141.50	147.25	144.37	193.00	243.27	218.13	231.07	303.73	267.40
C ₄ F ₁	40.96	42.03	41.50	173.00	151.03	162.01	248.00	269.98	258.99	298.10	328.97	313.53
C ₄ F ₂	44.73	47.22	45.98	173.70	168.22	170.96	264.93	284.17	274.55	310.30	333.60	321.95
C ₅ F ₀	30.07	41.20	35.63	130.57	135.44	133.01	204.77	222.10	213.43	265.73	253.33	259.53
C ₅ F ₁	32.77	47.44	40.10	131.57	141.73	136.65	227.10	253.53	240.32	278.73	304.47	291.60
C ₅ F ₂	35.47	51.73	43.60	132.33	150.29	141.31	240.10	301.35	270.72	290.20	310.67	300.43
C ₆ F ₀	35.93	38.53	37.23	112.00	116.75	114.38	192.87	212.60	202.73	216.30	277.27	246.78
C ₆ F ₁	39.33	42.64	40.99	122.90	134.19	128.54	210.37	249.32	229.84	217.13	305.60	261.37
C ₆ F ₂	45.00	47.27	46.13	164.67	151.89	158.28	238.93	304.10	271.52	250.63	330.97	290.80
C ₇ F ₀	34.80	44.61	39.71	110.71	128.06	119.38	201.60	226.60	214.10	217.55	271.27	244.41
C ₇ F ₁	38.87	47.53	43.20	121.35	131.66	126.51	224.27	259.71	241.99	242.37	285.27	263.82
C ₇ F ₂	43.13	53.33	48.23	176.90	178.31	177.61	254.27	289.77	272.02	274.37	329.23	301.80
C ₈ F ₀	23.27	40.87	32.07	93.70	133.49	113.60	171.63	207.67	189.65	204.07	252.80	228.43
C ₈ F ₁	30.23	44.67	37.45	133.27	141.18	137.23	197.47	243.57	220.52	237.57	289.30	263.43
C ₈ F ₂	37.93	47.00	42.47	138.43	142.07	140.25	213.98	276.07	245.02	286.33	323.57	304.95
C ₉ F ₀	40.33	42.39	41.36	158.93	160.07	159.50	213.13	231.99	222.56	267.97	291.40	279.68
C ₉ F ₁	44.87	47.21	46.04	161.73	162.77	162.25	232.60	271.00	251.80	274.93	326.60	300.77
C ₉ F ₂	47.13	53.40	50.27	182.40	184.71	183.55	253.47	303.00	278.23	293.53	343.30	318.42
SEm±	0.44	0.65	0.39	2.13	2.10	1.50	3.91	3.62	2.66	3.50	3.06	2.32
CD (P=0.05)	1.26	1.85	1.11	6.05	5.95	4.19	11.10	10.27	7.47	9.92	8.68	6.51

Table 6a. Effect of row ratio and nutrient management on leaf area of maize

Treatments	Leaf area (cm ² plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system (C)												
C ₁ - Sole Maize (M)	192.61	226.78	209.70	306.89	428.00	367.45	544.39	580.06	562.22	628.80	696.97	662.88
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	209.39	236.10	222.74	418.14	454.32	436.23	579.40	682.29	630.84	654.78	744.10	699.44
C ₅ - M + R (1:1)	203.40	232.24	217.82	395.10	448.12	421.61	564.18	664.91	614.54	645.25	732.16	688.70
C ₆ - M + C (2:1)	201.05	214.25	207.65	318.45	438.85	378.65	545.41	590.04	567.72	629.30	704.13	666.72
C ₇ - M + R (2:1)	187.39	222.83	205.11	328.38	430.67	379.52	555.01	600.88	577.95	626.55	702.47	664.51
C ₈ - M + C (2:2)	201.42	225.93	213.68	381.66	433.22	407.44	552.96	630.98	591.97	630.36	706.62	668.49
C ₉ - M + R (2:2)	200.67	228.19	214.43	362.52	441.12	401.82	557.90	656.90	607.40	642.41	714.80	678.60
SEm±	1.93	1.85	1.34	2.08	2.46	1.61	2.43	2.54	1.76	4.80	5.34	3.59
CD (P=0.05)	5.48	5.24	3.75	5.89	6.98	4.51	6.90	7.21	4.93	13.62	15.16	10.07
2. Nutrient management (F)												
F ₀ - Control	159.28	180.44	169.86	296.83	355.76	326.30	462.64	521.82	492.23	564.05	629.07	596.56
F ₁ - 50 % NPK	200.37	236.26	218.32	347.03	431.12	389.08	562.88	632.69	597.78	635.62	716.59	676.10
F ₂ - 100 % NPK	238.60	263.15	250.88	432.34	530.67	481.50	645.58	733.80	689.69	710.67	797.73	754.20
SEm±	1.11	1.07	0.77	1.20	1.42	0.93	1.40	1.47	1.02	2.77	3.08	2.07
CD (P=0.05)	3.16	3.03	2.16	3.40	4.03	2.61	3.99	4.17	2.85	7.86	8.75	5.81

Table 6b. Interaction effect of row ratio and nutrient management on leaf area of maize

Interaction (C x F)	Leaf area (cm ² plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	154.07	165.59	159.83	266.72	324.63	295.67	442.93	450.59	446.76	555.84	602.94	579.39
C ₁ F ₁	198.92	240.29	219.60	268.06	421.04	344.55	562.07	592.13	577.10	637.02	710.58	673.80
C ₁ F ₂	224.84	274.46	249.65	385.90	538.33	462.11	628.17	697.45	662.81	693.54	777.38	735.46
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	171.15	180.97	176.06	336.09	366.13	351.11	480.88	562.95	521.92	585.60	607.20	596.40
C ₄ F ₁	211.67	244.60	228.14	410.64	456.72	433.68	599.95	676.40	638.17	652.65	730.55	691.60
C ₄ F ₂	245.35	282.72	264.03	507.68	540.11	523.90	657.36	807.52	732.44	726.10	894.56	810.33
C ₅ F ₀	171.15	183.88	177.52	312.30	353.87	333.08	490.19	606.69	548.44	525.80	681.08	603.44
C ₅ F ₁	204.43	240.48	222.46	376.07	449.87	412.97	534.75	659.52	597.13	629.90	740.91	685.41
C ₅ F ₂	234.63	272.36	253.50	496.93	540.62	518.77	667.59	728.52	698.05	780.05	774.49	777.27
C ₆ F ₀	152.73	172.64	162.69	252.27	350.04	301.15	459.57	494.40	476.99	593.00	615.67	604.33
C ₆ F ₁	198.63	224.02	211.32	321.43	426.21	373.82	529.83	584.66	557.24	624.53	692.91	658.72
C ₆ F ₂	251.79	246.09	248.94	381.67	540.29	460.98	646.82	691.06	668.94	670.38	803.80	737.09
C ₇ F ₀	147.43	182.01	164.72	286.63	361.35	323.99	491.02	456.24	473.63	549.13	624.57	586.85
C ₇ F ₁	186.61	234.67	210.64	311.36	421.52	366.44	559.19	626.17	592.68	640.22	704.62	672.42
C ₇ F ₂	228.11	251.82	239.97	387.16	509.13	448.14	614.83	720.23	667.53	690.31	778.22	734.27
C ₈ F ₀	161.05	186.52	173.78	331.40	367.17	349.29	394.87	531.48	463.18	554.94	633.24	594.09
C ₈ F ₁	196.95	232.42	214.69	371.95	410.77	391.36	595.31	638.84	617.07	617.32	718.53	667.93
C ₈ F ₂	246.27	258.85	252.56	441.62	521.71	481.67	668.72	722.62	695.67	718.81	768.08	743.45
C ₉ F ₀	157.39	191.46	174.43	292.43	367.14	329.79	479.05	550.37	514.71	584.06	638.80	611.43
C ₉ F ₁	205.38	237.33	221.36	369.72	431.73	400.72	559.06	651.12	605.09	647.68	718.01	682.84
C ₉ F ₂	239.23	255.78	247.50	425.41	524.49	474.95	635.61	769.20	702.40	695.50	787.58	741.54
SEm±	3.34	3.20	2.31	3.60	4.26	2.79	4.21	4.40	3.05	8.31	9.25	6.22
CD (P=0.05)	9.49	9.08	6.49	10.20	12.09	7.82	11.96	12.50	8.55	23.58	26.25	17.44

Table 7a. Effect of row ratio and nutrient management on leaf stem ratio of maize

Treatments	Leaf stem ratio											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	2.900	2.605	2.752	0.222	0.303	0.262	0.428	0.378	0.403	0.300	0.302	0.301
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	2.895	2.630	2.762	0.308	0.311	0.310	0.436	0.417	0.426	0.315	0.319	0.317
C ₅ - M + R (1:1)	3.059	2.811	2.935	0.337	0.335	0.336	0.467	0.438	0.453	0.324	0.342	0.333
C ₆ - M + C (2:1)	2.921	2.628	2.774	0.258	0.321	0.290	0.440	0.385	0.412	0.306	0.307	0.307
C ₇ - M + R (2:1)	2.790	2.699	2.745	0.259	0.290	0.274	0.443	0.379	0.411	0.314	0.312	0.313
C ₈ - M + C (2:2)	3.258	2.646	2.952	0.261	0.354	0.307	0.435	0.385	0.410	0.300	0.304	0.302
C ₉ - M + R (2:2)	4.036	2.747	3.391	0.323	0.328	0.326	0.462	0.395	0.429	0.328	0.330	0.329
SEm±	0.048	0.021	0.026	0.003	0.004	0.003	0.005	0.005	0.004	0.004	0.002	0.002
CD (P=0.05)	0.138	0.059	0.074	0.009	0.011	0.007	0.015	0.014	0.010	0.010	0.006	0.006
2. Nutrient management												
F ₀ - Control	2.821	2.404	2.613	0.202	0.265	0.233	0.347	0.318	0.333	0.268	0.273	0.271
F ₁ - 50 % NPK	3.062	2.563	2.813	0.299	0.333	0.316	0.407	0.378	0.393	0.301	0.304	0.302
F ₂ - 100 % NPK	3.377	2.392	2.884	0.342	0.363	0.352	0.579	0.493	0.536	0.368	0.290	0.329
SEm±	0.029	0.012	0.016	0.002	0.002	0.001	0.003	0.003	0.002	0.002	0.001	0.001
CD (P=0.05)	0.082	0.034	0.044	0.005	0.007	0.004	0.009	0.008	0.006	0.006	0.003	0.003

Table 7b. Interaction effect of row ratio and nutrient management on leaf stem ratio of maize

Interaction (C x F)	Leaf stem ratio											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	2.784	2.659	2.721	0.247	0.275	0.261	0.371	0.328	0.349	0.267	0.282	0.275
C ₁ F ₁	2.646	2.307	2.476	0.360	0.346	0.353	0.421	0.411	0.416	0.329	0.338	0.334
C ₁ F ₂	3.269	2.851	3.060	0.405	0.384	0.394	0.611	0.574	0.592	0.376	0.404	0.390
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	2.586	2.301	2.444	0.256	0.252	0.254	0.350	0.325	0.337	0.269	0.270	0.269
C ₄ F ₁	2.882	2.470	2.676	0.280	0.302	0.291	0.396	0.355	0.376	0.300	0.305	0.303
C ₄ F ₂	3.215	3.118	3.166	0.389	0.380	0.385	0.562	0.505	0.533	0.377	0.383	0.380
C ₅ F ₀	3.017	2.461	2.739	0.091	0.292	0.191	0.337	0.322	0.329	0.260	0.262	0.261
C ₅ F ₁	3.134	2.672	2.903	0.242	0.337	0.289	0.409	0.378	0.393	0.280	0.285	0.282
C ₅ F ₂	3.025	3.299	3.162	0.333	0.280	0.307	0.558	0.455	0.507	0.360	0.358	0.359
C ₆ F ₀	2.820	2.567	2.693	0.191	0.255	0.223	0.342	0.329	0.336	0.265	0.271	0.268
C ₆ F ₁	2.860	2.399	2.629	0.275	0.325	0.300	0.405	0.390	0.398	0.285	0.288	0.286
C ₆ F ₂	3.082	2.920	3.001	0.309	0.382	0.345	0.571	0.435	0.503	0.369	0.361	0.365
C ₇ F ₀	2.758	2.276	2.517	0.171	0.242	0.207	0.344	0.297	0.321	0.278	0.280	0.279
C ₇ F ₁	2.868	2.636	2.752	0.289	0.307	0.298	0.418	0.360	0.389	0.297	0.295	0.296
C ₇ F ₂	2.745	3.184	2.965	0.316	0.320	0.318	0.566	0.479	0.523	0.365	0.361	0.363
C ₈ F ₀	2.646	2.140	2.393	0.190	0.264	0.227	0.335	0.318	0.326	0.263	0.266	0.265
C ₈ F ₁	3.244	2.692	2.968	0.301	0.376	0.339	0.393	0.380	0.386	0.283	0.285	0.284
C ₈ F ₂	3.884	3.107	3.495	0.291	0.421	0.356	0.556	0.435	0.496	0.353	0.360	0.357
C ₉ F ₀	3.139	2.423	2.781	0.269	0.274	0.271	0.348	0.310	0.329	0.276	0.281	0.279
C ₉ F ₁	4.066	2.767	3.416	0.348	0.339	0.344	0.409	0.372	0.391	0.329	0.329	0.329
C ₉ F ₂	4.902	3.052	3.977	0.353	0.371	0.362	0.628	0.569	0.599	0.379	0.379	0.379
SEm±	0.084	0.036	0.046	0.006	0.007	0.004	0.009	0.008	0.006	0.006	0.004	0.004
CD (P=0.05)	0.238	0.102	0.128	0.016	0.020	0.013	0.026	0.024	0.017	0.017	0.010	0.010

Table 8a. Effect of row ratio and nutrient management on fresh weight of maize

Treatments	Fresh weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	19.00	22.20	20.60	169.65	181.45	175.55	475.68	524.87	500.27	754.67	763.89	759.28
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	27.12	25.19	26.16	206.50	227.41	216.95	518.72	557.49	538.11	799.57	816.91	808.24
C ₅ - M + R (1:1)	22.42	24.02	23.22	197.09	212.82	204.96	502.22	552.22	527.22	773.62	791.95	782.79
C ₆ - M + C (2:1)	18.82	22.97	20.89	171.33	188.98	180.16	476.41	531.19	503.80	753.67	766.45	760.06
C ₇ - M + R (2:1)	19.51	22.39	20.95	187.86	184.21	186.03	483.46	537.02	510.24	766.46	775.58	771.02
C ₈ - M + C (2:2)	20.90	22.77	21.84	187.86	193.94	190.90	477.77	526.77	502.27	734.28	748.61	741.45
C ₉ - M + R (2:2)	20.19	22.99	21.59	189.92	199.89	194.90	477.53	533.01	505.27	738.85	749.74	744.30
SEm±	0.20	0.18	0.13	1.15	1.30	0.87	2.72	3.06	2.05	2.73	2.25	1.77
CD (P=0.05)	0.57	0.50	0.37	3.26	3.70	2.43	7.71	8.69	5.74	7.76	6.38	4.96
2. Nutrient management												
F ₀ - Control	15.32	12.95	14.14	144.41	122.42	133.41	407.55	339.80	373.67	617.07	485.98	551.53
F ₁ - 50 % NPK	20.50	22.36	21.43	142.15	196.43	169.29	472.32	516.99	494.65	752.41	767.12	759.77
F ₂ - 100 % NPK	27.59	23.83	25.71	234.34	241.33	237.83	582.33	658.66	620.50	708.56	927.96	818.26
SEm±	0.12	0.10	0.08	0.66	0.75	0.50	1.57	1.77	1.18	1.58	1.30	1.02
CD (P=0.05)	0.33	0.29	0.22	1.88	2.13	1.41	4.45	5.02	3.31	4.48	3.68	2.87

Table 8b. Interaction effect of row ratio and nutrient management on fresh weight of maize

Interaction (C x F)	Fresh weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	0.00	16.08	14.99	138.12	144.46	141.29	406.52	421.24	413.88	608.93	613.26	611.09
C ₁ F ₁	19.15	20.93	20.04	170.57	182.97	176.77	453.10	517.88	485.49	749.60	746.27	747.93
C ₁ F ₂	23.93	29.61	26.77	200.27	216.93	208.60	567.41	635.47	601.44	905.48	932.15	918.82
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	16.87	16.72	16.79	157.87	176.93	167.40	416.03	462.69	439.36	647.81	666.15	656.98
C ₄ F ₁	24.87	24.24	24.55	195.63	227.47	211.55	497.17	543.84	520.50	793.40	823.40	808.40
C ₄ F ₂	39.63	34.61	37.12	266.00	277.83	271.91	642.95	665.95	654.45	957.51	961.18	959.34
C ₅ F ₀	17.33	18.44	17.89	159.77	164.72	162.24	407.62	447.96	427.79	626.19	638.86	632.53
C ₅ F ₁	20.73	22.49	21.61	188.61	206.37	197.49	478.13	531.80	504.97	776.29	796.29	786.29
C ₅ F ₂	29.20	31.13	30.17	242.90	267.37	255.14	620.91	676.91	648.91	918.38	940.72	929.55
C ₆ F ₀	14.62	15.56	15.09	134.10	156.83	145.47	406.13	415.79	410.96	618.20	615.20	616.70
C ₆ F ₁	18.97	22.79	20.88	171.03	193.17	182.10	469.05	499.72	484.39	748.24	764.90	756.57
C ₆ F ₂	22.87	30.55	26.71	208.87	216.93	212.90	554.06	678.06	616.06	894.57	919.24	906.91
C ₇ F ₀	15.37	16.41	15.89	139.87	155.24	147.55	407.39	439.72	423.56	628.17	634.83	631.50
C ₇ F ₁	18.93	21.44	20.19	184.00	185.30	184.65	467.87	524.54	496.21	754.36	768.36	761.36
C ₇ F ₂	24.23	29.32	26.77	239.70	212.08	225.89	575.13	646.80	610.96	916.87	923.54	920.20
C ₈ F ₀	14.00	16.64	15.32	139.87	149.17	144.52	403.56	424.90	414.23	591.30	598.96	595.13
C ₈ F ₁	20.50	22.05	21.28	184.00	181.70	182.85	464.68	486.68	475.68	716.14	728.47	722.30
C ₈ F ₂	28.20	29.63	28.92	239.70	250.94	245.32	565.05	668.72	616.88	895.41	918.41	906.91
C ₉ F ₀	15.13	16.74	15.94	141.27	154.43	147.85	405.58	445.85	425.71	598.91	606.58	602.75
C ₉ F ₁	20.37	22.58	21.48	185.53	198.03	191.78	476.22	514.43	495.33	728.84	742.18	735.51
C ₉ F ₂	25.07	29.63	27.35	242.95	247.21	245.08	550.80	638.74	594.77	888.80	900.47	894.64
SEm±	0.35	0.31	0.23	1.99	2.26	1.50	4.71	5.30	3.55	4.73	3.89	3.07
CD (P=0.05)	0.98	0.87	0.65	5.65	6.40	4.22	13.36	15.05	9.94	13.44	11.05	8.60

Table 9a. Effect of row ratio and nutrient management on dry weight of maize

Treatments	Dry weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	2.81	3.26	3.03	24.56	26.71	25.63	85.34	95.28	90.31	175.48	173.51	174.49
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	4.06	3.46	3.76	30.54	33.59	32.07	96.65	104.97	100.81	194.26	202.51	198.38
C ₅ - M + R (1:1)	3.29	3.52	3.41	29.01	31.34	30.18	95.77	99.84	97.80	185.56	190.91	188.24
C ₆ - M + C (2:1)	2.75	3.34	3.05	27.22	28.50	27.86	85.45	96.43	90.94	173.46	184.57	179.02
C ₇ - M + R (2:1)	2.88	3.29	3.09	25.05	29.47	27.26	85.22	97.31	91.26	180.52	184.60	182.56
C ₈ - M + C (2:2)	2.98	3.30	3.14	24.80	27.32	26.06	85.88	95.78	90.83	174.94	177.69	176.32
C ₉ - M + R (2:2)	3.12	3.35	3.23	27.89	31.06	29.47	86.75	97.25	92.00	183.19	187.34	185.27
SEm±	0.03	0.02	0.02	0.17	0.18	0.13	0.57	0.61	0.42	1.99	1.82	1.35
CD (P=0.05)	0.09	0.05	0.05	0.49	0.51	0.35	1.63	1.74	1.18	5.64	5.16	3.78
2. Nutrient management												
F ₀ - Control	2.63	2.76	2.69	20.37	17.72	19.05	74.80	80.77	77.78	126.99	128.74	127.87
F ₁ - 50 % NPK	2.96	3.09	3.03	26.37	28.95	27.66	85.75	94.34	90.04	172.89	175.41	174.15
F ₂ - 100 % NPK	3.79	4.23	4.01	34.30	37.40	35.85	105.62	119.26	112.44	243.30	253.48	248.39
SEm±	0.02	0.01	0.01	0.10	0.10	0.07	0.33	0.35	0.24	1.15	1.05	0.78
CD (P=0.05)	0.05	0.03	0.03	0.28	0.29	0.20	0.94	1.00	0.68	3.26	2.98	2.18

Table 9b. Interaction effect of row ratio and nutrient management on dry weight of maize

Interaction (C x F)	Dry weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	2.36	2.67	2.52	19.54	20.85	20.20	74.62	77.80	76.21	118.41	115.02	116.72
C ₁ F ₁	2.69	2.95	2.82	24.94	26.92	25.93	84.90	94.33	89.61	168.55	174.45	171.50
C ₁ F ₂	3.37	4.16	3.76	29.19	32.35	30.77	96.49	113.70	105.10	239.47	231.07	235.27
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	3.19	2.87	3.03	22.74	25.68	24.21	75.90	85.33	80.61	135.02	140.21	137.61
C ₄ F ₁	3.93	3.29	3.61	29.02	33.64	31.33	93.02	98.28	95.65	176.91	190.95	183.93
C ₄ F ₂	5.04	4.21	4.63	39.87	41.45	40.66	121.02	131.29	126.16	270.83	276.38	273.60
C ₅ F ₀	2.84	3.00	2.92	23.15	22.87	23.01	74.79	83.03	78.91	131.46	134.51	132.98
C ₅ F ₁	2.92	3.18	3.05	27.90	28.50	28.20	86.45	97.00	91.72	176.92	183.84	180.38
C ₅ F ₂	4.10	4.39	4.25	35.97	42.65	39.31	126.07	119.49	122.78	248.31	254.38	251.34
C ₆ F ₀	2.46	2.60	2.53	19.67	21.51	20.59	74.62	76.65	75.63	129.85	128.79	129.32
C ₆ F ₁	2.67	3.13	2.90	26.81	26.57	26.69	84.89	90.76	87.83	173.38	175.46	174.42
C ₆ F ₂	3.12	4.30	3.71	35.18	37.41	36.30	96.83	121.88	109.36	217.15	249.47	233.31
C ₇ F ₀	2.57	2.73	2.65	18.12	22.41	20.27	74.66	82.88	78.77	126.44	129.17	127.81
C ₇ F ₁	2.67	3.03	2.85	24.07	29.23	26.65	81.76	95.33	88.55	174.66	173.09	173.87
C ₇ F ₂	3.42	4.12	3.77	32.97	36.77	34.87	99.23	113.71	106.47	240.45	251.55	246.00
C ₈ F ₀	2.54	2.77	2.66	18.98	22.47	20.73	74.29	78.55	76.42	116.55	122.89	119.72
C ₈ F ₁	2.87	2.96	2.91	24.83	27.59	26.21	84.34	88.60	86.47	162.19	157.03	159.61
C ₈ F ₂	3.52	4.17	3.85	30.60	31.91	31.25	99.02	120.20	109.61	246.08	253.16	249.62
C ₉ F ₀	2.43	2.67	2.55	20.40	23.69	22.04	74.71	81.15	77.93	131.21	130.62	130.92
C ₉ F ₁	2.98	3.11	3.04	26.97	30.21	28.59	84.88	96.07	90.47	177.58	173.07	175.33
C ₉ F ₂	3.95	4.26	4.11	36.29	39.28	37.79	100.67	114.53	107.60	240.78	258.33	249.56
SEm±	0.05	0.03	0.03	0.30	0.31	0.22	0.99	1.06	0.73	3.44	3.15	2.33
CD (P=0.05)	0.15	0.09	0.09	0.85	0.88	0.61	2.82	3.01	2.04	9.77	8.94	6.54

Table 10a. Effect of row ratio and nutrient management on number of leaves of maize

Treatments	Number of leaves plant ⁻¹											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	6.18	6.68	6.43	7.63	9.94	8.79	11.34	12.83	12.09	13.22	14.26	13.74
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	6.12	6.63	6.38	7.60	9.88	8.74	11.10	12.40	11.75	12.62	13.98	13.30
C ₅ - M + R (1:1)	5.84	6.57	6.21	7.37	9.86	8.61	11.27	12.73	12.00	12.72	13.98	13.35
C ₆ - M + C (2:1)	5.94	6.59	6.27	7.50	9.61	8.55	10.91	12.50	11.71	12.66	13.90	13.28
C ₇ - M + R (2:1)	5.94	6.59	6.27	7.49	9.65	8.57	10.94	12.31	11.63	12.66	13.86	13.26
C ₈ - M + C (2:2)	5.87	6.58	6.22	7.33	9.75	8.54	10.71	12.35	11.53	12.50	13.93	13.22
C ₉ - M + R (2:2)	6.12	6.67	6.39	7.41	9.63	8.52	10.63	12.66	11.65	12.86	13.83	13.34
SEm±	0.05	0.04	0.03	0.03	0.04	0.03	0.07	0.08	0.05	0.07	0.04	0.04
CD (P=0.05)	0.15	0.10	0.09	0.09	0.11	0.07	0.21	0.23	0.15	0.18	0.10	0.10
2. Nutrient management												
F ₀ - Control	5.23	6.11	5.67	6.74	7.95	7.34	9.42	10.89	10.16	11.25	12.84	12.05
F ₁ - 50 % NPK	6.19	6.51	6.35	7.38	9.73	8.56	10.99	12.75	11.87	12.87	14.10	13.48
F ₂ - 100 % NPK	6.55	7.20	6.88	8.30	11.61	9.96	12.55	13.99	13.27	14.13	14.95	14.54
SEm±	0.03	0.02	0.02	0.02	0.02	0.01	0.04	0.05	0.03	0.04	0.02	0.02
CD (P=0.05)	0.08	0.06	0.05	0.05	0.06	0.04	0.12	0.13	0.09	0.11	0.06	0.06

Table 10b. Interaction effect of row ratio and nutrient management on number of leaves of maize

Interaction (C x F)	Number of leaves plant ⁻¹											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	5.43	6.27	5.85	6.97	8.10	7.53	9.47	11.20	10.33	11.60	13.47	12.53
C ₁ F ₁	6.30	6.47	6.38	7.40	9.83	8.62	11.53	12.91	12.22	13.57	14.33	13.95
C ₁ F ₂	6.80	7.30	7.05	8.53	11.90	10.22	13.03	14.39	13.71	14.50	14.97	14.73
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	4.77	6.03	5.40	7.07	8.00	7.53	9.37	10.87	10.12	11.07	12.83	11.95
C ₄ F ₁	6.53	6.60	6.57	7.40	9.80	8.60	10.93	12.53	11.73	12.77	14.20	13.48
C ₄ F ₂	7.07	7.27	7.17	8.33	11.83	10.08	13.00	13.80	13.40	14.03	14.90	14.47
C ₅ F ₀	5.07	6.03	5.55	6.57	8.03	7.30	9.57	11.03	10.30	11.13	12.80	11.97
C ₅ F ₁	6.03	6.47	6.25	7.33	9.80	8.57	11.27	13.01	12.14	12.80	14.20	13.50
C ₅ F ₂	6.43	7.20	6.82	8.20	11.74	9.97	12.97	14.14	13.56	14.23	14.93	14.58
C ₆ F ₀	5.40	6.10	5.75	6.70	7.83	7.27	9.30	10.93	10.12	11.10	12.73	11.92
C ₆ F ₁	6.00	6.57	6.28	7.46	9.67	8.56	10.90	12.83	11.87	12.80	14.00	13.40
C ₆ F ₂	6.43	7.10	6.77	8.33	11.33	9.83	12.53	13.73	13.13	14.07	14.97	14.52
C ₇ F ₀	5.33	5.97	5.65	6.70	7.90	7.30	9.53	10.33	9.93	11.10	12.67	11.88
C ₇ F ₁	6.13	6.60	6.37	7.50	9.63	8.57	11.00	12.60	11.80	12.90	13.97	13.43
C ₇ F ₂	6.37	7.20	6.78	8.27	11.42	9.85	12.30	14.00	13.15	13.97	14.93	14.45
C ₈ F ₀	5.27	6.10	5.69	6.53	7.93	7.23	9.53	10.87	10.20	11.07	12.80	11.93
C ₈ F ₁	6.07	6.43	6.25	7.23	9.69	8.46	10.84	12.47	11.65	12.53	14.07	13.30
C ₈ F ₂	6.27	7.20	6.73	8.21	11.63	9.92	11.77	13.72	12.74	13.90	14.93	14.42
C ₉ F ₀	5.33	6.27	5.80	6.63	7.85	7.24	9.20	10.97	10.08	11.67	12.60	12.13
C ₉ F ₁	6.27	6.47	6.37	7.37	9.65	8.51	10.47	12.88	11.68	12.70	13.90	13.30
C ₉ F ₂	6.77	7.27	7.02	8.23	11.40	9.82	12.23	14.13	13.18	14.20	15.00	14.60
SEm±	0.09	0.06	0.05	0.06	0.07	0.04	0.13	0.14	0.09	0.11	0.06	0.06
CD (P=0.05)	0.25	0.18	0.15	0.16	0.19	0.12	0.36	0.40	0.27	0.32	0.18	0.18

Table 11a. Effect of row ratio and nutrient management on stem girth of maize

Treatments	Stem girth of maize (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	2.82	3.10	2.96	4.71	4.92	4.82	6.10	6.24	6.17	6.98	7.10	7.04
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	2.63	2.77	2.70	4.59	4.81	4.70	5.98	6.21	6.09	6.93	6.95	6.94
C ₅ - M + R (1:1)	2.46	2.92	2.69	4.47	4.89	4.68	5.80	6.26	6.03	6.83	6.86	6.84
C ₆ - M + C (2:1)	2.63	3.00	2.82	4.49	4.92	4.71	5.81	6.20	6.00	6.82	6.99	6.91
C ₇ - M + R (2:1)	2.50	2.91	2.70	4.54	4.80	4.67	5.84	6.22	6.03	6.87	6.90	6.88
C ₈ - M + C (2:2)	2.53	2.89	2.71	4.51	4.79	4.65	5.91	6.22	6.07	6.88	6.78	6.83
C ₉ - M + R (2:2)	2.78	3.07	2.92	4.61	4.95	4.78	6.06	6.21	6.13	6.98	7.07	7.02
SEm±	0.03	0.04	0.02	0.03	0.04	0.02	0.03	0.03	0.02	0.03	0.03	0.02
CD (P=0.05)	0.08	0.10	0.06	0.08	0.10	0.06	0.09	0.09	0.06	0.09	0.07	0.06
2. Nutrient management												
F ₀ - Control	2.19	2.34	2.27	3.97	3.21	3.59	4.95	5.31	5.13	6.47	6.55	6.51
F ₁ - 50 % NPK	2.58	2.99	2.78	4.48	4.92	4.70	6.05	6.31	6.18	6.96	6.97	6.97
F ₂ - 100 % NPK	3.10	2.73	2.92	5.22	5.56	5.39	6.79	7.05	6.92	7.27	7.32	7.29
SEm±	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01
CD (P=0.05)	0.05	0.07	0.04	0.05	0.06	0.04	0.05	0.05	0.04	0.05	0.04	0.03

Table 11b. Interaction effect of row ratio and nutrient management on stem girth of maize

Interaction (C x F)	Stem girth (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	2.30	2.57	2.43	4.10	4.20	4.15	5.07	5.75	5.41	6.53	6.80	6.67
C ₁ F ₁	2.93	3.20	3.07	4.63	4.90	4.77	6.43	6.00	6.22	7.00	7.10	7.05
C ₁ F ₂	3.23	3.53	3.38	5.40	5.67	5.53	6.80	6.97	6.88	7.40	7.40	7.40
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	2.27	2.27	2.27	4.00	4.07	4.03	4.97	5.20	5.08	6.47	6.53	6.50
C ₄ F ₁	2.53	2.80	2.67	4.50	4.80	4.65	6.10	6.43	6.27	7.00	6.98	6.99
C ₄ F ₂	3.10	3.23	3.17	5.27	5.56	5.42	6.87	7.00	6.93	7.33	7.33	7.33
C ₅ F ₀	2.10	2.40	2.25	3.77	4.03	3.90	4.97	5.27	5.12	6.50	6.37	6.43
C ₅ F ₁	2.40	2.78	2.59	4.60	5.17	4.88	5.63	6.50	6.07	6.87	6.87	6.87
C ₅ F ₂	2.87	3.57	3.22	5.03	5.47	5.25	6.80	7.00	6.90	7.13	7.33	7.23
C ₆ F ₀	2.27	2.23	2.25	3.90	3.97	3.93	4.87	5.13	5.00	6.40	6.70	6.55
C ₆ F ₁	2.60	3.03	2.82	4.43	5.13	4.78	5.88	6.23	6.06	6.93	7.00	6.97
C ₆ F ₂	3.03	3.73	3.38	5.13	5.67	5.40	6.67	7.23	6.95	7.13	7.28	7.21
C ₇ F ₀	2.03	2.27	2.15	4.00	4.07	4.03	5.10	5.33	5.22	6.37	6.43	6.40
C ₇ F ₁	2.47	2.73	2.60	4.35	4.73	4.54	5.83	6.20	6.02	6.90	6.97	6.93
C ₇ F ₂	3.00	3.72	3.36	5.27	5.60	5.43	6.60	7.13	6.87	7.33	7.30	7.32
C ₈ F ₀	2.10	2.13	2.12	4.00	4.10	4.05	4.77	5.13	4.95	6.43	6.27	6.35
C ₈ F ₁	2.23	3.13	2.68	4.37	4.77	4.57	6.07	6.53	6.30	6.93	6.77	6.85
C ₈ F ₂	3.27	3.39	3.33	5.17	5.51	5.34	6.90	7.00	6.95	7.27	7.30	7.28
C ₉ F ₀	2.27	2.53	2.40	4.03	4.44	4.24	4.93	5.37	5.15	6.60	6.77	6.68
C ₉ F ₁	2.87	3.27	3.07	4.50	4.97	4.73	6.37	6.25	6.31	7.07	7.13	7.10
C ₉ F ₂	3.20	3.40	3.30	5.30	5.43	5.37	6.87	7.00	6.93	7.27	7.30	7.28
SEm±	0.05	0.06	0.04	0.05	0.06	0.04	0.05	0.06	0.04	0.05	0.05	0.04
CD (P=0.05)	0.14	0.17	0.11	0.14	0.18	0.11	0.15	0.16	0.11	0.15	0.13	0.10

4.1.2 Cowpea

4.1.2.1 Plant height (cm)

The plant height of the fodder cowpea was ranged from 35.45 cm to 312.51 cm (Table 12a). During two years of investigation, growth and development of the plant was much better in second years of investigation when compared to first year. The highest plant height of fodder cowpea was measured from C₁ at 20 DAS (40.00 cm), 40 DAS (183.62 cm), 60 DAS (266.42 cm) and 80 DAS (312.51 cm). The lowest plant height at 20 DAS (35.45 cm), 40 DAS (153.09 cm), 60 DAS (233.86 cm) and 80 DAS (298.81 cm) was observed at C₆ which was statistically followed by C₄ (36.10 cm), C₈ (36.62 cm) at 20 DAS, C₈ (156.07 cm) and C₄ (163.65 cm) at 40 DAS, C₆ at 60 DAS (236.86 cm) and then C₄ (306.88 cm) and C₈ (306.79 cm) at 80 DAS. The plant height at sole crop and different row ratio at 2:2 and 1:1 produce more higher plant height than 2:1 row ratio (Gaikwad *et al.*, 2022). Comparably, Kussie *et al.* (2024) also observed the higher plant of cowpea at sole plot followed by maize with cowpea at 2:2 and 1:1 row ratio. However, Ginwal *et al.* (2019a) reported the higher plant of cowpea at 1:1 row ratio followed by 2:2, while sole crop recorded the lower plant height of cowpea.

Application of nutrients showed the improvement of plant height of fodder cowpea (Table 12a). Among all the treatments, the lowest growth of the plant was observed where nutrients were not applied (control) in all stages of the observation. At 20 DAS, the plant height of fodder cowpea was ranged from 33.98 cm to 40.14 cm, and 124.57 cm to 200.74 cm at 40 DAS. From 60 DAS and 80 DAS, the plant height ranged from 206.95 cm to 292.01 cm and 235.90 cm to 387.50 cm. Statistically, the highest plant height at 20 DAS (40.14 cm), 40 DAS (200.74 cm), 60 DAS (292.01 cm) and 80 DAS (387.50 cm) were recorded from F₂ (100 % RDF NPK), while the lowest plant height at 20 DAS (33.98 cm), 40 DAS (124.57 cm), 60 DAS (206.95 cm) and 80 DAS (235.90 cm) was obtained at F₀ (control plot) in all the stages of the observation. Similarly, increased in plant height of the cowpea with increase in nutrient level was reported by Asangla (2015). Gaikwad *et al.* (2022) studied the effect of nutrients management on maize-cowpea intercropping system and observed the higher plant height of cowpea from the treatment receiving higher doses of nutrients (125 % RDF).

Interaction effect of cropping system and nutrient management on plant height of fodder cowpea was found to be statistically significant in all stages of the observation (Table 12b). Among the treatment combinations, the highest plant height of fodder cowpea was recorded from a treatment receiving nutrients application. The highest plant height of fodder cowpea at 20 DAS was recorded from C₂F₂ (43.57 cm) and it was followed by C₈F₂ (39.83 cm) and C₄F₂ (39.30 cm), while the lowest was obtained at C₄F₀ (32.03 cm), C₈F₀ (32.86 cm) and C₆F₀ (33.62 cm) respectively. The highest plant height at 40 DAS (210.57 cm), 60 DAS (331.32 cm) and 80 DAS (394.30 cm) was measured at C₂F₂ and which were act in accordance with treatment C₄F₂ at 40 DAS (207.56 cm) and 60 DAS (300.92 cm) and then from C₈F₂ at 80 DAS (393.60 cm). The similar trends of lower plant height of fodder cowpea were recorded mostly in all treatments where nutrients were not applied (control). The lowest was recorded at C₄F₀ (111.80 cm), C₈F₀ (112.05 cm), C₆F₀ (119.61 cm) at 40 DAS. At 60 DAS and 80 DAS, it was recorded from C₈F₀ (185.58 cm), C₄F₀ (207.28 cm) and C₆F₀ (230.77cm), C₈F₀ (235.77 cm), C₄F₀ (236.43 cm) respectively. Growing of cowpea with maize at 1:1 row ratio which received higher nutrient doses registered the higher plant height of cowpea was reported by Asangla (2015).

4.1.2.2 Leaf length (cm)

The result showed that the leaf length of the fodder cowpea was found significant with crop grown under different row ratios (Table 13a). However, there was not much variation on leaf length of the plant. The longest leaf length of the fodder cowpea at 20 DAS was observed at C₈ (4.68 cm) and C₂ (4.61 cm), while the shortest leaf length (4.47 cm) was recorded at C₆ (4.47 cm). Furthermore, the longest leaf length of the plant at 40 DAS (7.74 cm), 60 DAS, (12.67 cm) and 80 DAS (13.36 cm) was recorded at C₆ and it was in accordance with C₂ (4.61 cm) at 20 DAS, C₄ at 40 DAS (7.70 cm), 60 DAS (12.15 cm) and 80 DAS was observed at C₄ (13.16 cm). The shortest leaf length at 40 DAS (7.45 cm) and 60 DAS (11.98 cm) was seen in C₈ and C₂ at 80 DAS (12.87 cm). Similarly, Ginwal *et al.*, (2019a) also reported the longer leaf length at 2:1 and 1:1 row ratio as compared to sole cropping.

The leaf length of fodder cowpea was ranged between 3.75 cm to 14.27 cm (Table 13a) and it was seen that the leaf length of the plant increased with increasing in the nutrient levels. The longest leaf length of the plant was found in F₂ (100 % NPK) at 20 DAS (5.39 cm), 40 DAS (8.63 cm), 60 DAS (13.55 cm) and 80 DAS (14.27 cm) and the treatment F₀ (Control) recorded the shortest leaf length at 20 DAS (3.75 cm), 40 DAS (6.44 cm), 60 DAS (10.72 cm) and 80 DAS (11.83 cm) respectively. The observation of the longest leaf length under higher nutrients doses was probably due to meeting of their essential needs for their growth received from higher nutrients application.

The interaction effect was found significant (Table 13b) among the treatment combinations and leaf length of the plant was ranged from 3.61 cm to 14.51 cm long. The combinations results showed that nutrient application produced longer leaf length of the plant than the control treatment. Among all the treatment combinations, the longer and comparable leaf length was seen in treatment receiving 100 % RDF viz., C₄F₂ (5.42 cm), C₈F₂ (5.39 cm), C₈F₂ (5.38 cm) and C₂F₂ (5.37 cm) at 20 DAS and from 40 DAS to 80 DAS onwards, it was observed at C₆F₂ (8.78 cm, 14.07 cm, 14.51 cm) and which was on par with C₄F₂ (8.77 cm, 13.72 cm, 14.39 cm). The shortest and comparable leaf length at 40 DAS (6.30 cm) and 60 DAS (10.43 cm) was obtained in C₈F₀ which was in trend with C₂F₀ (6.38 cm, 10.68 cm) and C₄F₀ (10.71 cm) at 60 DAS. Similarly, C₂F₀ recorded the shortest leaf length (11.63 cm) at 80 DAS, which was significantly on par with C₄F₀ (11.75 cm) and C₈F₀ (11.85 cm). The longer leaf length of fodder cowpea in interaction with different row ratio and nutrient management might be due to the less competition for nutrients among the crops.

4.1.2.3 Leaf width (cm)

Wide range of leaf width was recorded during the two years of investigation (Table 14a). The leaf width of the plant ranged from 3.46 cm to 9.28 cm. The widest leaf width at 20 DAS was recorded from C₈ (3.99 cm), C₂ (3.76 cm) and C₄ (3.63 cm), while C₆ (3.46 cm) maintained the minimum leaf width among them. The treatment C₂ significantly maintained the widest leaf width at 40 DAS (5.20 cm), 60 DAS (7.46 cm) and 80 DAS (9.28 cm) followed by C₄ and C₈. The minimum leaf width of fodder

cowpea at 40 DAS (5.04 cm), 60 DAS (8.63) and 80 DAS (9.13 cm) was recorded at C₆. The widest leaf width of the fodder cowpea was registered in sole crop followed by 1:1 and 2:2 row ratio. This finding was supportive with findings reported by Gaidwad *et al.* (2022). However, in contrast to above studies, Ginwal *et al.* (2019a) reported the longer leaf width of cowpea sown under 1:1 and 2:1 row ratio than sole crop.

During different stages of observation under nutrient management (Table 14a), the treatment receiving different levels of nutrient significantly recorded the wider leaf width of the plant. The widest leaf width was observed at F₂ (100 % RDF) at 20 DAS (4.56 cm), 40 DAS (6.45 cm), 60 DAS (8.21 cm) and 80 DAS (10.35 cm), while F₀ (control) produced the minimum leaf width of the plant in all stages of the observation *viz.*, 20 DAS (2.98 cm), 40 DAS (3.64 cm), 60 DAS (6.14 cm) and 80 DAS (7.87 cm), respectively. The wider observation of leaf width at 100 % RDF were might be due to adequate supply of nutrients to the plant. Likewise, Gaikwad *et al.* (2022) also reported the increased in leaf width of cowpea with increased in nutrients application.

The result (Table 14b) revealed that interaction effect of different row ratio and nutrient management on leaf width of the fodder cowpea was significant among the treatment combinations. widest leaf width of the plant at 20 DAS was observed in C₈F₂ (5.30 cm), C₂F₂ (4.68 cm) and C₄F₂ (4.20 cm), while the minimum was observed in C₆F₀ (2.85 cm) and C₂F₀ (2.88 cm). The treatment C₂F₂ recorded the widest leaf width at 40 DAS (6.52 cm), 60 DAS (9.03 cm) and 80 DAS (10.38 cm), which was statistically on par with C₈F₂ (6.50 cm, 10.35 cm) at 40 DAS and C₄F₂ (6.43 cm, 10.36 cm) at 80 DAS. However, the minimum leaf width was measured in C₆F₀ (3.48 cm), C₂F₀ (3.61 cm) and C₄F₀ (3.69 cm) at 40 DAS. Treatment C₆F₀ managed the minimum leaf width at 60 DAS (5.79 cm) and 80 DAS (7.62 cm) respectively. Application of nutrient at 100 % RDF was found to be suitable for crop growth.

4.1.2.4 Leaf to stem ratio

The data depicted that different row ratio and nutrient management had significant effect on leaf stem ratio of fodder cowpea (Table 15a). The leaf stem ratio

of the plant at 20 DAS was ranged from 0.987 to 1.203 and it was found higher than the remaining stages of the observation mainly due to faster growth of leaf part than stem in early growth stage of the plant. The highest and the lowest leaf stem ratio of fodder cowpea was seen in C₄ (1.203) and C₈ (0.987) at 20 DAS. However, from the second observation onward, C₂ significantly recorded the highest leaf stem ratio at 40 DAS (0.949), 60 DAS (0.807) and 80 DAS (0.780) followed by C₄ (0.895, 0.782 and 0.772) and likewise, among the treatments, the lowest leaf stem ratio of fodder cowpea at 40 DAS (0.722), 60 DAS (0.749) and 80 DAS (0.725) was seen at C₈ respectively. The higher observation of leaf stem ratio in treatment C₁ and C₄ was mainly due to higher growth and more weight in the leaf part. However, the lower observation at C₈ was might be due to lower numbers of leaves plant⁻¹ and which lead leads to lower weight of the leaves.

An examination of the data given in Table 15a revealed that leaf stem ratio of fodder cowpea was significantly influenced by nutrient management. It indicated that the difference in results of leaf stem ratio parameters was obtained due to treatment effect only. The leaf stem ratio at 20 DAS recorded the highest and then from 40 DAS onward, it was found to be decreased. Among the nutrient management, the higher leaf stem ratio of fodder cowpea was observed in F₂ at 20 DAS (1.182), 40 DAS (0.858), 60 DAS (0.804) and 80 DAS (0.770), while F₀ recorded the lowest leaf stem ratio at 20 DAS (1.057), 40 DAS (0.783), 60 DAS (0.743) and 80 DAS (0.736). Application of nutrients at higher level significantly recorded higher leaf stem ratio than control treatment due to sufficient available of nutrients in the soil which meets their requirement for growth and development.

The result of interaction (Table 15b) on different row ratio and nutrient management showed the significant influence on leaf stem ratio of fodder cowpea. The treatment interactions revealed that leaf stem ratio of fodder cowpea was increased with increase in nutrients level. Among all the treatment combinations, the higher leaf stem ratio was recorded at C₄F₂ (1.246) and C₂F₂ (1.239), while C₈F₀ (0.930) recorded the lowest leaf stem ratio at 20 DAS. The C₂F₂ recorded the highest leaf stem ratio at 40 DAS (0.969), 60 DAS (0.843) and 80 DAS (0.803) respectively. However, the lowest leaf stem ratio of fodder cowpea was recorded in C₆F₀ (0.642) at 40 DAS, while at 60

DAS and 80 DAS treatment C₈F₀ (0.728, 0.719) registered the lowest leaf stem ratio of fodder cowpea. The higher leaf stem ratio was mainly due to the abundant available nutrient in the soil and which promote to their growth and development.

4.1.2.5 Stem girth (cm)

The stem girth of the plant was ranged from 1.21 cm to 3.17 cm (Table 16a). The treatment C₈ (1.62 cm) managed to hold the largest stem girth of the plant at 20 DAS, while C₂- sole cowpea significantly produced the largest stem girth of the plant at 40 DAS (2.22 cm), 60 DAS (2.93 cm) and 80 DAS (3.17 cm). The smallest stem girth at 20 DAS was recorded at C₆ (1.21 cm), while C₆ maintained the smallest stem girth of the plant at 40 DAS (2.04 cm), 60 DAS (2.68 cm) and 80 DAS (2.96 cm). The observation of larger stem girth of fodder cowpea in sole crop might be due to lesser competition within them for resources like nutrients, light and spaces. Among the different row ratios, the smaller stem girth of the fodder cowpea at 2:1 was probably on account of higher competition for resources as the maize population are more in this row ratio. This finding was in similar with the findings reported by Ginwal *et al.* (2019b). They observed the higher stem girth of cowpea at sole crop than different row ratio.

The nutrient management option produced a wide range of stem girth of the plant (Table 16a) and was ranged from 0.86 cm to 3.72 cm. Among all the treatments, the largest stem girth at 20 DAS (2.03 cm), 40 DAS (2.64 cm), 60 DAS (3.62 cm) and 80 DAS (3.72 cm) was registered at F₂. Likewise, the smallest stem girth of the fodder cowpea was recorded in F₀ (control) at 20 DAS (0.86 cm), 40 DAS (1.51 cm), 60 DAS (2.10 cm) and 80 DAS (2.43 cm) respectively. The larger stem girth of the fodder cowpea observed under higher application of nutrients was mainly due to abundant availability of nutrients in the soil.

The interaction result (Table 16b) revealed that different row ratio and different nutrient level had a significant variation on stem girth of the plant at both stages of the investigation. Regarding the different row ratio, the stem girth of the fodder cowpea showed not much variation. However, nutrient management revealed

that significant variation in stem girth of the fodder cowpea. The treatment F₂ recorded the largest stem girth of the plant at C₈F₂ (2.22 cm) and C₄F₂ (2.10 cm) at 20 DAS, while C₂F₂ and C₆F₂ at 40 DAS (2.78 cm). At 60 DAS, comparable stem girth was recorded at C₈F₂ (3.70 cm), C₆F₂ (3.64 cm) and C₂F₂ (3.62 cm) and furthermore at 80 DAS, the largest stem girth was found in C₄F₂ (3.92 cm) followed by C₈F₂ (3.68 cm), C₂F₂ (3.68 cm). The lowest stem girth at 20 DAS was observed from C₆F₀ (0.70 cm), C₈F₀ (0.93 cm) and C₂F₀ (0.92 cm), while C₆F₀ (1.37 cm) and C₈F₀ (1.38 cm) at 40 DAS and 60 DAS. The smallest stem girth at 80 DAS was recorded at C₈F₀ (2.28 cm). From the result, it was clear that nutrient had a significant impact on plant growth and development.

4.1.2.6 Number of leaves plant⁻¹

Result (Table 17a) indicated that different row ratio had significant impact on number of leaves plant⁻¹ of the fodder cowpea. Significantly, the higher number of leaves plant⁻¹ was counted at C₂ (5.70) followed by C₄ (5.41) and the lowest was recorded at C₈ (4.78) at 20 DAS. Continuously, C₂ statistically maintained the highest number of leaves plant⁻¹ among the different row ratio at 40 DAS (40.51), 60 DAS (58.50) and 80 DAS (95.77) followed by C₄ at 40 DAS (28.27), 60 DAS (55.33) and at 80 DAS (87.99). The lowest number of leaves plant⁻¹ at 40 DAS (23.38), 60 DAS (39.07) and 80 DAS (70.88) was registered at C₈. Ginwal *et al.* (2019a) also observed the highest number of leaves plant⁻¹ at 1:1 row ratio than 2:1 row ratio and sole crop. Similar finding of higher number of leaves plant⁻¹ at 1:1 row ratio was also reported by Asangla (2015).

Regarding the nutrient management (Table 17a), the number of leaves plant⁻¹ were significantly increase with treatment F₁ (50 % RDF) and F₂ (100 % RDF) in compared to F₀ (control) at both studied stages. Among all the treatments, F₂ counted the highest numbers of leaves plant⁻¹ at 20 DAS (5.95), 40 DAS (36.77), 60 DAS (58.71) and 80 DAS (104.29) respectively and statistically, the lowest number of leaves plant⁻¹ was counted at F₀ in all stages of the observation *i.e.*, 20 DAS (4.40), 40 DAS (22.28), 60 DAS (37.94) and 80 DAS (62.98). Asangla (2015) also studied the effect

different levels of nutrients on growth parameters of cowpea and observed the increase in number of leaves plant⁻¹ with increase in nutrients application.

The interaction result was found statistically significant (Table 17b) and also revealed that a treatment combinations receiving higher doses of nutrient counted higher number of leaves plant⁻¹. Among all the treatment combinations, the highest number of leaves plant⁻¹ at 20 DAS were counted in C₂F₂ (6.52) and C₄F₂ (6.43). The treatment C₂F₂ counted the highest number of leaves plant⁻¹ at 40 DAS (47.60), 60 DAS (72.30) and 80 DAS (113.93), which was followed by treatments C₆F₂ at 40 DAS (37.77) and C₄F₂ at 60 DAS (68.35) and 80 DAS (111.93). The lower and comparable number of leaves plant⁻¹ was counted at C₄F₀ at 20 DAS (4.02) and C₆F₀ at 40 DAS (16.35), while C₈F₀ counted the lowest at 60 DAS (32.93) and 80 DAS (51.10) respectively. Growing of fodder cowpea as sole stand and growing with fodder maize at 1:1 along with application of nutrients at higher doses showed more compactible system.

4.1.2.7 Number of primary branches plant⁻¹

The data (table 18a) revealed that both years had a significant impact on primary branches of fodder cowpea. The primary branches plant⁻¹ were counted at three different stages *i.e.*, 20 DAS, 40 DAS and 60 DAS. During, the two years of investigation, C- sole cowpea recorded the highest number of primary branches plant⁻¹ at 20 DAS (1.80), 40 DAS (4.31) and 60 DAS (5.23) and the lowest number of branches plant⁻¹ was observed in C₆ (1.27) at 20 DAS and C₈ at 40 DAS (2.29) and 60 DAS (4.31). The higher number of primary branches plant⁻¹ of fodder cowpea at sole crop might be due to less competition and more access of resources like nutrients, sunlight and spaces uniformly. The lower primary branches plant⁻¹ in 2:2 and 2:1 row ratio was mainly as a consequence of competition for resources.

The data presented in Table 18a, indicated that primary branches of fodder cowpea was significantly influenced due to nutrient management. The treatment F₂ (100 % RDF) counted the highest primary branches plant⁻¹ of fodder cowpea at 20 DAS (1.97), 40 DAS (3.57) and 60 DAS (5.58), while treatment F₀ (control) produced the

lowest primary branches plant⁻¹ of the fodder cowpea at 20 DAS (1.10), 40 DAS (2.38) and 60 DAS (4.35) respectively. Application of optimum dose of nutrients improved plant growth like branches by supplying their needs of nutrients for their growth and development.

It is evident from the data shown in Table 18b that primary branches of fodder cowpea were varied with interaction between different row ratio and nutrient management. From the results, it is revealed that nutrient management had a significant influence on primary branches of the plant. The different row ratio which received higher doses of nutrient application produced higher number of primary branches plant⁻¹ than control. At 20 DAS, treatments C₂F₂, C₄F₂ and C₈F₂ recorded the highest number of primary branches plant⁻¹ of fodder cowpea, while the lowest number were counted at C₆F₀ (1.01) and C₄F₀ (1.05) when in compared to other treatment combinations. Similarly, treatment C₂F₂ significantly maintained the highest primary branches plant⁻¹ of fodder cowpea at 40 DAS (4.85) and 60 DAS (6.08) when compared to other treatment combinations and then treatment C₈F₀ produced the lowest number of primary branches at 40 DAS (1.35) and 60 DAS (4.08). The combinations of sole crop with higher nutrient applications leads to higher production of primary branches plant⁻¹ of fodder cowpea because of their free competition for resources and abundant of nutrient in the soil.

4.1.2.8 Fresh weight of plant (g plant⁻¹)

The result (Table 19a) revealed that during both years of investigation, the factor combinations (different row ratio and nutrient management) had a significant impact on fresh weight of the fodder cowpea. Among the different row ratio, the higher fresh weight of fodder cowpea was obtained at C₄ (19.71 g plant⁻¹) and C₂ (19.27 g plant⁻¹), while treatment C₆ (12.92 g plant⁻¹) maintained the lowest fresh weight at 20 DAS. However, from 40 DAS onward, C₂ statistically recorded the highest fresh weight of the fodder cowpea at 40 DAS (272.98 g plant⁻¹), 60 DAS (398.58 g plant⁻¹) and 80 DAS (454.30 g plant⁻¹) and then it was followed by C₄ at 40 DAS (203.29 g plant⁻¹), 60 DAS (323.15 g plant⁻¹) and 80 DAS (432.37 g plant⁻¹). Among all the treatments, the lowest fresh weight at 40 DAS (160.67 g plant⁻¹), 60 DAS (269.18 g plant⁻¹) and 80

DAS (376.56 g plant⁻¹) was observed at C₈. The higher fresh weight of fodder cowpea at sole crop was mainly due to higher vegetative growth of the plant and the lower observation at 2:2 row ratio was might be due to higher competition of the crops which could be a reason to lower the growth of plant.

It is evident from the result shown in Table 19a that fresh weight of the fodder cowpea was varied remarkably among the nutrient management. The fresh weight of the plant was ranged 11.97 g plant⁻¹ to 509.42 g plant⁻¹ and the fresh weight was increase with increase in nutrient levels. Among the different nutrient levels, treatment F₂ (100 % RDF) recorded significantly the highest fresh weight of fodder cowpea at 20 DAS (22.37 g plant⁻¹), 40 DAS (246.07 g plant⁻¹), 60 DAS (421.51 g plant⁻¹) and 80 DAS (509.42 g plant⁻¹) respectively, while the lowest fresh weight in all the stages of the observation *i.e.*, 20 DAS (11.97 g plant⁻¹), 40 DAS (155.28 g plant⁻¹), 60 DAS (225.16 g plant⁻¹) and 80 DAS (211.16 g plant⁻¹) was seen at F₀ (control) in comparison with F₁ (50 % RDF) and F₂ (100 % RDF). The observation of higher fresh weight of fodder cowpea under the treatment receiving higher doses of nutrients was significantly due to sufficient availability of nutrients to the plant.

The interaction result (Table 19b) was statistically significant in both years. The data revealed that the fresh weight production from different row ratio was significantly affected with the application of nutrients. The higher application of nutrients significantly produced higher fresh weight of fodder cowpea comparison to treatments receiving lower level of nutrients. The higher fresh weight at 20 DAS was seen at C₄F₂ (26.14 g plant⁻¹), C₂F₂ (23.90 g plant⁻¹) and C₈F₂ (23.19 g plant⁻¹), while the lowest fresh weight was recorded at C₆F₀ (9.58 g plant⁻¹). The treatment C₂F₂ significantly hold the highest fresh weight of fodder cowpea at 40 DAS (342.53 g plant⁻¹), 60 DAS (527.47 g plant⁻¹) and 80 DAS (589.39 g plant⁻¹), which was followed by C₄F₂ at 40 DAS (255.89 g plant⁻¹), 60 DAS (422.40 g plant⁻¹) and 80 DAS (543.77 g plant⁻¹) respectively. The lowest fresh weight of the fodder cowpea was observed at C₈F₀ at 40 DAS (134.24 g plant⁻¹), 60 DAS (182.68 g plant⁻¹) and 80 DAS (267.64 g plant⁻¹).

4.1.2.9 Dry weight of plant (g plant⁻¹)

The result (Table 20a) indicated that different row ratio and nutrient management caused a significant variation in dry weight of the fodder cowpea. Among the different row ratio, treatment C₄ (3.39 g plant⁻¹) and C₂ (3.62 g plant⁻¹) recorded the highest dry weight of fodder cowpea at 20 DAS, while the lowest was obtained at C₆ (2.57 g plant⁻¹). From the next observation onwards, treatment C₂ significantly produced the highest dry weight of fodder cowpea at 40 DAS (28.62 g plant⁻¹), 60 DAS (82.04 g plant⁻¹) and 80 DAS (106.98 g plant⁻¹). The lower and comparable dry weight of the fodder cowpea was observed in C₈ at 40 DAS (19.22 g plant⁻¹), 60 DAS (58.75 g plant⁻¹) and 80 DAS (86.21 g plant⁻¹) respectively. The higher observation of dry weight plant⁻¹ was obtained in sole crop followed by 1:1 row ratio which might be due to higher vegetative growth of the plant.

The application of nutrients at F₀ (control), F₁ (50 % RDF) and F₂ (100 % RDF) revealed the wide variation of dry weight of fodder cowpea (Table 20a). The results showed that the higher dry weight of the plant was obtained from the treatment receiving higher doses of nutrients in comparison to control. The dry weight ranged from 2.58 g plant⁻¹ to 137.33 g plant⁻¹. The treatment F₂ (100 % RDF) recorded the highest dry weight of fodder cowpea at 20 DAS (3.74 g plant⁻¹), 40 DAS (33.38 g plant⁻¹), 60 DAS (100.35 g plant⁻¹) and 80 DAS (137.33 g plant⁻¹) respectively. The higher growth observation resulted from higher vegetative growth was due to higher availability of nutrients into the soil.

The result (Table 20b) showed that combinations of fodder maize with fodder cowpea at different row ratio was significantly influenced by the nutrient management. The dry weight of fodder cowpea was increase with increasing nutrient level. Among all the treatment combinations, the highest dry weight at 20 DAS was recorded from C₄F₂ (4.38 g plant⁻¹) and C₂F₂ (4.10 g plant⁻¹), while treatment C₆F₀ (2.27 g plant⁻¹) produced the lowest dry weight of fodder cowpea and it was statistically on par with C₈F₀ (2.38 g plant⁻¹). Furthermore, C₂F₂ maintained the highest dry weight at 40 DAS (40.53 g plant⁻¹), 60 DAS (122.46 g plant⁻¹) and 80 DAS (154.35 g plant⁻¹) respectively. The lowest dry weight of fodder cowpea at 40 DAS (11.29 g plant⁻¹), 60

DAS ($32.16 \text{ g plant}^{-1}$) and 80 DAS ($47.75 \text{ g plant}^{-1}$) was observed at C₈F₀. The combination of sole crop with nutrient management produced higher dry weight of cowpea due to more complementary effect of the plants.

Table 12a. Effect of row ratio and nutrient management on plant height of cowpea

Treatments	Plant height (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	37.52	42.49	40.00	165.47	201.78	183.62	223.30	309.54	266.42	303.96	321.07	312.51
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	33.04	39.15	36.10	134.40	192.90	163.65	235.21	274.74	254.98	304.16	309.60	306.88
C ₅ - M + R (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ - M + C (2:1)	32.14	38.76	35.45	125.26	180.93	153.09	210.21	257.51	233.86	293.88	303.74	298.81
C ₇ - M + R (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ - M + C (2:2)	31.36	41.89	36.62	131.47	180.67	156.07	222.20	251.51	236.86	297.32	316.27	306.79
C ₉ - M + R (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.16	0.22	0.14	1.08	1.24	0.82	1.78	1.73	1.24	1.33	2.55	1.44
CD (P=0.05)	0.46	0.61	0.38	3.07	3.53	2.31	5.04	4.91	3.48	3.78	7.24	4.03
2. Nutrient management												
F ₀ - Control	30.73	37.24	33.98	118.60	130.55	124.57	180.60	233.30	206.95	228.77	243.03	235.90
F ₁ - 50 % NPK	33.38	40.55	36.97	140.10	193.92	167.01	212.96	277.29	245.13	288.39	302.29	295.34
F ₂ - 100 % NPK	36.43	43.84	40.14	158.74	242.74	200.74	274.63	309.39	292.01	382.33	392.68	387.50
SEm±	0.09	0.13	0.08	0.62	0.72	0.48	1.02	1.00	0.72	0.77	1.47	0.83
CD (P=0.05)	0.27	0.36	0.22	1.77	2.04	1.34	2.91	2.83	2.01	2.18	4.18	2.33

Table 12b. Interaction effect of row ratio and nutrient management on plant height of cowpea

Interaction (C x F)	Plant height (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	36.13	38.74	37.44	136.43	173.23	154.83	168.93	263.13	216.03	226.60	254.67	240.63
C ₂ F ₁	37.60	40.42	39.01	169.23	201.70	185.47	206.20	297.63	251.92	295.27	309.93	302.60
C ₂ F ₂	38.83	48.30	43.57	190.73	230.40	210.57	294.77	367.87	331.32	390.00	398.60	394.30
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	29.73	34.32	32.03	122.13	101.47	111.80	180.43	234.13	207.28	235.27	237.60	236.43
C ₄ F ₁	34.07	39.87	36.97	131.60	211.60	171.60	228.10	285.37	256.73	296.60	301.60	299.10
C ₄ F ₂	35.33	43.26	39.30	149.48	265.63	207.56	297.10	304.73	300.92	380.60	389.60	385.10
C ₅ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₀	28.87	38.37	33.62	107.07	132.15	119.61	184.60	253.20	218.90	227.27	234.27	230.77
C ₆ F ₁	30.80	38.61	34.71	121.70	174.64	148.17	206.27	258.80	232.53	281.60	295.70	288.65
C ₆ F ₂	36.77	38.96	37.86	147.00	236.00	191.50	239.77	260.53	250.15	372.77	381.27	377.02
C ₇ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₀	28.20	37.51	32.86	108.77	115.33	112.05	188.43	182.73	185.58	225.93	245.60	235.77
C ₈ F ₁	31.07	43.31	37.19	137.87	187.75	162.81	211.27	267.37	239.32	280.10	301.93	291.02
C ₈ F ₂	34.80	44.86	39.83	147.77	238.93	193.35	266.90	304.43	285.67	385.93	401.27	393.60
C ₉ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.28	0.38	0.24	1.87	2.16	1.43	3.07	3.00	2.15	2.31	4.42	2.49
CD (P=0.05)	0.80	1.08	0.67	5.32	6.12	4.01	8.73	8.50	6.02	6.55	12.53	6.99

Table 13a. Effect of row ratio and nutrient management on leaf length of cowpea

Treatments	Leaf length (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	4.51	4.71	4.61	7.45	7.61	7.53	11.77	12.29	12.03	12.77	12.98	12.87
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	4.56	4.56	4.56	7.68	7.72	7.70	11.92	12.37	12.15	12.80	13.51	13.16
C ₅ - M + R (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ - M + C (2:1)	4.31	4.63	4.47	7.62	7.87	7.74	12.38	12.97	12.67	13.16	13.57	13.36
C ₇ - M + R (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ - M + C (2:2)	4.39	4.96	4.68	7.39	7.51	7.45	11.48	12.49	11.98	12.86	12.97	12.91
C ₉ - M + R (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.02	0.02	0.02	0.02	0.03	0.02	0.04	0.05	0.03	0.05	0.05	0.04
CD (P=0.05)	0.07	0.06	0.05	0.06	0.07	0.05	0.13	0.15	0.10	0.15	0.15	0.10
2. Nutrient management												
F ₀ - Control	3.53	3.98	3.75	6.43	6.45	6.44	10.38	11.07	10.72	11.63	12.03	11.83
F ₁ - 50 % NPK	4.47	4.72	4.60	7.57	7.94	7.75	12.02	12.69	12.35	12.94	13.32	13.13
F ₂ - 100 % NPK	5.33	5.46	5.39	8.61	8.64	8.63	13.26	13.83	13.55	14.12	14.42	14.27
SEm±	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.02	0.03	0.03	0.02
CD (P=0.05)	0.04	0.04	0.03	0.04	0.04	0.03	0.07	0.09	0.06	0.08	0.09	0.06

Table 13b. Interaction effect of row ratio and nutrient management on leaf length of cowpea

Interaction (C X F)	Leaf length (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	3.77	4.00	3.88	6.38	6.37	6.38	10.37	10.99	10.68	11.57	11.70	11.63
C ₂ F ₁	4.53	4.63	4.58	7.53	7.88	7.71	11.47	12.65	12.06	12.73	12.93	12.83
C ₂ F ₂	5.23	5.50	5.37	8.45	8.57	8.51	13.47	13.23	13.35	14.00	14.30	14.15
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	3.57	3.80	3.68	6.53	6.50	6.52	10.27	11.16	10.71	11.22	12.27	11.75
C ₄ F ₁	4.65	4.50	4.58	7.67	7.97	7.82	11.72	12.28	12.00	12.84	13.83	13.34
C ₄ F ₂	5.47	5.37	5.42	8.83	8.70	8.77	13.78	13.66	13.72	14.34	14.43	14.39
C ₅ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₀	3.29	3.93	3.61	6.48	6.63	6.56	10.82	11.33	11.07	11.93	12.23	12.08
C ₆ F ₁	4.27	4.57	4.42	7.63	8.13	7.88	12.47	13.28	12.88	13.40	13.60	13.50
C ₆ F ₂	5.37	5.40	5.38	8.73	8.83	8.78	13.85	14.29	14.07	14.15	14.86	14.51
C ₇ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₀	3.50	4.17	3.83	6.30	6.30	6.30	10.07	10.79	10.43	11.80	11.90	11.85
C ₈ F ₁	4.44	5.17	4.81	7.43	7.77	7.60	12.43	12.53	12.48	12.77	12.90	12.83
C ₈ F ₂	5.23	5.55	5.39	8.43	8.48	8.46	11.93	14.15	13.04	14.00	14.10	14.05
C ₉ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.04	0.04	0.03	0.04	0.04	0.03	0.08	0.09	0.06	0.09	0.09	0.06
CD (P=0.05)	0.12	0.11	0.08	0.11	0.12	0.08	0.22	0.26	0.17	0.25	0.26	0.18

Table 14a. Effect of row ratio and nutrient management on leaf width of cowpea

Treatments	Leaf width (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	3.72	3.80	3.76	4.88	5.52	5.20	7.08	7.84	7.46	9.14	9.42	9.28
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	3.68	3.57	3.63	4.83	5.47	5.15	7.06	7.53	7.29	9.12	9.30	9.21
C ₅ - M + R (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ - M + C (2:1)	3.52	3.41	3.46	4.79	5.29	5.04	6.14	7.52	6.83	8.98	9.22	9.10
C ₇ - M + R (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ - M + C (2:2)	3.54	4.45	3.99	4.81	5.46	5.13	6.85	7.27	7.06	9.04	9.25	9.15
C ₉ - M + R (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.03	0.02	0.02	0.04	0.03	0.03	0.05	0.03	0.03	0.03	0.04	0.03
CD (P=0.05)	0.07	0.07	0.05	0.12	0.10	0.08	0.14	0.09	0.08	0.10	0.11	0.07
2. Nutrient management												
F ₀ - Control	2.70	3.25	2.98	3.56	3.72	3.64	5.78	6.51	6.14	7.74	8.00	7.87
F ₁ - 50 % NPK	3.54	3.66	3.60	4.89	5.72	5.30	6.71	7.56	7.14	9.23	9.43	9.33
F ₂ - 100 % NPK	4.59	4.52	4.56	6.02	6.88	6.45	7.86	8.55	8.21	10.24	10.47	10.35
SEm±	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.01
CD (P=0.05)	0.04	0.04	0.03	0.07	0.06	0.04	0.08	0.05	0.05	0.06	0.06	0.04

Table 14b. Interaction effect of row ratio and nutrient management on leaf width of cowpea

Interaction (C X F)	Leaf width (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	2.83	2.93	2.88	3.57	3.64	3.61	5.87	6.43	6.15	7.84	8.25	8.05
C ₂ F ₁	3.70	3.75	3.72	5.04	5.89	5.47	6.70	7.72	7.21	9.30	9.52	9.41
C ₂ F ₂	4.63	4.73	4.68	6.01	7.04	6.52	8.67	9.38	9.03	10.27	10.49	10.38
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	2.80	3.46	3.13	3.53	3.85	3.69	6.37	6.50	6.44	7.87	8.06	7.96
C ₄ F ₁	3.50	3.60	3.55	4.90	5.75	5.32	7.03	7.57	7.30	9.20	9.42	9.31
C ₄ F ₂	4.73	3.66	4.20	6.05	6.82	6.43	7.77	8.52	8.14	10.30	10.42	10.36
C ₅ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₀	2.65	3.05	2.85	3.52	3.43	3.48	4.95	6.63	5.79	7.67	7.66	7.67
C ₆ F ₁	3.42	3.59	3.51	4.88	5.65	5.26	6.08	7.74	6.91	9.17	9.46	9.31
C ₆ F ₂	4.49	3.59	4.04	5.97	6.80	6.39	7.41	8.19	7.80	10.10	10.55	10.32
C ₇ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₀	2.53	3.55	3.04	3.63	3.93	3.78	5.93	6.46	6.20	7.57	8.02	7.79
C ₈ F ₁	3.56	3.70	3.63	4.73	5.51	5.12	7.03	7.22	7.13	9.27	9.33	9.30
C ₈ F ₂	4.52	6.09	5.30	6.06	6.95	6.50	7.60	8.13	7.86	10.30	10.41	10.35
C ₉ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.05	0.04	0.03	0.07	0.06	0.05	0.08	0.06	0.05	0.06	0.07	0.04
CD (P=0.05)	0.13	0.12	0.09	0.21	0.17	0.13	0.24	0.16	0.14	0.17	0.19	0.12

Table 15a. Effect of row ratio and nutrient management on leaf stem ratio of cowpea

Treatments	Leaf stem ratio											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	1.242	1.069	1.156	0.980	0.918	0.949	0.821	0.793	0.807	0.779	0.781	0.780
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	1.272	1.135	1.203	0.875	0.915	0.895	0.782	0.781	0.782	0.768	0.776	0.772
C ₅ - M + R (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ - M + C (2:1)	1.220	1.133	1.177	0.755	0.716	0.736	0.766	0.761	0.764	0.748	0.724	0.736
C ₇ - M + R (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ - M + C (2:2)	1.000	0.974	0.987	0.741	0.702	0.722	0.757	0.741	0.749	0.728	0.723	0.725
C ₉ - M + R (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.009	0.007	0.006	0.004	0.004	0.003	0.005	0.006	0.004	0.002	0.002	0.002
CD (P=0.05)	0.026	0.019	0.016	0.012	0.012	0.008	0.015	0.016	0.011	0.007	0.006	0.005
2. Nutrient management												
F ₀ - Control	1.081	1.032	1.057	0.791	0.776	0.783	0.752	0.735	0.743	0.736	0.735	0.736
F ₁ - 50 % NPK	1.214	1.091	1.153	0.847	0.822	0.834	0.778	0.780	0.779	0.757	0.751	0.754
F ₂ - 100 % NPK	1.254	1.110	1.182	0.876	0.841	0.858	0.816	0.793	0.804	0.774	0.767	0.770
SEm±	0.005	0.004	0.003	0.002	0.002	0.002	0.003	0.003	0.002	0.001	0.001	0.001
CD (P=0.05)	0.015	0.011	0.009	0.007	0.007	0.005	0.008	0.009	0.006	0.004	0.004	0.003

Table 15b. Interaction effect of row ratio and nutrient management on leaf stem ratio of cowpea

Interaction (C X F)	Leaf stem ratio											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	1.021	1.012	1.016	0.965	0.888	0.927	0.786	0.750	0.768	0.759	0.756	0.757
C ₂ F ₁	1.331	1.092	1.211	0.984	0.918	0.951	0.811	0.810	0.811	0.782	0.778	0.780
C ₂ F ₂	1.374	1.104	1.239	0.991	0.948	0.969	0.867	0.819	0.843	0.798	0.808	0.803
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	1.195	1.092	1.144	0.842	0.878	0.860	0.749	0.741	0.745	0.730	0.756	0.743
C ₄ F ₁	1.289	1.151	1.220	0.861	0.932	0.896	0.781	0.792	0.787	0.772	0.779	0.775
C ₄ F ₂	1.330	1.162	1.246	0.923	0.936	0.930	0.817	0.810	0.813	0.802	0.793	0.798
C ₅ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₀	1.204	1.072	1.138	0.639	0.645	0.642	0.734	0.730	0.732	0.736	0.712	0.724
C ₆ F ₁	1.220	1.147	1.183	0.795	0.736	0.766	0.763	0.775	0.769	0.751	0.724	0.737
C ₆ F ₂	1.237	1.181	1.209	0.830	0.767	0.799	0.802	0.779	0.790	0.758	0.737	0.748
C ₇ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₀	0.922	0.953	0.937	0.717	0.692	0.705	0.739	0.717	0.728	0.721	0.716	0.719
C ₈ F ₁	1.051	0.976	1.013	0.747	0.702	0.724	0.756	0.743	0.749	0.724	0.723	0.724
C ₈ F ₂	1.101	0.993	1.047	0.760	0.713	0.737	0.777	0.764	0.770	0.738	0.729	0.733
C ₉ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.022	0.012	0.013	0.007	0.007	0.005	0.009	0.010	0.007	0.004	0.004	0.003
CD (P=0.05)	0.064	0.033	0.035	0.021	0.021	0.015	0.025	0.027	0.018	0.013	0.011	0.008

Table 16a. Effect of row ratio and nutrient management on stem girth of cowpea

Treatments	Stem girth (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	1.43	1.58	1.51	2.22	2.22	2.22	2.88	2.98	2.93	3.03	3.30	3.17
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	1.40	1.67	1.53	2.14	2.19	2.16	2.80	2.90	2.85	3.00	3.22	3.11
C ₅ - M + R (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ - M + C (2:1)	1.16	1.27	1.21	1.97	2.11	2.04	2.63	2.73	2.68	2.90	3.01	2.96
C ₇ - M + R (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ - M + C (2:2)	1.51	1.72	1.62	2.09	2.12	2.11	2.78	2.88	2.83	2.92	3.09	3.01
C ₉ - M + R (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.01
CD (P=0.05)	0.03	0.04	0.03	0.05	0.04	0.03	0.05	0.05	0.03	0.04	0.07	0.04
2. Nutrient management												
F ₀ - Control	0.73	0.98	0.86	1.46	1.55	1.51	2.07	2.14	2.10	2.30	2.56	2.43
F ₁ - 50 % NPK	1.41	1.62	1.52	2.26	2.25	2.25	2.71	2.79	2.75	2.98	3.08	3.03
F ₂ - 100 % NPK	1.98	2.08	2.03	2.60	2.68	2.64	3.55	3.69	3.62	3.62	3.83	3.72
SEm±	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.04	0.02

Table 16b. Interaction effect of row ratio and nutrient management on the stem girth of cowpea

Interaction (C X F)	Stem girth (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	0.83	1.02	0.93	1.47	1.50	1.48	2.23	2.34	2.29	2.43	2.80	2.62
C ₂ F ₁	1.53	1.75	1.64	2.44	2.37	2.40	2.87	2.90	2.88	3.07	3.33	3.20
C ₂ F ₂	1.93	1.97	1.95	2.77	2.80	2.78	3.55	3.69	3.62	3.60	3.77	3.68
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	0.67	1.10	0.88	1.73	1.85	1.79	2.00	2.10	2.05	2.17	2.63	2.40
C ₄ F ₁	1.50	1.73	1.62	2.21	2.25	2.23	2.77	2.83	2.80	3.00	3.03	3.02
C ₄ F ₂	2.03	2.17	2.10	2.47	2.47	2.47	3.63	3.76	3.70	3.83	4.00	3.92
C ₅ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₀	0.63	0.77	0.70	1.30	1.40	1.35	2.00	2.06	2.03	2.37	2.47	2.42
C ₆ F ₁	1.03	1.17	1.10	2.17	2.10	2.13	2.46	2.54	2.50	2.80	2.90	2.85
C ₆ F ₂	1.80	1.87	1.83	2.44	2.83	2.64	3.43	3.59	3.51	3.53	3.67	3.60
C ₇ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₀	0.80	1.03	0.92	1.33	1.47	1.40	2.03	2.07	2.05	2.23	2.33	2.28
C ₈ F ₁	1.59	1.83	1.71	2.20	2.30	2.25	2.73	2.88	2.81	3.03	3.07	3.05
C ₈ F ₂	2.13	2.30	2.22	2.73	2.60	2.67	3.57	3.70	3.64	3.50	3.87	3.68
C ₉ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.02	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.02	0.03	0.04	0.03
CD (P=0.05)	0.06	0.07	0.05	0.09	0.07	0.06	0.09	0.08	0.06	0.07	0.12	0.07

Table 17a. Effect of row ratio and nutrient management on number of leaves of cowpea

Treatments	Number of leaves plant ⁻¹											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	5.66	5.75	5.70	26.31	54.71	40.51	49.90	67.10	58.50	90.04	101.49	95.77
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	4.70	6.12	5.41	25.60	30.93	28.27	52.49	58.18	55.33	81.71	94.27	87.99
C ₅ - M + R (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ - M + C (2:1)	4.17	6.04	5.11	25.32	27.16	26.24	37.60	44.71	41.16	75.10	88.71	81.91
C ₇ - M + R (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ - M + C (2:2)	3.70	5.87	4.78	21.82	24.93	23.38	36.16	41.99	39.07	59.82	81.93	70.88
C ₉ - M + R (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.04	0.03	0.02	0.12	0.23	0.13	0.22	0.32	0.19	0.42	0.59	0.36
CD (P=0.05)	0.11	0.08	0.07	0.33	0.65	0.36	0.61	0.91	0.54	1.20	1.66	1.01
2. Nutrient management												
F ₀ - Control	3.92	4.89	4.40	18.22	26.35	22.28	34.06	41.83	37.94	59.27	66.68	62.98
F ₁ - 50 % NPK	4.75	6.05	5.40	25.31	34.18	29.75	44.52	53.27	48.89	76.18	94.10	85.14
F ₂ - 100 % NPK	5.00	6.90	5.95	30.77	42.77	36.77	53.53	63.89	58.71	94.56	114.02	104.29
SEm±	0.02	0.02	0.01	0.07	0.13	0.07	0.12	0.18	0.11	0.24	0.34	0.21
CD (P=0.05)	0.07	0.05	0.04	0.19	0.38	0.21	0.35	0.52	0.31	0.69	0.96	0.58

Table 17b. Interaction effect of row ratio and nutrient management on number of leaves of cowpea

Interaction (C X F)	Number of leaves plant ⁻¹											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	4.77	4.80	4.78	18.73	47.27	33.00	36.27	54.10	45.18	70.93	73.27	72.10
C ₂ F ₁	5.73	5.87	5.80	27.93	53.93	40.93	49.10	66.93	58.02	92.60	109.93	101.27
C ₂ F ₂	6.47	6.58	6.52	32.27	62.93	47.60	64.33	80.27	72.30	106.60	121.27	113.93
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	3.43	4.60	4.02	20.27	21.27	20.77	37.10	40.33	38.72	55.93	70.93	63.43
C ₄ F ₁	5.07	6.50	5.78	27.43	30.27	28.85	55.93	61.93	58.93	83.27	93.93	88.60
C ₄ F ₂	5.60	7.27	6.43	29.10	41.27	35.18	64.43	72.27	68.35	105.93	117.93	111.93
C ₅ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₀	3.97	5.17	4.57	16.10	16.60	16.35	31.93	37.93	34.93	63.27	67.27	65.27
C ₆ F ₁	4.17	5.70	4.93	23.60	25.60	24.60	36.93	42.27	39.60	70.27	85.27	77.77
C ₆ F ₂	4.37	7.27	5.82	36.27	39.27	37.77	43.93	53.93	48.93	91.77	113.60	102.68
C ₇ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₀	3.50	5.00	4.25	17.77	20.27	19.02	30.93	34.93	32.93	46.93	55.27	51.10
C ₈ F ₁	4.03	6.13	5.08	22.27	26.93	24.60	36.10	41.93	39.02	58.60	87.27	72.93
C ₈ F ₂	3.57	6.47	5.02	25.43	27.60	26.52	41.43	49.10	45.27	73.93	103.27	88.60
C ₉ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.07	0.05	0.04	0.20	0.40	0.22	0.37	0.55	0.33	0.73	1.01	0.63
CD (P=0.05)	0.20	0.14	0.12	0.58	1.13	0.63	1.06	1.57	0.94	2.08	2.88	1.75

Table 18a. Effect of row ratio and nutrient management on primary branches of cowpea

Treatments	Primary branches plant ⁻¹								
	20 DAS			40 DAS			60 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	1.59	2.01	1.80	4.11	4.50	4.31	5.18	5.28	5.23
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	1.47	1.57	1.52	2.74	2.78	2.76	5.08	5.12	5.10
C ₅ - M + R (1:1)	-	-	-	-	-	-	-	-	-
C ₆ - M + C (2:1)	1.26	1.28	1.27	2.69	2.83	2.76	5.03	5.14	5.09
C ₇ - M + R (2:1)	-	-	-	-	-	-	-	-	-
C ₈ - M + C (2:2)	1.53	1.58	1.55	2.20	2.39	2.29	4.28	4.35	4.31
C ₉ - M + R (2:2)	-	-	-	-	-	-	-	-	-
SEm±	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.01
CD (P=0.05)	0.03	0.03	0.02	0.05	0.05	0.03	0.05	0.04	0.03
2. Nutrient management									
F ₀ - Control	1.070	1.128	1.099	2.183	2.575	2.379	4.302	4.390	4.346
F ₁ - 50 % NPK	1.418	1.655	1.537	3.067	3.217	3.142	4.828	4.911	4.869
F ₂ - 100 % NPK	1.897	2.039	1.968	3.558	3.583	3.571	5.544	5.613	5.579
SEm±	0.005	0.007	0.004	0.010	0.010	0.007	0.011	0.008	0.007
CD (P=0.05)	0.015	0.019	0.012	0.029	0.029	0.020	0.031	0.022	0.019

Table 18b. Interaction effect of row ratio and nutrient management on primary branches of cowpea

Interaction (C X F)	Primary branches plant ⁻¹								
	20 DAS			40 DAS			60 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-
C ₂ F ₀	1.17	1.30	1.23	3.23	4.03	3.63	4.30	4.40	4.35
C ₂ F ₁	1.53	2.23	1.88	4.33	4.53	4.43	5.18	5.33	5.26
C ₂ F ₂	2.07	2.49	2.28	4.77	4.93	4.85	6.07	6.10	6.08
C ₃ F ₀	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-
C ₄ F ₀	1.03	1.07	1.05	2.00	2.67	2.33	4.50	4.51	4.51
C ₄ F ₁	1.33	1.47	1.40	2.93	2.67	2.80	5.07	5.13	5.10
C ₄ F ₂	2.03	2.17	2.10	3.30	3.00	3.15	5.67	5.70	5.68
C ₅ F ₀	-	-	-	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-	-	-	-
C ₆ F ₀	1.01	1.01	1.01	2.17	2.23	2.20	4.37	4.51	4.44
C ₆ F ₁	1.29	1.32	1.30	2.67	2.83	2.75	4.90	4.97	4.93
C ₆ F ₂	1.49	1.50	1.50	3.23	3.43	3.33	5.81	5.95	5.88
C ₇ F ₀	-	-	-	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-	-	-	-
C ₈ F ₀	1.07	1.13	1.10	1.33	1.37	1.35	4.03	4.13	4.08
C ₈ F ₁	1.52	1.60	1.56	2.33	2.83	2.58	4.17	4.21	4.19
C ₈ F ₂	2.00	2.00	2.00	2.93	2.97	2.95	4.63	4.71	4.67
C ₉ F ₀	-	-	-	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-	-	-	-
SEm±	0.02	0.02	0.01	0.03	0.03	0.02	0.03	0.02	0.02
CD (P=0.05)	0.04	0.06	0.04	0.09	0.09	0.06	0.09	0.07	0.06

Table 19a. Effect of row ratio and nutrient management on fresh weight of cowpea

Treatments	Fresh weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	17.76	20.79	19.27	222.56	323.39	272.98	370.76	426.40	398.58	430.43	478.17	454.30
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	18.53	20.89	19.71	196.03	210.55	203.29	311.16	335.15	323.15	414.56	450.18	432.37
C ₅ - M + R (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ - M + C (2:1)	12.18	13.66	12.92	164.31	178.93	171.62	265.43	319.80	292.62	379.04	428.51	403.78
C ₇ - M + R (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ - M + C (2:2)	15.68	17.99	16.83	158.31	163.02	160.67	244.66	293.70	269.18	352.20	400.93	376.56
C ₉ - M + R (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.09	0.11	0.07	0.78	1.30	0.76	1.59	2.90	1.65	2.35	2.89	1.86
CD (P=0.05)	0.27	0.32	0.20	2.21	3.70	2.13	4.51	8.22	4.63	6.67	8.20	5.22
2. Nutrient management												
F ₀ - Control	10.95	13.00	11.97	141.72	168.84	155.28	213.41	236.90	225.16	276.43	145.89	211.16
F ₁ - 50 % NPK	15.67	18.76	17.21	184.66	225.47	205.06	293.49	338.46	315.98	435.49	441.50	438.49
F ₂ - 100 % NPK	21.49	23.24	22.37	229.53	262.60	246.07	387.10	455.92	421.51	470.26	548.58	509.42
SEm±	0.05	0.06	0.04	0.45	0.75	0.44	0.92	1.67	0.95	1.36	1.67	1.08
CD (P=0.05)	0.15	0.18	0.12	1.28	2.14	1.23	2.60	4.75	2.68	3.85	4.74	3.02

Table 19b. Interaction effect of row ratio and nutrient management on fresh weight of cowpea

Interaction (C X F)	Fresh weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	12.53	16.09	14.31	145.78	235.62	190.70	277.57	291.73	284.65	288.87	326.78	307.83
C ₂ F ₁	18.20	21.01	19.60	225.03	346.37	285.70	362.73	404.49	383.61	442.87	488.50	465.68
C ₂ F ₂	22.53	25.27	23.90	296.87	388.19	342.53	471.97	582.98	527.47	559.57	619.22	589.39
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	11.87	13.83	12.85	150.03	157.73	153.88	218.37	239.46	228.92	294.43	346.50	320.47
C ₄ F ₁	18.20	22.10	20.15	193.03	207.17	200.10	306.90	329.39	318.15	419.37	446.39	432.88
C ₄ F ₂	25.53	26.74	26.14	245.03	266.74	255.89	408.20	436.60	422.40	529.87	557.66	543.77
C ₅ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₀	8.87	10.30	9.58	136.70	147.91	142.31	190.53	218.24	204.39	269.53	357.36	313.45
C ₆ F ₁	11.80	14.07	12.94	159.37	181.52	170.44	270.73	323.46	297.10	519.53	405.23	462.38
C ₆ F ₂	15.87	16.62	16.24	196.87	207.36	202.11	335.03	417.71	376.37	348.07	522.95	435.51
C ₇ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₀	10.53	11.77	11.15	134.37	134.11	134.24	167.17	198.18	182.68	252.87	282.41	267.64
C ₈ F ₁	14.47	17.87	16.17	161.20	166.83	164.01	233.60	296.51	265.05	360.20	425.87	393.04
C ₈ F ₂	22.03	24.34	23.19	179.37	188.12	183.74	333.20	386.40	359.80	443.53	494.49	469.01
C ₉ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.16	0.19	0.13	1.35	2.26	1.32	2.75	5.02	2.86	4.07	5.01	3.23
CD (P=0.05)	0.46	0.55	0.35	3.83	6.41	3.69	7.81	14.24	8.03	11.55	14.21	9.05

Table 20a. Effect of row ratio and nutrient management on dry weight of cowpea

Treatments	Dry weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	3.40	3.85	3.62	23.56	33.68	28.62	79.57	84.51	82.04	102.81	111.15	106.98
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	3.53	3.86	3.69	25.09	26.83	25.96	66.40	69.89	68.14	91.52	96.75	94.13
C ₅ - M + R (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ - M + C (2:1)	2.52	2.63	2.57	20.10	21.10	20.60	60.66	69.17	64.91	88.01	98.41	93.21
C ₇ - M + R (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ - M + C (2:2)	2.90	3.29	3.09	18.58	19.86	19.22	55.11	62.40	58.75	82.72	89.69	86.21
C ₉ - M + R (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.02	0.02	0.01	0.11	0.15	0.10	0.52	0.59	0.39	0.36	0.35	0.25
CD (P=0.05)	0.05	0.05	0.04	0.31	0.44	0.27	1.46	1.67	1.10	1.02	1.01	0.71
2. Nutrient management												
F ₀ - Control	2.44	2.71	2.58	13.00	15.07	14.03	36.75	40.34	38.54	51.50	58.37	54.93
F ₁ - 50 % NPK	3.21	3.64	3.43	21.25	25.52	23.39	62.80	70.19	66.50	88.53	97.65	93.09
F ₂ - 100 % NPK	3.60	3.88	3.74	31.25	35.50	33.38	96.76	103.93	100.35	133.78	140.88	137.33
SEm±	0.01	0.01	0.01	0.06	0.09	0.05	0.30	0.34	0.23	0.21	0.20	0.15
CD (P=0.05)	0.03	0.03	0.02	0.18	0.25	0.15	0.84	0.96	0.63	0.59	0.58	0.41

Table 20b. Interaction effect of row ratio and nutrient management on dry weight of cowpea

Interaction (C X F)	Dry weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	2.61	3.24	2.92	14.15	19.60	16.88	44.58	46.14	45.36	61.21	66.34	63.77
C ₂ F ₁	3.67	4.03	3.85	23.25	33.66	28.45	75.05	81.55	78.30	97.14	108.49	102.82
C ₂ F ₂	3.91	4.28	4.10	33.28	47.78	40.53	119.09	125.83	122.46	150.08	158.62	154.35
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	2.59	2.87	2.73	14.51	16.40	15.45	38.42	42.27	40.35	51.15	58.01	54.58
C ₄ F ₁	3.70	4.24	3.97	24.77	27.20	25.99	64.65	68.60	66.63	88.62	93.83	91.23
C ₄ F ₂	4.28	4.48	4.38	35.98	36.90	36.44	96.13	98.79	97.46	134.78	138.41	136.60
C ₅ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₀	2.28	2.25	2.27	12.16	12.88	12.52	34.16	38.46	36.31	47.98	60.30	54.14
C ₆ F ₁	2.55	2.83	2.69	18.59	22.23	20.41	59.48	67.84	63.66	87.76	97.61	92.68
C ₆ F ₂	2.71	2.81	2.76	29.54	28.19	28.86	88.33	101.20	94.76	128.29	137.34	132.81
C ₇ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₀	2.27	2.48	2.38	11.16	11.41	11.29	29.82	34.49	32.16	45.64	49.85	47.75
C ₈ F ₁	2.93	3.45	3.19	18.40	19.02	18.71	52.00	62.79	57.39	80.58	89.43	85.01
C ₈ F ₂	3.49	3.93	3.71	26.19	29.15	27.67	83.51	89.90	86.71	121.95	129.78	125.87
C ₉ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	0.03	0.03	0.02	0.19	0.27	0.16	0.89	1.02	0.68	0.62	0.61	0.44
CD (P=0.05)	0.08	0.09	0.06	0.54	0.76	0.46	2.53	2.89	1.90	1.77	1.74	1.23

4.1.3 Rice bean

4.1.3.1 Plant height (cm)

The periodical plant height of fodder rice bean recorded at 20 DAS, 40 DAS, 60 DAS and 80 DAS was significantly influenced by different row ratio and nutrient management (Table 21a). Among all the different row ratio, the sole crop treatment C₃ significantly recorded the highest plant height of fodder rice bean at 20 DAS (36.36 cm), 40 DAS (114.58 cm), 60 DAS (214.81 cm) and 80 DAS (225.13 cm). The lowest plant height at 20 DAS (32.36 cm), 40 DAS (105.98 cm), 60 DAS (140.91 cm) and 80 DAS (191.49 cm) was observed at C₇. Similarly, Gaikwad *et al.* (2022) also reported the highest plant height at sole crop was and then at different row ratio, 1:2 and 1:1 give more higher plant height than 2:1 row ratio. The higher plant of cowpea at sole plot followed maize with cowpea at 2:2 and 1:1 row ratio was also reported by Kussie *et al.* (2024).

The nutrient management result from the table 21a showed that treatments receiving higher nutrients doses produced the higher plant height of fodder rice bean than the control treatment. The treatment F₂ (100 % RDF) significantly recorded the highest plant height at 20 DAS (39.21 cm), 40 DAS (134.74 cm), 60 DAS (195.97 cm) and 80 DAS (249.27 cm) among the nutrient management treatment. The lowest plant height at 20 DAS (29.06 cm), 40 DAS (83.64 cm), 60 DAS (121.79 cm) and 80 DAS (165.83 cm) was obtained at F₀ (control). Similarly, Asangla (2015) also reported the increased in plant height of cowpea with increased in nutrient levels.

The interaction result (Table 21b) showed that plant height of the fodder rice bean was improved with application of nutrients. Among all the treatments, the highest plant height of fodder rice bean at 20 DAS (43.01 cm), 40 DAS (143.72 cm), 60 DAS (262.05 cm) and 80 DAS (270.10 cm) was recorded at C₃F₂ and was followed by C₉F₂ at 40 DAS (141.83 cm) and 80 DAS (255.60 cm), from then on treatment C₃F₁ recorded the highest plant height at 60 DAS (228.10 cm). The shortest plant height at 20 DAS was recorded at C₇F₀ (26.79 cm) and which was on statistically on par with C₅F₀ (27.65 cm). At 40 DAS, the lower and comparable plant height was recorded at C₅F₀ (79.51

cm) and C₇F₀ (79.90 cm). Furthermore, the lowest plant height at 60 DAS and 80 DAS was seen at C₇F₀ (103.77 cm, 153.27 cm) and C₉F₀ (107.27 cm, 155.27 cm) respectively.

4.1.3.2 Leaf length (cm)

Result (Table 22a) revealed that growing of fodder rice bean at different row ratio showed not much variation in leaf length of fodder rice bean. Among all the different row ratio, the longest leaf length at 20 (4.38 cm) was recorded at C₃- sole rice bean. Likewise, the highest leaf length of the fodder rice bean at 40 DAS (7.46 cm, 7.35 cm), 60 DAS (12.32 cm, 12.03 cm) and 80 DAS (11.93 cm, 12.03 cm) was observed at C₃ and C₉ respectively. The shortest leaf length at 20 DAS and 80 DAS recorded at C₇ (4.21 cm, 10.82), while C₅ maintained the shortest leaf length at 40 DAS (7.20 cm) and 60 DAS (11.03 cm) respectively. The longer leaf length obtained in sole crop followed by 2:2. 1:1 row ratio might be due to free competition within the crops for resources like sunlight, spaces and nutrients and also possibility of nitrogen fixation in the soil. However, in contrast to this, Ginwal *et al.* (2019a) reported the longer leaf length at 2:1 and 1:1 row ratio as compared to sole cropping.

In case of nutrient management, the result (Table 22a) revealed that nutrients application caused a wide variation in leaf length of fodder rice bean. Significantly, application of nutrient at F₂ (100 % RDF) produced the highest leaf length in all stages of the observation *i.e.*, 20 DAS (5.23 cm), 40 DAS (8.34 cm), 60 DAS (13.11 cm) and 80 DAS (12.63 cm), while the shortest leaf length among all the nutrient treatments at 20 DAS (3.26 cm), 40 DAS (6.29 cm), 60 DAS (10.18 cm) and 80 DAS (10.52 cm) was observed in F₀ (control). The obtained of longer leaf length at treatment receiving higher doses of nutrients was mostly due to adequate availability of nutrients into soil resulting in supply their needs for growth and development.

It is clear from the result (Table 22b) that the factor combination (different row ratio and nutrient management) had a varied impact on leaf length of fodder rice bean. At 20 DAS, the highest and the shortest leaf length of fodder rice bean was recorded at C₃F₂ (5.35 cm) and C₇F₀ (3.18 cm). The higher and comparable leaf length

at 40 DAS was observed at C₃F₂ (8.46 cm) and C₉F₂ (8.41 cm), while the shortest was obtained at C₅F₀ (6.17 cm). However, at 60 DAS, it was recorded from the treatments C₃F₂ and C₉F₂ (14.18 cm, 13.18 cm), while at 80 DAS, C₃F₂ and C₅F₂ (12.95 cm, 12.96 cm) statistically recorded the highest leaf length of fodder rice bean. The shortest leaf length at 60 DAS and 80 DAS was observed at C₅F₀ (9.86 cm) and C₇F₀ (9.85 cm). The observation of longer leaf length under sole and then at 1:1 and 2:2 row ratio along with 100 % RDF practices might be due to less competition for resources and suitable companion.

4.1.3.3 Leaf width (cm)

The result (Table 23a) revealed that the longest leaf width of fodder rice bean at 20 DAS (4.49 cm) was recorded from C₃ and the lowest was registered at C₇ (3.31 cm). Similarly, the widest leaf width of fodder rice bean at 40 DAS was recorded in C₉ (5.95 cm), while C₇ maintained the widest leaf width at 60 DAS (6.86 cm) and 80 DAS (7.59 cm). The minimum leaf width of fodder rice bean at 40 DAS (5.75 cm), 60 DAS (6.26 cm) and 80 DAS (7.21 cm) was seen at C₃. Ginwal *et al.* (2019a) also reported the wider leaf width of cowpea sown under 1:1 and 2:1 row ratio than sole crop. However, Gaidwad *et al.* (2022) reported the wider leaf width of cowpea under sole crop.

The result showed (Table 23a) that nutrient management caused a variation in leaf length of fodder rice bean. Among all the treatment combinations, the treatment F₂ (100 % RDF) significantly maintained the widest leaf width of fodder rice bean at 20 DAS (4.40 cm), 40 DAS (6.66 cm), 60 DAS (7.42 cm) and 80 DAS (8.48 cm). In comparisons with other treatments, the minimum leaf width was recorded from F₀ (control) at 20 DAS (3.21 cm), 40 DAS (5.17 cm), 60 DAS (5.58 cm) and 80 DAS (6.10 cm) respectively. The similar results of increase in leaf width with increase in nutrients application of fodder rice bean was also reported by Gaikwad *et al.* (2022).

Result (Table 23b) revealed that both different row ratio and nutrient management had a significant impact on leaf width of fodder rice bean. Among all the treatment combinations, the treatment C₃F₂ (5.11 cm) recorded the widest leaf width,

while C₇F₀ (2.86 cm) maintained the minimum leaf width at 20 DAS. Similarly, C₉F₂ and C₅F₂ significantly produced the widest leaf width at 40 DAS (6.85 cm, 6.66 cm). At 60 DAS and 80 DAS, the widest leaf width was observed from C₇F₂ (7.66 cm) and C₅F₂ (8.73 cm). However, C₅F₀ recorded the minimum leaf width at 40 DAS (5.10 cm) and 80 DAS (5.89 cm), while C₉F₀ (5.23) recorded the minimum leaf width at 60 DAS.

4.1.3.4 Leaf stem ratio

The result (24a) indicated that different row ratio had a significant effect on leaf stem ratio of fodder rice bean. The data showed that leaf stem ratio of fodder rice bean was high at 20 DAS and the next observation onward, the leaf stem ratio was decreased. Among all the different row ratio, the highest leaf stem ratio was recorded from C₃ at 20 DAS (1.271), 40 DAS (0.831), 60 DAS (0.750) and 80 DAS (0.720) followed by C₅ and C₇. Likewise, C₉ recorded the lowest leaf stem ratio at 20 DAS (1.125), 40 DAS (0.727), 60 DAS (0.715) and 80 DAS (0.700) respectively.

The nutrient management result (Table 24a) revealed that the leaf stem ratio of fodder rice bean was found to be increase with increase in nutrient levels. The highest leaf stem ratio of fodder rice bean was observed in F₂ (100 % RDF) at 20 DAS (1.254), 40 DAS (0.794), 60 DAS (0.745) and 80 DAS (0.724). However, the lowest leaf stem ratio of fodder rice bean was recorded in F₀ (control) at 20 DAS (1.114), 40 DAS (0.731), 60 DAS (0.713) and 80 DAS (0.697) in comparison to other treatments.

The interaction result (24b) showed a significant variation in leaf stem ratio of fodder rice bean. Among all the treatment combinations, the treatment C₃F₂ recorded the highest leaf stem ratio at 20 DAS (1.376), 40 DAS (0.882), 60 DAS (0.768) and 80 DAS (0.734). At 20 DAS, the lowest leaf stem ratio was recorded at C₉F₀ (1.063), while the treatment C₇F₀ recorded the lowest leaf stem ratio at 40 DAS (0.696) and 60 DAS (0.702) and then treatment C₉F₀ (0.688) produced the lowest leaf stem ratio at 80 DAS.

4.1.3.5 Stem girth (cm)

The result (Table 25a) indicated that different row ratio and nutrient management exert a significant variation on stem girth of fodder rice bean at both the

years of investigation. With regard to different row ratio, the stem girth of fodder rice bean was found to be the highest in C₃ at 20 DAS (1.278 cm), 40 DAS (2.122 cm), 60 DAS (2.689 cm) and 80 DAS (2.800 cm) respectively. The lowest leaf stem ratio of the fodder rice bean was observed in C₇ at 20 DAS (0.964 cm), 40 DAS (2.017 cm), 60 DAS (2.322 cm) and 80 DAS (2.456 cm). Similar findings of higher stem girth of cowpea were obtained under sole crop than different row ratio by Ginwal *et al.* (2019a).

The result (Table 25a) showed that the stem girth of fodder rice bean was increase with increase in nutrient levels. The highest stem girth was recorded in F₂ (100 % RDF) at 20 DAS (1.287 cm), 40 DAS (2.506 cm), 60 DAS (3.025 cm) and 80 DAS (3.255 cm), while the lowest stem girth was observed from F₀ (control) at 20 DAS (0.960 cm), 40 DAS (1.573 cm), 60 DAS (2.019 cm) and 80 DAS (2.080 cm).

The interaction result (25b) showed the wide variation in stem girth of fodder rice bean. The highest stem girth of fodder rice bean was recorded from C₃F₂ (1.417 cm) and while the lowest stem girth was seen in C₇F₀ (0.750 cm) at 20 DAS. The treatment C₃F₂ recorded the highest stem girth at 40 DAS (2.650 cm), 60 DAS (3.250 cm) and 80 DAS (3.600 cm), while the lowest stem girth was observed from treatment C₅F₀ at 40 DAS (1.583 cm), 60 DAS (1.858 cm) and then from C₇F₀ (2.053 cm) at 80 DAS.

4.1.3.6 Number of leaves plant⁻¹

The number of leaves plant⁻¹ was statistically significant with both the factors (different row ratio and nutrient management). With regards to different row ratio, the results data (Table 26a) indicated that significantly at 20 DAS, the higher number of leaves plant⁻¹ was counted in C₇ (5.72) and the lower number of leaves plant⁻¹ were counted from C₉ (5.23) and C₃ (5.24). Thereafter, the sole crop C₃ significantly continue to registered the highest number of leaves plant⁻¹ from 40 DAS (17.07), 60 DAS (35.40) and 80 DAS (68.23), alongside the lowest number of leaves plant⁻¹ was counted in C₇ at 40 DAS (13.36), 60 DAS (23.96) and 80 DAS (44.52) respectively. This finding was in confirmatory with Ginwal *et al.* (2019a). Similarly, observation of higher number of leaves plant⁻¹ at 1:1 row ratio in compared to sole, 2:1 and 3:1 row

ratio was also reported by Asangla (2015). In contrast to this, Gaikwad *et al.* (2022) reported the higher number of leaves plant⁻¹ at sole followed by 1:2, 1:1 row ratio and the least number of leaves plant⁻¹ was obtained at 2:1 row ratio.

Regarding the nutrient management practices (Table 26a), the number of leaves plant⁻¹ was significantly increase with increase in nutrient levels in both studied years. The number of leaves plant⁻¹ of fodder rice bean were ranged from 4.77 to 69.21. Among all the treatment combinations, the highest number of leaves plant⁻¹ was significantly counted in F₂ (100 % RDF) at 20 DAS (5.95), 40 DAS (19.26), 60 DAS (36.28) and 80 DAS (69.21). In the same way, the lowest number of leaves plant⁻¹ at 20 DAS (4.77), 40 DAS (11.68), 60 DAS (21.42) and 80 DAS (48.48) was counted at F₀ (control) respectively. Correspondingly, Asangla (2015) also reported the higher number of leaves plant⁻¹ under high level of nutrient application.

It is evident from the interaction result (Table 26b) that both different row ratio and nutrient management factors produced a notable variation in number of leaves plant⁻¹. Among all the treatment combinations, the highest number of leaves plant⁻¹ at 20 DAS was counted in C₇F₂ (6.68). On the other hand, the highest number of leaves plant⁻¹ at 40 DAS (21.35), 60 DAS (44.23) and 80 DAS (77.72) was registered from C₃F₂. The lowest number of leaves plant⁻¹ was recorded in C₅F₀ (4.63) at 20 DAS, then again it was recorded from C₇F₀ at 40 DAS (10.10), 60 DAS (18.02) and C₉F₀ at 80 DAS (36.27) respectively. The observation of higher number of leaves plant⁻¹ under different row ratio which received higher doses of nutrient applications were might be owing to plenty of nutrient available to the crop and less competition between them. Similarly, Asangla (2015) also reported the higher number leaves plant⁻¹ under the combination of different row ratio with higher doses of nutrient application than control.

4.1.3.7 Number of primary branches plant⁻¹

The primary branches plant⁻¹ of fodder rice bean were significantly varied by both different row ratio and nutrient management (Table 27a). Among the different row ratio, the highest primary branches plant⁻¹ at 20 DAS were recorded from C₅ (1.111)

and then C₃ maintained the highest primary branches plant⁻¹ of fodder rice bean at 40 DAS (2.528) and 60 DAS (3.778). The lowest primary branches plant⁻¹ of fodder rice bean were recorded in C₇ at 20 DAS (1.000), 40 DAS (2.390) and 60 DAS (3.222). The higher primary branches plant⁻¹ under sole followed by 1:1 row ratio was probably due to less competition for resources like space, nutrients and sunlight.

It is seen from the data (Table 27a) that primary branches of the fodder rice bean were not varied remarkably among the nutrient management. The higher primary branches plant⁻¹ were observed from F₂ (100 % RDF) at 20 DAS (1.099 cm), 40 DAS (2.938 cm) and 60 DAS (4.246 cm). The higher number of primary branches plant⁻¹ of fodder rice bean under higher nutrient application was mainly by adequate availability of nutrient for their growth and development.

The result (Table 27b) of interaction displayed that different row ratio and nutrient management did not produce a wide variation in primary branches of fodder rice bean at 20 DAS. However, from 40 DAS to 60 DAS onward, variation in the primary branches of fodder rice bean was observed. The highest primary branches plant⁻¹ at 20 DAS were seen in C₅F₂ (1.213) and the lowest was registered at C₇F₀ (1.000) and then on C₃F₂ maintained the highest primary branches plant⁻¹ at 40 DAS (3.333) and 60 DAS (4.667). The C₃F₀ and C₅F₀ recorded the lowest primary branches plant⁻¹ at 40 DAS (1.833) and 60 DAS (2.70). The different row ratio which received higher doses of nutrients registered higher primary branches plant⁻¹ of fodder rice bean was due to higher available of nutrient for plant and less competition for resources.

4.1.3.8 Fresh weight of plant (g plant⁻¹)

The result (Table 28a) revealed that different row ratio of fodder maize with fodder rice bean and nutrient management caused a significant variation in fresh weight of fodder rice bean. The fresh weight of the plant was found to be low at 20 DAS, due to slower growth of the plant at initial stages of the growth. However, from 40 DAS onward, the fresh weight of the plant was increase due to drastic changes in the plant growth. Regarding the different row ratio, C₃ significantly hold the highest fresh weight of the fodder rice bean at 20 DAS (13.37 g plant⁻¹), 40 DAS (67.45 g plant⁻¹), 60 DAS

(149.74 g plant⁻¹) and 80 DAS (248.29 g plant⁻¹). Likewise, the treatment C₇ recorded the lowest fresh weight of the fodder rice bean at 20 DAS (6.43), 40 DAS (52.34 g plant⁻¹), 60 DAS (90.15 g plant⁻¹) and 80 DAS (188.41 g plant⁻¹) respectively. The observation of higher fresh weight of fodder rice bean at sole crop was mainly due to higher vegetative growth of the plant and the lower observation at 2:1 row ratio was might be due to higher competition of the crops, which could be the reason to produced lower growth of plant.

The data presented in the Table 28a showed that nutrient management had a significant influence on fresh weight of fodder rice bean. The fresh weight of the plant increase with increase in nutrient levels. The highest fresh weight of the fodder rice bean was seen in F₂ (100 % RDF) at 20 DAS (12.08 g plant⁻¹), 40 DAS (78.46 g plant⁻¹), 60 DAS (139.60 g plant⁻¹) and 80 DAS (266.88 g plant⁻¹), where the lowest fresh weight was recorded from F₀ (control) at 20 DAS (7.00 g plant⁻¹), 40 DAS (39.86 g plant⁻¹), 60 DAS (87.14 g plant⁻¹) and 80 DAS (192.32 g plant⁻¹). The higher fresh weight of fodder rice bean was recorded under high nutrient application may be due to sufficient availability of nutrients to the plant.

The interaction data presented in the Table 28b indicated that fresh weight of fodder rice bean had significant influenced due to different row ratio. However, the application of nutrients at different levels caused a signification variation in fresh weight of fodder rice bean. At 20 DAS, the highest fresh weight of fodder rice bean had been recorded from C₃F₂ (16.54 g plant⁻¹) and followed by C₃F₁ (13.62 g plant⁻¹). Constantly, the treatment C₃F₂ significantly maintained the highest fresh weight of fodder rice bean at 40 DAS (94.27 g plant⁻¹), 60 DAS (187.75 g plant⁻¹) and 80 DAS (276.28 g plant⁻¹). Likewise, the treatment C₇F₀ significantly recorded the lowest fresh weight of fodder rice bean at 20 DAS (4.33 g plant⁻¹), 40 DAS (34.24 g plant⁻¹), 60 DAS (65.15 g plant⁻¹) and 80 DAS (150.61 g plant⁻¹) in compared to the remaining treatments.

4.1.3.9 Dry weight of plant (g plant⁻¹)

The result indicated that different row ratio and nutrient management had significant impact on dry weight of fodder rice bean (Table 29a). The highest dry weight of fodder rice bean was recorded from sole crop C₃ at 20 DAS (1.842 g plant⁻¹), 40 DAS (6.176 g plant⁻¹), 60 DAS (18.043 g plant⁻¹) and 80 DAS (34.555 g plant⁻¹) respectively. Likewise, the treatment C₇ produced the lowest dry weight of fodder rice bean at 20 DAS (0.928 g plant⁻¹), 40 DAS (4.853 g plant⁻¹), 60 DAS (11.673 g plant⁻¹) and 80 DAS (21.702 g plant⁻¹) among all the treatments. The observation of higher dry weight plant⁻¹ of fodder rice bean in sole crop followed by 1:1 row ratio was mainly due to higher fresh weight of plant.

The dry weight of fodder rice bean was remarkably influenced by nutrient management. The application nutrient at different levels showed a wide ranged in dry weight of fodder rice bean (Table 29a). Among all the treatments, the highest dry weight plant⁻¹ was recorded in F₂ (100 % RDF) at 20 DAS (1.636 g plant⁻¹), 40 DAS (7.253 g plant⁻¹), 60 DAS (20.772 g plant⁻¹) and 80 DAS (36.800 g plant⁻¹) and the lowest was observed from treatment F₀ (control) at 20 DAS (1.040 g plant⁻¹), 40 DAS (3.337 g plant⁻¹), 60 DAS (7.787 g plant⁻¹) and 80 DAS (17.932 g plant⁻¹), respectively. The nutrient management practices improved the higher dry weight of the plant by promoting higher vegetative growth due to adequate availability of nutrients into the soil.

The interaction between different row ratio and nutrient management had significant influence on dry weight of fodder rice bean (Table 29b). Among all the treatment combinations, the highest dry weight of fodder rice bean was continuously registered in C₃F₂ at 20 DAS (2.223 g plant⁻¹), 40 DAS (8.763 g plant⁻¹), 60 DAS (26.597 g plant⁻¹) and 80 DAS (45.108 g plant⁻¹). Likewise, the lowest dry weight was noted in C₇F₀ at 20 DAS (0.623 g plant⁻¹), 40 DAS (2.947 g plant⁻¹), 60 DAS (6.043 g plant⁻¹) and 80 DAS (13.576) as compared to the other remaining treatments.

Table 21a. Effect of row ratio and nutrient management on plant height of rice bean

Treatments	Plant height (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	29.02	43.69	36.36	95.48	133.67	114.58	211.23	218.38	214.81	222.54	227.71	225.13
C ₄ - M + C (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ - M + R (1:1)	26.59	41.28	33.94	85.24	126.72	105.98	136.59	155.47	146.03	210.16	219.38	214.77
C ₆ - M + C (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ - M + R (2:1)	25.36	39.37	32.36	76.16	115.73	95.94	134.43	147.38	140.91	190.04	192.93	191.49
C ₈ - M + C (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ - M + R (2:2)	25.02	44.91	34.96	98.13	128.62	113.38	143.89	153.51	148.70	207.06	211.49	209.27
SEm±	0.12	0.19	0.11	0.75	0.95	0.60	1.01	0.99	0.71	1.10	1.10	0.78
CD (P=0.05)	0.35	0.54	0.32	2.12	2.69	1.69	2.87	2.82	1.99	3.12	3.13	2.18
2. Nutrient management												
F ₀ - Control	24.18	33.95	29.06	68.24	98.36	83.30	119.06	124.52	121.79	164.39	167.27	165.83
F ₁ - 50 % NPK	26.64	43.25	34.95	86.09	125.14	105.61	160.39	179.75	170.07	212.61	218.18	215.40
F ₂ - 100 % NPK	28.67	49.74	39.21	111.93	155.05	133.49	190.16	201.78	195.97	245.35	253.18	249.27
SEm±	0.07	0.11	0.07	0.43	0.55	0.35	0.58	0.57	0.41	0.63	0.64	0.45
CD (P=0.05)	0.20	0.31	0.18	1.22	1.55	0.98	1.66	1.63	1.15	1.80	1.81	1.26

Table 21b. Interaction effect of row ratio and nutrient management on plant height of rice bean

Interaction (C X F)	Plant height (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	25.33	32.79	29.06	70.60	104.83	87.72	150.60	157.93	154.27	173.77	176.27	175.02
C ₃ F ₁	28.53	45.45	36.99	86.37	131.43	108.90	225.93	230.27	228.10	229.27	231.27	230.27
C ₃ F ₂	33.19	52.83	43.01	129.47	164.75	147.11	257.17	266.93	262.05	264.60	275.60	270.10
C ₄ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₀	24.83	30.47	27.65	63.91	95.12	79.51	117.10	126.60	121.85	178.60	180.93	179.77
C ₅ F ₁	26.93	43.79	35.36	89.02	128.77	108.89	133.57	166.33	149.95	212.60	228.60	220.60
C ₅ F ₂	28.00	49.59	38.80	102.80	156.27	129.53	159.10	173.47	166.28	239.27	248.60	243.93
C ₆ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₀	23.20	30.39	26.79	65.53	94.27	79.90	101.93	105.60	103.77	151.93	154.60	153.27
C ₇ F ₁	25.80	38.69	32.25	73.20	111.70	92.45	137.27	159.27	148.27	194.60	192.93	193.77
C ₇ F ₂	27.07	49.04	38.05	89.73	141.23	115.48	164.10	177.27	170.68	223.60	231.27	227.43
C ₈ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₀	23.33	42.15	32.74	72.93	99.23	86.08	106.60	107.93	107.27	153.27	157.27	155.27
C ₉ F ₁	25.30	45.07	35.18	95.77	128.67	112.22	144.80	163.13	153.97	213.97	219.93	216.95
C ₉ F ₂	26.43	47.50	36.97	125.70	157.97	141.83	180.27	189.47	184.87	253.93	257.27	255.60
SEm±	0.21	0.33	0.20	1.29	1.64	1.04	1.75	1.72	1.23	1.90	1.91	1.35
CD (P=0.05)	0.60	0.94	0.55	3.67	4.66	2.93	4.98	4.89	3.45	5.40	5.42	3.78

Table 22a. Effect of row ratio and nutrient management on leaf length of rice bean

Treatments	Leaf length (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	4.30	4.46	4.38	7.39	7.52	7.46	12.08	12.57	12.32	11.76	12.11	11.93
C ₄ - M + C (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ - M + R (1:1)	4.22	4.32	4.27	7.15	7.25	7.20	10.46	11.59	11.03	11.49	11.88	11.69
C ₆ - M + C (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ - M + R (2:1)	4.13	4.28	4.21	7.20	7.43	7.31	10.99	11.73	11.36	9.98	11.67	10.82
C ₈ - M + C (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ - M + R (2:2)	4.06	4.39	4.23	7.31	7.39	7.35	11.56	12.03	11.79	11.53	12.54	12.03
SEm±	0.02	0.02	0.01	0.03	0.02	0.02	0.06	0.05	0.04	0.12	0.16	0.10
CD (P=0.05)	0.06	0.05	0.04	0.07	0.06	0.05	0.18	0.14	0.11	0.35	0.45	0.28
2. Nutrient management												
F ₀ - Control	3.20	3.31	3.26	6.24	6.34	6.29	9.83	10.53	10.18	10.15	10.89	10.52
F ₁ - 50 % NPK	4.21	4.45	4.33	7.29	7.42	7.35	11.26	11.93	11.59	11.35	12.07	11.71
F ₂ - 100 % NPK	5.12	5.33	5.23	8.26	8.42	8.34	12.73	13.48	13.11	12.07	13.19	12.63
SEm±	0.46	0.01	0.01	0.01	0.01	0.01	0.04	0.03	0.02	0.07	0.09	0.06
CD (P=0.05)	0.03	0.03	0.02	0.04	0.04	0.03	0.10	0.08	0.06	0.20	0.26	0.16

Table 22b. Interaction effect of row ratio and nutrient management on leaf length of rice bean

Interaction (C X F)	Leaf length (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	3.33	3.43	3.38	6.38	6.47	6.42	10.33	11.09	10.71	10.93	10.54	10.74
C ₃ F ₁	4.30	4.50	4.40	7.39	7.57	7.48	12.03	12.12	12.08	11.73	12.50	12.12
C ₃ F ₂	5.27	5.43	5.35	8.41	8.52	8.46	13.87	14.50	14.18	12.60	13.29	12.95
C ₄ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₀	3.27	3.25	3.26	6.15	6.19	6.17	9.33	10.39	9.86	9.93	10.98	10.46
C ₅ F ₁	4.27	4.43	4.35	7.18	7.25	7.22	10.39	11.62	11.01	11.87	11.42	11.65
C ₅ F ₂	5.11	5.29	5.20	8.13	8.31	8.22	11.67	12.77	12.22	12.67	13.25	12.96
C ₆ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₀	3.13	3.23	3.18	6.20	6.45	6.33	9.37	10.43	9.90	8.93	10.76	9.85
C ₇ F ₁	4.20	4.38	4.29	7.23	7.44	7.34	11.20	11.49	11.35	10.10	11.47	10.78
C ₇ F ₂	5.07	5.23	5.15	8.18	8.38	8.28	12.40	13.27	12.83	10.90	12.77	11.83
C ₈ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₀	3.07	3.33	3.20	6.24	6.24	6.24	10.30	10.22	10.26	10.80	11.28	11.04
C ₉ F ₁	4.07	4.48	4.28	7.35	7.43	7.39	11.40	12.48	11.94	11.68	12.87	12.28
C ₉ F ₂	5.03	5.37	5.20	8.33	8.49	8.41	12.98	13.38	13.18	12.10	13.46	12.78
SEm±	0.03	0.03	0.02	0.04	0.04	0.03	0.11	0.08	0.07	0.22	0.28	0.18
CD (P=0.05)	0.10	0.09	0.06	0.13	0.11	0.08	0.31	0.24	0.19	0.61	0.79	0.49

Table 23a. Effect of row ratio and nutrient management on leaf width of rice bean

Treatments	Leaf width (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	4.12	4.85	4.49	5.55	5.96	5.75	6.13	6.38	6.26	6.39	8.04	7.21
C ₄ - M + C (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ - M + R (1:1)	3.75	3.89	3.82	5.74	5.94	5.84	6.43	6.66	6.55	7.11	7.95	7.53
C ₆ - M + C (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ - M + R (2:1)	3.56	3.06	3.31	5.52	6.21	5.87	6.69	7.03	6.86	6.75	8.43	7.59
C ₈ - M + C (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ - M + R (2:2)	3.30	3.90	3.60	5.66	6.24	5.95	6.21	6.54	6.38	6.64	7.90	7.27
SEm±	0.03	0.02	0.02	0.02	0.03	0.02	0.03	0.05	0.03	0.03	0.03	0.02
CD (P=0.05)	0.08	0.07	0.05	0.07	0.07	0.05	0.09	0.14	0.08	0.10	0.09	0.06
2. Nutrient management												
F ₀ - Control	3.11	3.31	3.21	4.99	5.35	5.17	5.43	5.73	5.58	5.56	6.65	6.10
F ₁ - 50 % NPK	3.63	3.96	3.80	5.46	6.01	5.73	6.45	6.61	6.53	7.01	8.23	7.62
F ₂ - 100 % NPK	4.31	4.50	4.40	6.41	6.91	6.66	7.21	7.63	7.42	7.59	9.36	8.48
SEm±	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.03	0.02	0.02	0.02	0.01
CD (P=0.05)	0.04	0.04	0.03	0.04	0.04	0.03	0.05	0.08	0.05	0.05	0.05	0.04

Table 23b. Interaction effect of row ratio and nutrient management on leaf width of rice bean

Interaction (C X F)	Leaf width (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	3.30	4.02	3.66	4.93	5.30	5.12	5.45	5.50	5.47	5.38	6.92	6.15
C ₃ F ₁	4.30	5.08	4.69	5.47	5.79	5.63	6.03	6.22	6.13	6.72	7.49	7.11
C ₃ F ₂	4.76	5.46	5.11	6.24	6.78	6.51	6.90	7.43	7.17	7.05	9.71	8.38
C ₄ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₀	3.10	3.20	3.15	5.07	5.13	5.10	5.48	5.92	5.70	5.37	6.40	5.89
C ₅ F ₁	3.53	3.85	3.69	5.55	6.00	5.78	6.51	6.63	6.57	7.57	8.40	7.98
C ₅ F ₂	4.63	4.61	4.62	6.62	6.70	6.66	7.30	7.44	7.37	8.40	9.06	8.73
C ₆ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₀	3.00	2.71	2.86	4.97	5.43	5.20	5.66	6.20	5.93	5.47	7.04	6.26
C ₇ F ₁	3.50	3.04	3.27	5.41	6.17	5.79	6.95	7.06	7.00	6.93	8.75	7.84
C ₇ F ₂	4.19	3.42	3.80	6.20	7.03	6.62	7.48	7.84	7.66	7.84	9.49	8.67
C ₈ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₀	3.03	3.31	3.17	5.00	5.53	5.27	5.15	5.31	5.23	6.01	6.25	6.13
C ₉ F ₁	3.20	3.87	3.54	5.41	6.07	5.74	6.32	6.52	6.42	6.82	8.27	7.55
C ₉ F ₂	3.66	4.51	4.08	6.57	7.13	6.85	7.17	7.81	7.49	7.08	9.19	8.14
SEm±	0.05	0.04	0.03	0.04	0.05	0.03	0.06	0.09	0.05	0.06	0.05	0.04
CD (P=0.05)	0.13	0.11	0.09	0.11	0.13	0.09	0.16	0.24	0.14	0.16	0.15	0.11

Table 24a. Effect of row ratio and nutrient management on leaf stem ratio of rice bean

Treatments	Leaf stem ratio											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	1.350	1.192	1.271	0.807	0.854	0.831	0.737	0.762	0.750	0.720	0.721	0.720
C ₄ - M + C (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ - M + R (1:1)	1.193	1.123	1.158	0.761	0.770	0.765	0.730	0.733	0.731	0.711	0.717	0.714
C ₆ - M + C (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ - M + R (2:1)	1.226	1.137	1.182	0.734	0.740	0.737	0.721	0.727	0.724	0.705	0.702	0.704
C ₈ - M + C (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ - M + R (2:2)	1.171	1.078	1.125	0.725	0.728	0.727	0.719	0.711	0.715	0.703	0.697	0.700
SEm±	0.006	0.008	0.005	0.005	0.005	0.004	0.003	0.004	0.002	0.003	0.003	0.002
CD (P=0.05)	0.017	0.023	0.014	0.014	0.014	0.010	0.007	0.010	0.006	0.008	0.007	0.005
2. Nutrient management												
F ₀ - Control	1.142	1.086	1.114	0.709	0.752	0.731	0.714	0.713	0.713	0.695	0.700	0.697
F ₁ - 50 % NPK	1.234	1.133	1.183	0.766	0.774	0.770	0.724	0.739	0.732	0.709	0.706	0.707
F ₂ - 100 % NPK	1.329	1.180	1.254	0.795	0.793	0.794	0.743	0.747	0.745	0.726	0.722	0.724
SEm±	0.003	0.005	0.003	0.003	0.003	0.002	0.001	0.002	0.001	0.002	0.001	0.001
CD (P=0.05)	0.010	0.013	0.008	0.008	0.008	0.006	0.004	0.006	0.003	0.004	0.004	0.003

Table 24b. Interaction effect of row ratio and nutrient management on leaf stem ratio of rice bean

Interaction (C X F)	Leaf stem ratio											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	1.168	1.130	1.149	0.705	0.834	0.770	0.723	0.738	0.731	0.700	0.711	0.706
C ₃ F ₁	1.362	1.215	1.289	0.831	0.848	0.840	0.733	0.768	0.750	0.725	0.718	0.722
C ₃ F ₂	1.520	1.232	1.376	0.885	0.879	0.882	0.757	0.780	0.768	0.736	0.732	0.734
C ₄ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₀	1.157	1.092	1.124	0.740	0.757	0.749	0.718	0.711	0.714	0.699	0.715	0.707
C ₅ F ₁	1.195	1.106	1.151	0.761	0.770	0.766	0.727	0.736	0.732	0.711	0.712	0.712
C ₅ F ₂	1.228	1.172	1.200	0.781	0.783	0.782	0.746	0.751	0.748	0.722	0.725	0.724
C ₆ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₀	1.161	1.080	1.121	0.685	0.707	0.696	0.704	0.701	0.702	0.692	0.686	0.689
C ₇ F ₁	1.214	1.123	1.169	0.745	0.748	0.747	0.717	0.737	0.727	0.701	0.701	0.701
C ₇ F ₂	1.302	1.208	1.255	0.771	0.765	0.768	0.744	0.742	0.743	0.724	0.719	0.721
C ₈ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₀	1.083	1.042	1.063	0.707	0.710	0.709	0.712	0.700	0.706	0.689	0.687	0.688
C ₉ F ₁	1.165	1.085	1.125	0.726	0.729	0.728	0.719	0.717	0.718	0.699	0.692	0.696
C ₉ F ₂	1.265	1.107	1.186	0.741	0.746	0.744	0.727	0.716	0.722	0.721	0.713	0.717
SEm±	0.010	0.014	0.009	0.009	0.009	0.006	0.004	0.006	0.004	0.005	0.004	0.003
CD (P=0.05)	0.029	0.039	0.024	0.024	0.025	0.017	0.012	0.017	0.010	0.013	0.013	0.009

Table 25a. Effect of row ratio and nutrient management on stem girth of rice bean

Treatments	Stem girth (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	1.211	1.344	1.278	2.011	2.233	2.122	2.678	2.700	2.689	2.756	2.844	2.800
C ₄ - M + C (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ - M + R (1:1)	1.122	1.277	1.199	1.911	2.172	2.042	2.411	2.512	2.462	2.568	2.621	2.594
C ₆ - M + C (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ - M + R (2:1)	0.950	0.978	0.964	1.878	2.156	2.017	2.344	2.300	2.322	2.411	2.500	2.456
C ₈ - M + C (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ - M + R (2:2)	1.069	1.153	1.111	2.006	2.183	2.094	2.378	2.502	2.440	2.608	2.644	2.626
SEm±	0.007	0.009	0.006	0.019	0.025	0.016	0.019	0.012	0.011	0.022	0.013	0.013
CD (P=0.05)	0.020	0.024	0.016	0.053	0.072	0.044	0.054	0.033	0.031	0.062	0.037	0.036
2. Nutrient management												
F ₀ - Control	0.917	1.003	0.960	1.492	1.654	1.573	2.000	2.038	2.019	2.053	2.108	2.080
F ₁ - 50 % NPK	1.127	1.208	1.168	1.992	2.279	2.135	2.375	2.407	2.391	2.493	2.550	2.522
F ₂ - 100 % NPK	1.221	1.353	1.287	2.371	2.642	2.506	2.983	3.067	3.025	3.211	3.300	3.255
SEm±	0.004	0.005	0.003	0.011	0.013	0.008	0.011	0.007	0.006	0.013	0.008	0.007
CD (P=0.05)	0.012	0.014	0.009	0.031	0.036	0.024	0.031	0.019	0.018	0.036	0.021	0.020

Table 25b. Interaction effect of row ratio and nutrient management on stem girth of rice bean

Interaction (C XF)	Stem girth (cm)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	1.067	1.177	1.122	1.333	1.567	1.450	2.267	2.267	2.267	2.167	2.267	2.217
C ₃ F ₁	1.233	1.357	1.295	2.133	2.400	2.267	2.500	2.600	2.550	2.533	2.633	2.583
C ₃ F ₂	1.333	1.500	1.417	2.567	2.733	2.650	3.267	3.233	3.250	3.567	3.633	3.600
C ₄ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₀	1.000	1.100	1.050	1.567	1.600	1.583	1.800	1.917	1.858	2.043	2.063	2.053
C ₅ F ₁	1.167	1.233	1.200	1.900	2.283	2.092	2.467	2.420	2.443	2.617	2.633	2.625
C ₅ F ₂	1.200	1.497	1.348	2.267	2.633	2.450	2.967	3.200	3.083	3.043	3.167	3.105
C ₆ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₀	0.733	0.767	0.750	1.567	1.733	1.650	1.900	1.900	1.900	1.933	2.000	1.967
C ₇ F ₁	1.000	1.033	1.017	1.800	2.167	1.983	2.200	2.200	2.200	2.333	2.433	2.383
C ₇ F ₂	1.117	1.133	1.125	2.267	2.567	2.417	2.933	2.800	2.867	2.967	3.067	3.017
C ₈ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₀	0.867	0.967	0.917	1.500	1.717	1.608	2.033	2.067	2.050	2.067	2.100	2.083
C ₉ F ₁	1.107	1.210	1.158	2.133	2.267	2.200	2.333	2.407	2.370	2.490	2.500	2.495
C ₉ F ₂	1.233	1.283	1.258	2.383	2.633	2.508	2.767	3.033	2.900	3.267	3.333	3.300
SEm±	0.012	0.015	0.010	0.033	0.039	0.025	0.033	0.020	0.019	0.038	0.023	0.022
CD (P=0.05)	0.035	0.042	0.027	0.092	0.109	0.071	0.094	0.058	0.054	0.107	0.064	0.061

Table 26a. Effect of row ratio and nutrient management on number of leaves of rice bean

Treatments	Number of leaves plant ⁻¹											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	4.04	6.44	5.24	11.64	22.49	17.07	30.09	40.71	35.40	62.96	73.50	68.23
C ₄ - M + C (1:1)							-	-	-			
C ₅ - M + R (1:1)	4.62	5.93	5.28	11.13	19.02	15.08	28.54	29.93	29.24	62.04	68.04	65.04
C ₆ - M + C (2:1)							-	-	-			
C ₇ - M + R (2:1)	5.51	5.93	5.72	10.68	16.04	13.36	22.04	25.88	23.96	41.42	47.61	44.52
C ₈ - M + C (2:2)							-	-	-			
C ₉ - M + R (2:2)	4.42	6.04	5.23	10.39	21.93	16.16	24.71	28.16	26.43	51.60	66.82	59.21
SEm±	0.02	0.03	0.02	0.07	0.11	0.06	0.15	0.16	0.11	0.30	0.34	0.23
CD (P=0.05)	0.06	0.09	0.05	0.20	0.30	0.18	0.44	0.44	0.31	0.85	0.97	0.64
2. Nutrient management												
F ₀ - Control	4.23	5.32	4.77	9.03	14.33	11.68	19.82	23.02	21.42	45.10	51.86	48.48
F ₁ - 50 % NPK	4.69	6.08	5.38	10.85	19.77	15.31	25.93	31.23	28.58	55.18	64.93	60.06
F ₂ - 100 % NPK	5.03	6.88	5.95	13.01	25.52	19.26	33.29	39.27	36.28	63.23	75.19	69.21
SEm±	0.01	0.02	0.01	0.04	0.06	0.04	0.09	0.09	0.06	0.17	0.20	0.13
CD (P=0.05)	0.04	0.05	0.03	0.11	0.17	0.10	0.25	0.26	0.18	0.49	0.56	0.37

Table 26b. Interaction effect of row ratio and nutrient management on number of leaves of rice bean

Interaction (C X F)	Number of leaves plant ⁻¹											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	3.80	5.80	4.80	10.40	15.27	12.83	23.47	30.27	26.87	53.93	58.63	56.28
C ₃ F ₁	4.07	6.60	5.33	11.77	22.27	17.02	28.93	41.27	35.10	64.10	77.27	70.68
C ₃ F ₂	4.27	6.93	5.60	12.77	29.93	21.35	37.87	50.60	44.23	70.83	84.60	77.72
C ₄ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₀	4.00	5.27	4.63	9.10	15.53	12.32	20.77	23.93	22.35	51.27	56.93	54.10
C ₅ F ₁	4.87	5.83	5.35	10.43	18.60	14.52	27.77	27.93	27.85	63.60	68.93	66.27
C ₅ F ₂	5.00	6.70	5.85	13.87	22.93	18.40	37.10	37.93	37.52	71.27	78.27	74.77
C ₆ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₀	5.07	4.93	5.00	8.60	11.60	10.10	16.10	19.93	18.02	34.27	38.27	36.27
C ₇ F ₁	5.37	5.60	5.48	11.27	16.27	13.77	22.60	26.10	24.35	39.60	47.27	43.43
C ₇ F ₂	6.10	7.27	6.68	12.17	20.27	16.22	27.43	31.60	29.52	50.40	57.30	53.85
C ₈ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₀	4.03	5.27	4.65	8.00	14.93	11.47	18.93	17.93	18.43	40.93	53.60	47.27
C ₉ F ₁	4.47	6.27	5.37	9.93	21.93	15.93	24.43	29.60	27.02	53.43	66.27	59.85
C ₉ F ₂	4.77	6.60	5.68	13.23	28.93	21.08	30.77	36.93	33.85	60.43	80.60	70.52
SEm±	0.04	0.05	0.03	0.12	0.18	0.11	0.27	0.27	0.19	0.52	0.59	0.39
CD (P=0.05)	0.11	0.15	0.09	0.34	0.52	0.31	0.76	0.77	0.53	1.46	1.68	1.10

Table 27a. Effect of row ratio and nutrient management on primary branches of rice bean

Treatments	Primary branches plant ⁻¹								
	20 DAS			40 DAS			60 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	1.056	1.078	1.067	2.400	2.656	2.528	3.711	3.844	3.778
C ₄ - M + C (1:1)							-	-	-
C ₅ - M + R (1:1)	1.100	1.122	1.111	2.467	2.522	2.494	3.433	3.578	3.506
C ₆ - M + C (2:1)							-	-	-
C ₇ - M + R (2:1)	1.000	1.000	1.000	2.369	2.411	2.390	3.156	3.289	3.222
C ₈ - M + C (2:2)							-	-	-
C ₉ - M + R (2:2)	1.033	1.022	1.028	2.467	2.533	2.500	3.589	3.767	3.678
SEm±	0.007	0.006	0.005	0.014	0.016	0.011	0.019	0.026	0.016
CD (P=0.05)	0.021	0.016	0.013	0.040	0.045	0.030	0.055	0.072	0.045
2. Nutrient management									
F ₀ - Control	1.000	1.000	1.000	1.910	2.025	1.968	2.858	3.017	2.938
F ₁ - 50 % NPK	1.052	1.058	1.055	2.483	2.575	2.529	3.358	3.550	3.454
F ₂ - 100 % NPK	1.090	1.108	1.099	2.883	2.992	2.938	4.200	4.292	4.246
SEm±	0.004	0.003	0.003	0.008	0.009	0.006	0.011	0.015	0.009
CD (P=0.05)	0.012	0.009	0.008	0.023	0.026	0.017	0.032	0.042	0.026

Table 27b. Interaction of row ratio and nutrient management on primary branches of rice bean

Interaction (C X F)	Primary branches plant ⁻¹								
	20 DAS			40 DAS			60 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-
C ₃ F ₀	1.000	1.000	1.000	1.667	2.000	1.833	3.000	3.133	3.067
C ₃ F ₁	1.067	1.100	1.083	2.333	2.500	2.417	3.533	3.667	3.600
C ₃ F ₂	1.100	1.133	1.117	3.200	3.467	3.333	4.600	4.733	4.667
C ₄ F ₀	-	-	-	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-	-	-	-
C ₅ F ₀	1.000	1.000	1.000	2.000	2.033	2.017	2.667	2.733	2.700
C ₅ F ₁	1.107	1.133	1.120	2.600	2.667	2.633	3.367	3.500	3.433
C ₅ F ₂	1.193	1.233	1.213	2.800	2.867	2.833	4.267	4.500	4.383
C ₆ F ₀	-	-	-	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-	-	-	-
C ₇ F ₀	1.000	1.000	1.000	1.973	2.000	1.987	2.767	2.900	2.833
C ₇ F ₁	1.000	1.000	1.000	2.433	2.500	2.467	3.200	3.400	3.300
C ₇ F ₂	1.000	1.000	1.000	2.700	2.733	2.717	3.500	3.567	3.533
C ₈ F ₀	-	-	-	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-	-	-	-
C ₉ F ₀	1.000	1.000	1.000	2.000	2.067	2.033	3.000	3.300	3.150
C ₉ F ₁	1.033	1.000	1.017	2.567	2.633	2.600	3.333	3.633	3.483
C ₉ F ₂	1.067	1.067	1.067	2.833	2.900	2.867	4.433	4.367	4.400
SEm±	0.013	0.010	0.008	0.025	0.027	0.018	0.034	0.044	0.028
CD (P=0.05)	0.036	0.028	0.023	0.070	0.077	0.051	0.096	0.126	0.078

Table 28a. Effect of row ratio and nutrient management on fresh weight of rice bean

Treatments	Fresh weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	10.60	16.14	13.37	55.48	79.42	67.45	146.26	153.23	149.74	240.98	255.60	248.29
C ₄ - M + C (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ - M + R (1:1)	8.31	9.18	8.75	51.48	63.73	57.60	92.52	97.99	95.25	237.70	243.21	240.45
C ₆ - M + C (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ - M + R (2:1)	6.22	6.64	6.43	43.81	60.87	52.34	87.76	92.54	90.15	187.20	189.63	188.41
C ₈ - M + C (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ - M + R (2:2)	8.81	10.95	9.88	44.26	70.02	57.14	110.21	126.95	118.58	234.49	242.55	238.52
SEm±	0.03	0.04	0.03	0.33	0.50	0.30	0.55	0.53	0.38	1.09	1.09	0.77
CD (P=0.05)	0.09	0.12	0.07	0.93	1.42	0.84	1.57	1.50	1.07	3.11	3.08	2.16
2. Nutrient management												
F ₀ - Control	6.20	7.79	7.00	32.62	47.10	39.86	82.27	92.02	87.14	190.44	194.61	192.53
F ₁ - 50 % NPK	8.61	10.88	9.74	46.99	68.19	57.59	109.18	117.92	113.55	222.37	232.33	227.35
F ₂ - 100 % NPK	10.65	13.51	12.08	66.66	90.25	78.46	136.12	143.08	139.60	262.47	271.29	266.88
SEm±	0.02	0.02	0.01	0.19	0.29	0.17	0.32	0.31	0.22	0.63	0.63	0.45
CD (P=0.05)	0.05	0.07	0.04	0.54	0.82	0.48	0.91	0.87	0.62	1.79	1.78	1.25

Table 28b. Interaction effect of row ratio and nutrient management on fresh weight of rice bean

Interaction (C X F)	Fresh weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	8.17	11.71	9.94	33.03	47.75	40.39	110.00	119.61	114.80	216.20	226.31	221.26
C ₃ F ₁	10.87	16.38	13.62	55.37	80.01	67.69	143.50	149.84	146.67	239.37	255.29	247.33
C ₃ F ₂	12.77	20.32	16.54	78.03	110.51	94.27	185.27	190.23	187.75	267.37	285.18	276.28
C ₄ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₀	5.53	6.68	6.11	37.20	52.95	45.08	70.40	83.13	76.77	193.03	193.43	193.23
C ₅ F ₁	8.63	9.11	8.87	50.53	64.17	57.35	94.57	96.47	95.52	228.53	246.65	237.59
C ₅ F ₂	10.77	11.75	11.26	66.70	74.08	70.39	112.60	114.36	113.48	291.53	289.54	290.54
C ₆ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₀	4.40	4.26	4.33	32.03	36.44	34.24	62.53	67.77	65.15	150.20	151.01	150.61
C ₇ F ₁	6.13	7.00	6.57	46.20	61.42	53.81	87.53	91.04	89.29	182.53	185.13	183.83
C ₇ F ₂	8.13	8.67	8.40	53.20	84.75	68.98	113.20	118.81	116.01	228.87	232.75	230.81
C ₈ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₀	6.70	8.51	7.60	28.20	51.24	39.72	86.13	97.58	91.86	202.33	207.69	205.01
C ₉ F ₁	8.80	11.02	9.91	35.87	67.15	51.51	111.10	134.33	122.71	239.03	242.26	240.65
C ₉ F ₂	10.92	13.32	12.12	68.70	91.68	80.19	133.40	148.94	141.17	262.10	277.69	269.89
SEm±	0.05	0.07	0.04	0.57	0.87	0.52	0.96	0.92	0.66	1.90	1.88	1.34
CD (P=0.05)	0.15	0.20	0.12	1.61	2.46	1.45	2.72	2.60	1.86	5.38	5.34	3.75

Table 29a. Effect of row ratio and nutrient management on dry weight of rice bean

Treatments	Dry weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	1.575	2.109	1.842	4.997	7.355	6.176	17.567	18.519	18.043	34.054	35.055	34.555
C ₄ - M + C (1:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ - M + R (1:1)	1.176	1.244	1.210	4.462	5.580	5.021	11.489	12.085	11.787	27.236	27.613	27.424
C ₆ - M + C (2:1)	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ - M + R (2:1)	0.913	0.944	0.928	4.291	5.415	4.853	11.181	12.164	11.673	21.619	21.785	21.702
C ₈ - M + C (2:2)	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ - M + R (2:2)	1.284	1.523	1.404	3.855	6.013	4.934	13.695	15.525	14.610	27.664	27.661	27.663
SEm±	0.005	0.010	0.005	0.025	0.033	0.021	0.061	0.053	0.041	0.206	0.115	0.118
CD (P=0.05)	0.013	0.028	0.015	0.071	0.093	0.058	0.174	0.150	0.114	0.585	0.326	0.331
2. Nutrient management												
F ₀ - Control	0.903	1.177	1.040	2.710	3.965	3.337	7.398	8.176	7.787	17.746	18.118	17.932
F ₁ - 50 % NPK	1.252	1.472	1.362	4.272	6.024	5.148	13.078	13.973	13.526	28.435	29.118	28.776
F ₂ - 100 % NPK	1.557	1.716	1.636	6.222	8.283	7.253	19.973	21.571	20.772	36.749	36.851	36.800
SEm±	0.003	0.006	0.003	0.014	0.019	0.012	0.035	0.031	0.023	0.119	0.066	0.068
CD (P=0.05)	0.008	0.016	0.009	0.041	0.054	0.033	0.101	0.087	0.066	0.338	0.188	0.191

Table 29b. Interaction effect of row ratio and nutrient management on dry weight of rice bean

Interaction (C X F)	Dry weight (g plant ⁻¹)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	1.169	1.716	1.442	2.704	4.676	3.690	9.653	10.208	9.931	20.685	21.949	21.317
C ₃ F ₁	1.614	2.108	1.861	5.044	7.107	6.075	17.404	17.800	17.602	36.693	37.784	37.238
C ₃ F ₂	1.943	2.502	2.223	7.245	10.282	8.763	25.645	27.549	26.597	44.784	45.433	45.108
C ₄ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₅ F ₀	0.832	1.067	0.950	3.027	3.806	3.417	6.323	7.048	6.685	18.084	18.111	18.097
C ₅ F ₁	1.196	1.314	1.255	4.372	5.641	5.006	11.188	11.644	11.416	27.207	28.448	27.827
C ₅ F ₂	1.499	1.352	1.426	5.986	7.294	6.640	16.955	17.565	17.260	36.416	36.280	36.348
C ₆ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₇ F ₀	0.643	0.603	0.623	2.734	3.160	2.947	5.984	6.102	6.043	13.549	13.604	13.576
C ₇ F ₁	0.910	0.997	0.953	4.283	5.609	4.946	10.979	11.873	11.426	21.350	21.527	21.439
C ₇ F ₂	1.186	1.231	1.208	5.857	7.477	6.667	16.578	18.518	17.548	29.959	30.225	30.092
C ₈ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₉ F ₀	0.967	1.323	1.145	2.375	4.217	3.296	7.629	9.345	8.487	18.668	18.807	18.738
C ₉ F ₁	1.287	1.468	1.378	3.390	5.741	4.566	12.741	14.578	13.659	28.490	28.711	28.600
C ₉ F ₂	1.599	1.778	1.688	5.800	8.081	6.941	20.714	22.651	21.683	35.835	35.465	35.650
SEm±	0.008	0.017	0.009	0.043	0.057	0.036	0.106	0.092	0.070	0.357	0.199	0.204
CD (P=0.05)	0.023	0.049	0.027	0.122	0.161	0.100	0.302	0.260	0.197	1.013	0.565	0.573

4.2 Yield studies

4.2.1 Green fodder yield (t ha⁻¹)

The result indicated that in both years, cropping system and nutrient management detain had a significant impact on green fodder yield of the fodder crops (Table 30a). The green fodder yield of fodder maize, fodder cowpea and fodder rice bean were significantly higher during second year (2023) as compared to first year of the investigation (2022). With reference to different row ratio, fodder maize planted under sole stand registered the highest green fodder (51.550 t ha⁻¹) as compared to those planted with fodder legume under different row ratio (*i.e.*, 1:1, 2:1, 2:2). Under different row ratio, the highest green fodder yield of fodder maize (43.711 t ha⁻¹, 44.272 t ha⁻¹) was observed when it was grown with fodder cowpea and fodder rice bean at 2:1 row ratio and the lowest green fodder yield of fodder maize was recorded at C₅ (34.350 t ha⁻¹) and C₉ (34.422 t ha⁻¹). Similarly, Ginwal *et al.* (2019b): Asangla (2015) also claimed that the higher green fodder yield of fodder maize production at sole crop (43.87 t ha⁻¹, 57.38 t ha⁻¹) which was followed by 2:1 row ratio (32.22 t ha⁻¹, 38.61 t ha⁻¹). This observation of higher green fodder yield of fodder maize at 2:1 row ratio was in conformity with research findings by Singh *et al.* (2005): Patel *et al.* (2008): Gupta *et al.* (2019). In 2022, Yadav and his coworker studied the effect of planting ratios on green fodder yield of fodder maize. They found that planting of fodder maize at 2:1 row ratio recorded the highest green fodder yield (478 q ha⁻¹).

With reference to different row ratio (Table 30a), fodder cowpea and fodder rice bean planted under sole stand registered the highest green fodder yield (34.389 t ha⁻¹ and 34.218 t ha⁻¹) and then it was observed at 2:2 row ratio (20.100 t ha⁻¹ and 19.207 t ha⁻¹) as compared to the crop planted under different row ratio *i.e.*, 1:1 and 2:1. The lowest green fodder yield of fodder maize, fodder cowpea and fodder rice bean were recorded at C₆ (12.876 t ha⁻¹) and C₇ (12.899 t ha⁻¹) respectively. Ginwal *et al.* (2019b) also observed the highest green fodder yield (29.96 t ha⁻¹) of fodder cowpea under sole crop. Correspondingly, Sharma (2008) and Tamta *et al.* (2019) also reported that the higher green fodder yield of fodder cowpea and fodder rice bean was obtained under sole crop and thereon, the higher green fodder yield under different row ratio was

recorded at 2:2 followed by 1:2 row ratio. Asangla (2015) also observed the highest green fodder yield of fodder cowpea grown as sole crop (31.98 t ha^{-1}). The higher obtained of green fodder yield production at sole crop and then at 1:2 row ratio was also proved by Tamta *et al.* (2019).

Among the nutrient management approaches, application of nutrients had a significant influence on green fodder yield of the fodder crops (Table 30a). The data revealed that green fodder yield of the fodder crops increase with increasing in nutrient levels. The highest green fodder yield of fodder maize (46.831 t ha^{-1}), fodder cowpea (24.423 t ha^{-1}) and fodder rice bean (25.309 t ha^{-1}) was registered from treatment F_2 (100 % RDF) respectively. In contrary, the lowest green fodder yield of fodder maize (31.686 t ha^{-1}), fodder cowpea (18.140 t ha^{-1}) and fodder rice bean (15.518 t ha^{-1}) was recorded at F_0 (control). The higher green fodder yield was obtained due to providing sufficient nutrients for their growth and development. Many researchers also confirmed an increase in green fodder yield with increase in nutrient application. Similarly, Nisar (2024) also reported that the highest green fodder yield (54.6 t ha^{-1}) of fodder maize under the application of $180 \text{ kg ha}^{-1} \text{ N}$. Subrahmanya *et al.* (2019) reported that application of N and P @ $150:75 \text{ kg ha}^{-1}$ recorded the highest green fodder yield. Krishna *et al.* (2022a) studied the effect of nutrient management on African tall maize variety and found that application of NPK @ $120:60:40 \text{ kg ha}^{-1}$ produced the highest green fodder yield of fodder maize. Rundan *et al.* (2023) studied the effect of nutrient management on maize-rice bean intercropping and found that the higher green fodder yield of fodder maize and fodder rice bean was production under 100 % RDF nutrients application. Similarly, Tamta (2019): Kumar *et al.* (2016): Yadav *et al.* (2022a) also reported that the higher green fodder yield production of fodder cowpea was under 100 % RDF nutrient application.

The interaction effect of different row ratio and nutrient management practices on green fodder yield of fodder maize, fodder cowpea, fodder rice bean and total green fodder yield was found significant (Table 30b). The fodder maize, fodder cowpea and fodder rice bean planted under sole stand along with the application of 100 % RDF recorded significantly the highest green fodder yield as compared to the rest of the nutrient treatment combinations. However, among all the treatment combinations,

C₁F₂ (59.350 t ha⁻¹), C₁F₁ (53.133 t ha⁻¹), C₆F₂ (51.617 t ha⁻¹) and C₇F₂ (51.117 t ha⁻¹) recorded the higher and comparable green fodder yield of fodder maize. In case of the intercrop, C₂F₂ (37.117 t ha⁻¹) followed by C₂F₁ (34.388 t ha⁻¹) recorded the highest green fodder yield of fodder cowpea and similarly treatment C₃F₂ (39.454 t ha⁻¹) and C₃F₁ (36.417 t ha⁻¹) registered the highest green fodder yield of fodder rice bean. Subsequently, the lower and comparable green fodder yield of fodder cowpea and fodder rice bean was recorded at C₆F₀ (10.200 t ha⁻¹), C₄F₀ (13.492 t ha⁻¹) and C₇F₀ (8.963 t ha⁻¹), C₅F₀ (12.625 t ha⁻¹) respectively.

4.2.2 Dry fodder yield (t ha⁻¹)

The studies showed that different row ratio and nutrient management approaches had a significant influence on dry fodder yield (Table 31a). All the fodder crops *i.e.*, fodder maize, fodder cowpea and fodder rice bean significantly produced the higher dry fodder yield under pure sole stand. In respect to different row ratio, the highest dry fodder yield of fodder maize was registered at sole maize C₁ (11.412 t ha⁻¹) and the second higher and comparable dry fodder yield was found at C₇ (9.291 t ha⁻¹) and C₆ (9.142 t ha⁻¹), while the lowest was seen at C₅ (7.116 t ha⁻¹) respectively. Furthermore, in case of intercrop *i.e.*, (fodder cowpea and fodder rice bean) the highest dry fodder yield was recorded at sole cowpea C₂ (5.652 t ha⁻¹) and sole rice bean C₃ (5.247 t ha⁻¹) and while the lowest dry fodder yield of fodder cowpea and fodder rice bean was observed at C₆ (2.786 t ha⁻¹) and C₇ (2.324 t ha⁻¹) respectively. Ginwal *et al.* (2019b) also reported that the higher dry matter yield of fodder maize and cowpea at sole plot followed by 2:1 row ratio. Manoj *et al.* (2020) observed the highest dry matter yield of fodder maize (7.16 t ha⁻¹) and fodder cowpea (4.99 t ha⁻¹) under sole plot. Asangla (2015) also reported the higher dry matter yield of fodder maize (16.53 t ha⁻¹) and fodder cowpea (9.13 t ha⁻¹) under sole crop.

Among the nutrient management practices (Table 31a), application of NPK @ 100 % RDF registered the highest dry fodder yield of fodder maize (10.247 t ha⁻¹), fodder cowpea (4.367 t ha⁻¹) and fodder rice bean (3.807 t ha⁻¹) as compared to other treatments. Comparatively among all the treatments, F₀ (control) recorded the lowest dry fodder yield of fodder maize (6.457 t ha⁻¹) fodder cowpea (3.509 t ha⁻¹) and fodder

rice bean (2.801 t ha⁻¹) respectively. Similarly, Rundani *et al.* (2023) also reported that application of 100 % RDF of nutrients to fodder maize and fodder rice bean produced the highest dry matter yield of fodder maize and fodder rice bean as compared to 50 % RDF and 75 % RDF. Likewise, Asangla (2019) also obtained the highest dry matter yield of fodder maize and fodder cowpea under nutrient applied at 100 % RDF.

The interaction result (Table 31b) revealed that both factors had a significant impact on dry fodder yield of fodder maize, cowpea and rice bean. It also disclosed that nutrient management practices had significant influence on dry fodder yield. The dry fodder yield was found to increase with increasing level of nutrients. Among all the treatment combinations, the highest dry fodder yield of fodder maize, fodder cowpea and fodder rice bean were registered from C₁F₂ (13.718 t ha⁻¹), C₂F₂ (5.930 t ha⁻¹) and C₃F₂ (5.667 t ha⁻¹) respectively. Similarly, the lowest dry fodder yield of fodder maize, fodder cowpea and fodder rice bean were recorded at C₅F₀ (5.166 t ha⁻¹), C₆F₀ (2.413 t ha⁻¹) and C₇F₀ (1.763 t ha⁻¹).

4.2.3 Total green fodder yield (t ha⁻¹)

The total green fodder yield of fodder crops was significantly influenced by both different row ratio and nutrient management practices (Table 32a). The total green fodder yield was significantly highest in intercropping than sole crop. With respect to different row ratio, the highest total green fodder yield of fodder maize + fodder cowpea and fodder maize + fodder rice bean was recorded at C₆ (56.588) and C₇ (57.171 t ha⁻¹), which was followed by treatments C₈ (55.294 t ha⁻¹) and C₉ (53.629 t ha⁻¹). Thereafter, the lowest total green fodder yield of fodder maize + fodder cowpea and fodder maize + fodder rice bean was recorded from C₄ (52.140 t ha⁻¹) and C₅ (52.076 t ha⁻¹) respectively. Iqbal *et al.* (2006) also observed the highest total green fodder yield (47.79 t ha⁻¹, 51.07 t ha⁻¹) of fodder maize with fodder cowpea and fodder rice bean at 1:1 row ratio. In similar to this findings, Asangla (2015) also reported that the higher total green fodder yield under 1:1 row ratio as compared to 2:1 and 3:1 row ratio.

The nutrient management approaches, significantly influence the total green fodder yield of the fodder crops (Table 32a). Among all the treatments,

application of nutrient at 100 % RDF (F_2) recorded the highest green fodder yield of fodder maize + fodder cowpea (58.222 t ha^{-1}) and fodder maize + fodder rice bean (58.998 t ha^{-1}) as compared to treatment F_1 (50.517 t ha^{-1} , 51.708 t ha^{-1}) and F_0 (41.238 t ha^{-1} , 38.481 t ha^{-1}) respectively. Iqbal *et al.* (2006) also reported the highest total green fodder of fodder maize with fodder cowpea and fodder rice bean under the application of NPK @ 150:100:100 kg ha^{-1} .

In reference to interactions, the total green fodder yield varied with both factors (Table 32b). The data revealed that sole crops recorded lowest total green fodder than other intercrops. The highest total green yield was recorded at C_6F_2 (67.150 t ha^{-1}) and C_7F_2 (67.033 t ha^{-1}) for fodder maize + fodder cowpea and fodder maize + fodder rice bean and which were followed by treatments C_8F_2 (65.208 t ha^{-1}) and C_9F_2 (65.779 t ha^{-1}). Likewise, among all the treatments, the lowest and comparable total green fodder yield of fodder maize + fodder cowpea and fodder maize + fodder rice bean was registered at C_4F_2 (62.283 t ha^{-1}) and C_5F_2 (63.371 t ha^{-1}) respectively.

4.2.4 Total dry fodder yield (t ha^{-1})

The total dry fodder yield was found to be influenced by both factors (Table 33a). Among all the different row ratio approaches, the fodder maize sown with fodder cowpea (C_6 - 11.928 t ha^{-1}) and fodder rice bean (C_7 - 11.615 t ha^{-1}) at 2:1 row ratio significantly recorded the highest total dry fodder yield in comparison to sole maize, sole cowpea, sole rice bean and different row ratio (1:1 and 2:2) respectively. The highest production of total dry fodder yield was obtained at fodder maize with fodder cowpea and fodder rice bean at 2:1 row ratio, which was probably due to higher dry fodder yield from fodder maize which recorded more due to higher plant population of fodder maize. Similarly, the higher total dry matter yield was registered at 2:1 row ratio as compared to 1:1 row ratio and sole crop (Gupta *et al.*, 2019). Asangla (2015) also obtained the highest total dry matter yield at 1:1 row ratio than 2:1 and 3:1 row ratio. Iqbal *et al.* (2006) also observed the highest total dry fodder yield (8.18 t ha^{-1} , 9.3 t ha^{-1}) of fodder maize with fodder cowpea and fodder rice bean grown at 1:1 row ratio.

Regarding the nutrient management approaches, it was found that the total dry fodder yield was increase with the increase in application of nutrients (Table 33a). The highest total dry fodder yield of fodder maize + fodder cowpea (12.045 t ha⁻¹) and fodder maize + fodder rice bean (11.584 t ha⁻¹) was observed from treatment F₂ (100 % RDF) as compared to F₁ (50 % RDF) and F₀ (control). Iqbal *et al.* (2006) also observed that application of NPK @ 150:100:100 kg ha⁻¹ managed the highest total dry matter yield as compared to control. Likewise, Asangla (2015) also reported the higher total dry matter yield of fodder crop at 120 N kg ha⁻¹.

The interaction result (Table 33b) showed that different row ratio which received 100 % RDF produced the higher total dry fodder yield as compared to treatments F₁ (50 % RDF) and F₀ (control). Among all the treatment combinations, the total dry fodder yield of fodder maize + fodder cowpea was recorded at C₆F₂ (14.358 t ha⁻¹) and the lowest total dry fodder yield was registered at C₄F₀ (8.602 t ha⁻¹). Incase of fodder maize + fodder rice bean, the treatment C₇F₂ (13.763 t ha⁻¹) registered the highest total dry fodder yield, while treatment C₅F₀ (7.470 t ha⁻¹) registered the lowest total dry fodder yield of fodder maize + fodder rice bean as compared to other treatments.

Table 30a. Effect of row ratio and nutrient management on green fodder yield of maize, cowpea and rice bean

Treatments	Green fodder yield (t ha ⁻¹)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	50.600	52.500	51.550	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	33.644	35.133	34.389	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	33.233	35.203	34.218
C ₄ - M + C (1:1)	34.244	36.033	35.139	16.167	17.836	17.001	-	-	-
C ₅ - M + R (1:1)	33.644	35.056	34.350	-	-	-	16.967	18.486	17.726
C ₆ - M + C (2:1)	42.733	44.689	43.711	12.489	13.264	12.876	-	-	-
C ₇ - M + R (2:1)	43.167	45.378	44.272	-	-	-	12.044	13.753	12.899
C ₈ - M + C (2:2)	34.100	36.289	35.194	19.622	20.578	20.100	-	-	-
C ₉ - M + R (2:2)	33.322	35.522	34.422	-	-	-	18.156	20.258	19.207
SEm±	0.220	0.225	0.157	0.106	0.103	0.074	0.214	0.227	0.156
CD (P=0.05)	0.623	0.637	0.440	0.300	0.292	0.207	0.608	0.645	0.438
2. Nutrient management									
F ₀ - Control	31.086	32.286	31.686	17.767	18.513	18.140	15.025	16.010	15.518
F ₁ - 50 % NPK	39.095	42.705	40.900	20.383	21.042	20.713	21.367	23.054	22.210
F ₂ - 100 % NPK	46.310	47.352	46.831	23.292	25.554	24.423	23.908	26.710	25.309
SEm±	0.127	0.130	0.091	0.061	0.059	0.043	0.124	0.131	0.090
CD (P=0.05)	0.360	0.368	0.254	0.173	0.168	0.119	0.351	0.373	0.253

Table 30b. Interaction effect of row ratio and nutrient management on green fodder yield of maize, cowpea and rice bean

Interaction (C X F)	Green fodder yield (t ha ⁻¹)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	41.633	42.700	42.167	-	-	-	-	-	-
C ₁ F ₁	51.267	55.000	53.133	-	-	-	-	-	-
C ₁ F ₂	58.900	59.800	59.350	-	-	-	-	-	-
C ₂ F ₀	-	-	-	30.667	32.658	31.663	-	-	-
C ₂ F ₁	-	-	-	33.667	35.108	34.388	-	-	-
C ₂ F ₂	-	-	-	36.600	37.633	37.117	-	-	-
C ₃ F ₀	-	-	-	-	-	-	26.233	27.333	26.783
C ₃ F ₁	-	-	-	-	-	-	35.667	37.167	36.417
C ₃ F ₂	-	-	-	-	-	-	37.800	41.108	39.454
C ₄ F ₀	27.367	28.833	28.100	13.333	13.650	13.492	-	-	-
C ₄ F ₁	35.000	37.733	36.367	16.333	16.025	16.179	-	-	-
C ₄ F ₂	40.367	41.533	40.950	18.833	23.833	21.333	-	-	-
C ₅ F ₀	25.200	26.000	25.600	-	-	-	12.167	13.083	12.625
C ₅ F ₁	34.500	37.500	36.000	-	-	-	18.000	19.267	18.633
C ₅ F ₂	41.233	41.667	41.450	-	-	-	20.733	23.108	21.921
C ₆ F ₀	34.667	36.100	35.383	9.900	10.500	10.200	-	-	-
C ₆ F ₁	42.467	45.800	44.133	12.333	13.458	12.896	-	-	-
C ₆ F ₂	51.067	52.167	51.617	15.233	15.833	15.533	-	-	-
C ₇ F ₀	35.533	36.933	36.233	-	-	-	8.367	9.558	8.963
C ₇ F ₁	43.567	47.367	45.467	-	-	-	12.767	14.867	13.817
C ₇ F ₂	50.400	51.833	51.117	-	-	-	15.000	16.833	15.917
C ₈ F ₀	27.767	28.200	27.983	17.167	17.242	17.204	-	-	-
C ₈ F ₁	33.833	38.367	36.100	19.200	19.575	19.388	-	-	-
C ₈ F ₂	40.700	42.300	41.500	22.500	24.917	23.708	-	-	-
C ₉ F ₀	25.433	27.233	26.333	-	-	-	13.333	14.067	13.700
C ₉ F ₁	33.033	37.167	35.100	-	-	-	19.033	20.917	19.975
C ₉ F ₂	41.500	42.167	41.833	-	-	-	22.100	25.792	23.946
SEm±	0.380	0.389	0.272	0.183	0.178	0.128	0.371	0.394	0.271
CD (P=0.05)	1.079	1.104	0.763	0.519	0.505	0.358	1.053	1.118	0.759

Table 31a. Effect of row ratio and nutrient management on dry fodder yield of maize, cowpea and rice bean

Treatments	Dry fodder yield (t ha ⁻¹)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	11.181	11.643	11.412	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	5.568	5.736	5.652	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	5.271	5.224	5.247
C ₄ - M + C (1:1)	7.187	7.617	7.402	3.293	3.578	3.436	-	-	-
C ₅ - M + R (1:1)	6.906	7.327	7.116	-	-	-	2.628	3.100	2.864
C ₆ - M + C (2:1)	8.920	9.364	9.142	2.719	2.853	2.786	-	-	-
C ₇ - M + R (2:1)	9.045	9.536	9.291	-	-	-	2.100	2.548	2.324
C ₈ - M + C (2:2)	7.144	7.615	7.379	3.650	3.927	3.789	-	-	-
C ₉ - M + R (2:2)	7.057	7.545	7.301	-	-	-	2.964	3.261	3.113
SEm±	0.046	0.047	0.033	0.020	0.020	0.014	0.035	0.036	0.025
CD (P=0.05)	0.130	0.133	0.092	0.057	0.058	0.040	0.099	0.103	0.071
2. Nutrient management									
F ₀ - Control	6.318	6.596	6.457	3.291	3.727	3.509	2.767	2.835	2.801
F ₁ - 50 % NPK	8.207	8.994	8.600	3.843	3.899	3.871	3.391	3.716	3.553
F ₂ - 100 % NPK	10.093	10.402	10.247	4.289	4.445	4.367	3.565	4.049	3.807
SEm±	0.026	0.027	0.019	0.012	0.012	0.008	0.020	0.021	0.015
CD (P=0.05)	0.075	0.077	0.053	0.033	0.033	0.023	0.057	0.059	0.041

Table 31b. Interaction effect of row ratio and nutrient management on dry matter yield of maize, cowpea and rice bean

Interaction (C X F)	Dry matter yield (t ha ⁻¹)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	8.607	8.773	8.690	-	-	-	-	-	-
C ₁ F ₁	11.423	12.234	11.829	-	-	-	-	-	-
C ₁ F ₂	13.513	13.923	13.718	-	-	-	-	-	-
C ₂ F ₀	-	-	-	5.176	5.414	5.295	-	-	-
C ₂ F ₁	-	-	-	5.658	5.803	5.731	-	-	-
C ₂ F ₂	-	-	-	5.868	5.991	5.930	-	-	-
C ₃ F ₀	-	-	-	-	-	-	4.868	4.532	4.700
C ₃ F ₁	-	-	-	-	-	-	5.341	5.408	5.375
C ₃ F ₂	-	-	-	-	-	-	5.603	5.732	5.667
C ₄ F ₀	5.540	5.872	5.706	2.658	3.135	2.896	-	-	-
C ₄ F ₁	7.248	7.878	7.563	3.347	3.258	3.302	-	-	-
C ₄ F ₂	8.774	9.099	8.937	3.876	4.341	4.109	-	-	-
C ₅ F ₀	5.065	5.267	5.166	-	-	-	2.181	2.428	2.304
C ₅ F ₁	6.981	7.720	7.350	-	-	-	2.745	3.329	3.037
C ₅ F ₂	8.671	8.995	8.833	-	-	-	2.958	3.543	3.251
C ₆ F ₀	7.001	7.362	7.181	2.120	2.707	2.413	-	-	-
C ₆ F ₁	8.706	9.448	9.077	2.705	2.802	2.754	-	-	-
C ₆ F ₂	11.052	11.282	11.167	3.331	3.051	3.191	-	-	-
C ₇ F ₀	7.243	7.579	7.411	-	-	-	1.678	1.849	1.763
C ₇ F ₁	9.008	9.823	9.416	-	-	-	2.324	2.659	2.492
C ₇ F ₂	10.885	11.208	11.046	-	-	-	2.297	3.137	2.717
C ₈ F ₀	5.598	5.729	5.663	3.208	3.652	3.430	-	-	-
C ₈ F ₁	7.109	7.973	7.541	3.663	3.734	3.698	-	-	-
C ₈ F ₂	8.725	9.142	8.934	4.079	4.396	4.238	-	-	-
C ₉ F ₀	5.171	5.591	5.381	-	-	-	2.341	2.530	2.435
C ₉ F ₁	6.970	7.880	7.425	-	-	-	3.151	3.468	3.309
C ₉ F ₂	9.031	9.162	9.097	-	-	-	3.401	3.785	3.593
SEm±	0.079	0.081	0.057	0.035	0.035	0.025	0.060	0.063	0.044
CD (P=0.05)	0.225	0.230	0.159	0.099	0.100	0.070	0.171	0.178	0.122

Table 32a. Effect of row ratio and nutrient management on total green fodder yield of maize, cowpea and rice bean

Treatments	Total green fodder yield (t ha ⁻¹)					
	Maize + Cowpea			Maize + Rice bean		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole maize (M)	50.600	52.500	51.550	50.600	52.500	51.550
C ₂ - Sole cowpea (C)	33.644	35.133	34.389	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	33.233	35.203	34.218
C ₄ - M + C (1:1)	50.411	53.869	52.140	-	-	-
C ₅ - M + R (1:1)	-	-	-	50.611	53.542	52.076
C ₆ - M + C (2:1)	55.222	57.953	56.588	-	-	-
C ₇ - M + R (2:1)	-	-	-	55.211	59.131	57.171
C ₈ - M + C (2:2)	53.722	56.867	55.294	-	-	-
C ₉ - M + R (2:2)	-	-	-	51.478	55.781	53.629
SEm±	0.201	0.229	0.152	0.255	0.329	0.208
CD (p=0.05)	0.570	0.650	0.427	0.725	0.934	0.584
2. Nutrient management						
F ₀ - control	40.500	41.977	41.238	37.580	39.382	38.481
F ₁ - 50 % NPK	48.820	52.213	50.517	49.567	53.850	51.708
F ₂ - 100 % NPK	56.840	59.603	58.222	57.533	60.462	58.998
SEm±	0.116	0.132	0.088	0.147	0.190	0.120
CD (p=0.05)	0.329	0.375	0.247	0.419	0.539	0.337

Table 32b. Interaction effect of row ratio and nutrient management on total green fodder yield of maize, cowpea and rice bean

Interaction (C X F)	Total green fodder yield (t ha ⁻¹)					
	Maize + Cowpea			Maize + Rice bean		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	41.633	42.700	42.167	41.633	42.700	42.167
C ₁ F ₁	51.267	55.000	53.133	51.267	55.000	53.133
C ₁ F ₂	58.900	59.800	59.350	58.900	59.800	59.350
C ₂ F ₀	30.667	32.658	31.663	-	-	-
C ₂ F ₁	33.667	35.108	34.388	-	-	-
C ₂ F ₂	36.600	37.633	37.117	-	-	-
C ₃ F ₀	-	-	-	26.233	27.333	26.783
C ₃ F ₁	-	-	-	35.667	37.167	36.417
C ₃ F ₂	-	-	-	37.800	41.108	39.454
C ₄ F ₀	40.700	42.483	41.592	-	-	-
C ₄ F ₁	51.333	53.758	52.546	-	-	-
C ₄ F ₂	59.200	65.367	62.283	-	-	-
C ₅ F ₀	-	-	-	37.367	39.083	38.225
C ₅ F ₁	-	-	-	52.500	56.767	54.633
C ₅ F ₂	-	-	-	61.967	64.775	63.371
C ₆ F ₀	44.567	46.600	45.583	-	-	-
C ₆ F ₁	54.800	59.258	57.029	-	-	-
C ₆ F ₂	66.300	68.000	67.150	-	-	-
C ₇ F ₀	-	-	-	43.900	46.492	45.196
C ₇ F ₁	-	-	-	56.333	62.233	59.283
C ₇ F ₂	-	-	-	65.400	68.667	67.033
C ₈ F ₀	44.933	45.442	45.188	-	-	-
C ₈ F ₁	53.033	57.942	55.488	-	-	-
C ₈ F ₂	63.200	67.217	65.208	-	-	-
C ₉ F ₀	-	-	-	38.767	41.300	40.033
C ₉ F ₁	-	-	-	52.067	58.083	55.075
C ₉ F ₂	-	-	-	63.600	67.958	65.779
SEm±	0.348	0.397	0.264	0.442	0.570	0.361
CD (P=0.05)	0.988	1.126	0.740	1.256	1.618	1.012

Table 33a. Effect of row ratio and nutrient management on total dry fodder yield of maize, cowpea and rice bean

Treatments	Total dry fodder yield (t ha ⁻¹)					
	Maize + Cowpea			Maize + Rice bean		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole maize (M)	11.181	11.643	11.412	11.181	11.643	11.412
C ₂ - Sole cowpea (C)	5.568	5.736	5.652	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	5.271	5.224	5.247
C ₄ - M + C (1:1)	10.481	11.195	10.838	-	-	-
C ₅ - M + R (1:1)	-	-	-	9.534	10.427	9.981
C ₆ - M + C (2:1)	11.638	12.217	11.928	-	-	-
C ₇ - M + R (2:1)	-	-	-	11.145	12.085	11.615
C ₈ - M + C (2:2)	10.794	11.542	11.168	-	-	-
C ₉ - M + R (2:2)	-	-	-	10.021	10.806	10.414
SEm±	0.041	0.052	0.033	0.047	0.060	0.038
CD (p=0.05)	0.117	0.147	0.093	0.132	0.170	0.106
2. Nutrient management						
F ₀ - control	7.981	8.529	8.255	7.431	7.710	7.570
F ₁ - 50 % NPK	9.972	10.626	10.299	9.589	10.504	10.047
F ₂ - 100 % NPK	11.844	12.245	12.045	11.272	11.897	11.584
SEm±	0.024	0.030	0.019	0.027	0.035	0.022
CD (P=0.05)	0.068	0.085	0.054	0.076	0.098	0.061

Table 33b. Interaction effect of row ratio and nutrient management on total dry fodder yield of maize, cowpea and rice bean

Interaction (C X F)	Total dry fodder yield (t ha ⁻¹)					
	Maize + Cowpea			Maize + Rice bean		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	8.607	8.773	8.690	8.607	8.773	8.690
C ₁ F ₁	11.423	12.234	11.829	11.423	12.234	11.829
C ₁ F ₂	13.513	13.923	13.718	13.513	13.923	13.718
C ₂ F ₀	5.176	5.414	5.295	-	-	-
C ₂ F ₁	5.658	5.803	5.731	-	-	-
C ₂ F ₂	5.868	5.991	5.930	-	-	-
C ₃ F ₀	-	-	-	4.868	4.532	4.700
C ₃ F ₁	-	-	-	5.341	5.408	5.375
C ₃ F ₂	-	-	-	5.603	5.732	5.667
C ₄ F ₀	8.197	9.007	8.602	-	-	-
C ₄ F ₁	10.595	11.137	10.866	-	-	-
C ₄ F ₂	12.650	13.441	13.046	-	-	-
C ₅ F ₀	-	-	-	7.246	7.695	7.470
C ₅ F ₁	-	-	-	9.726	11.049	10.388
C ₅ F ₂	-	-	-	11.629	12.538	12.084
C ₆ F ₀	9.121	10.069	9.595	-	-	-
C ₆ F ₁	11.411	12.251	11.831	-	-	-
C ₆ F ₂	14.383	14.333	14.358	-	-	-
C ₇ F ₀	-	-	-	8.921	9.428	9.174
C ₇ F ₁	-	-	-	11.333	12.482	11.907
C ₇ F ₂	-	-	-	13.182	14.344	13.763
C ₈ F ₀	8.806	9.381	9.093	-	-	-
C ₈ F ₁	10.771	11.707	11.239	-	-	-
C ₈ F ₂	12.804	13.538	13.171	-	-	-
C ₉ F ₀	-	-	-	7.512	8.122	7.817
C ₉ F ₁	-	-	-	10.121	11.348	10.734
C ₉ F ₂	-	-	-	12.431	12.948	12.689
SEm±	0.071	0.090	0.057	0.081	0.104	0.066
CD (P=0.05)	0.203	0.255	0.161	0.229	0.294	0.184

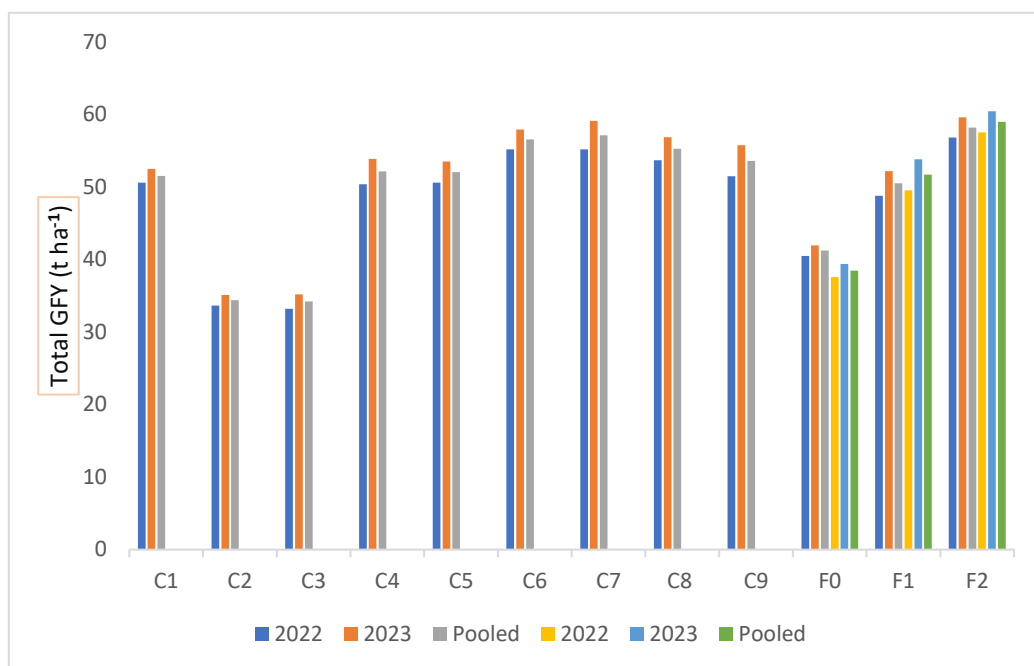


Fig.6. Effect of row ratio and nutrient management on total green fodder yield of maize, cowpea and rice bean

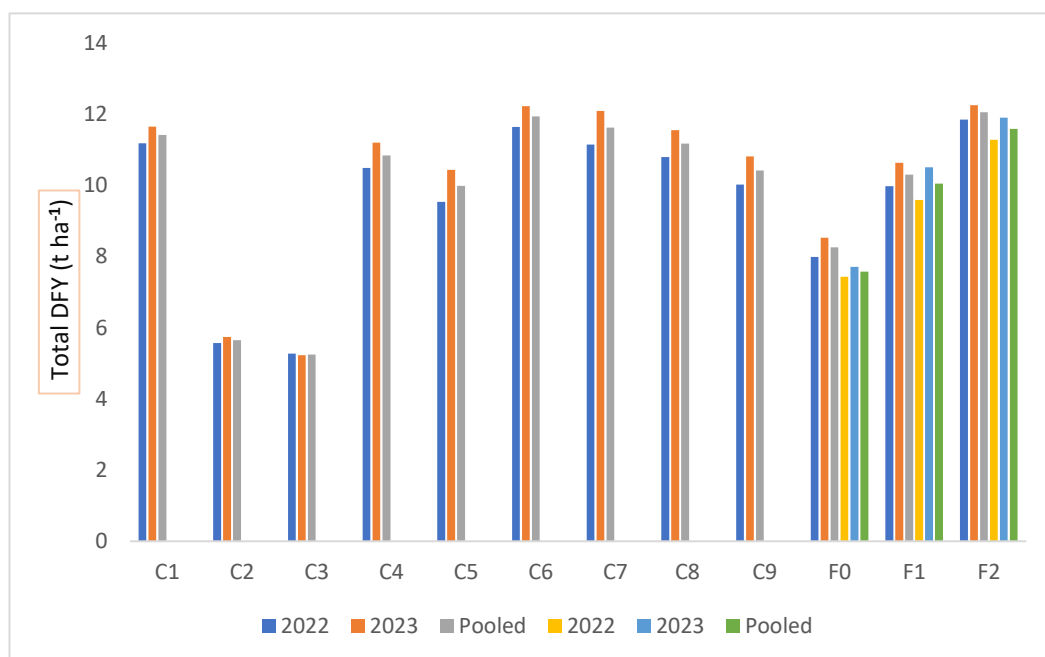


Fig.7. Effect of row ratio and nutrient management on total dry fodder yield of maize, cowpea and rice bean

4.3 Qualitative analysis

4.3.1 Crude protein content (%)

The result (Table 34a) revealed that the effect of different row ratio had a significant impact on crude protein content of fodder maize, fodder cowpea and fodder rice bean. While assessing the effect of different row ratio approaches, it was found that highest crude protein content of fodder maize was registered at C₇ (9.63 %) followed by C₆ (9.35 %), while the lowest crude protein content of fodder maize was recorded from C₁ (8.72 %) and C₅ (8.79 %). For fodder cowpea and fodder rice bean, the different row ratio caused not much variation in crude protein content. The crude protein content of the fodder cowpea and fodder rice bean was ranged from 16.16 % to 18.04 % and 14.98 % to 18.62 % respectively. The highest crude protein content of fodder cowpea and fodder rice bean was recorded at sole cowpea (C₂- 18.04 %) and sole rice bean (C₃- 18.62 %), while the remaining treatments registered similar trend of crude protein content in fodder cowpea and fodder rice bean. However, the lowest crude protein content of fodder cowpea and fodder rice bean was observed at C₆ (16.16 %) and C₉ (14.98 %). Ginwal *et al.* (2019a) reported that the highest crude protein content of maize at 1:1 (8.66 %) followed by 2:1 (8.65 %) and sole crop (8.33 %). The higher crude protein of cowpea was observed at 1:1 (16.24 %) followed sole crop (16.24 %). Kussie *et al.* (2024) also reported that the highest crude protein content of maize at 2:2 row ratio in comparison to 1:1 and sole, while the highest crude protein of cowpea was obtained at sole crop. In similar trend, Asangla (2015) also claimed that the lowest crude protein of fodder maize at sole crop. Likewise, Tamta *et al.* (2019) also observed the highest crude protein of fodder maize and fodder cowpea at 1:2 row ratio.

Regarding the nutrient management practices, the result (Table 34a) showed that the crude protein content in fodder crops was significantly influenced by application of nutrients at different levels. The data revealed that the crude protein content increase with increase in nutrient levels. The application of nutrient at 100 % RDF (F₂) registered significantly the highest crude protein of fodder maize (10.88 %), fodder cowpea (19.69 %) and fodder rice bean (18.63 %) as compared to other treatments F₁ and F₀ respectively. Similarly, among all the treatments, the lowest crude

protein content of fodder maize (7.33 %), fodder cowpea (13.89 %) and fodder rice bean (13.91 %) was recorded at F₀ (control). Ayub *et al.* (2002) also reported that the crude protein content in maize was found increase with increase in nutrient applications. They also observed that the highest crude protein content (9.62 %) under high nutrient application of N:P @ 160:80 kg ha⁻¹ than control, 120:40, 120:60 and 160:40 N:P kg ha⁻¹. However, the higher crude protein of fodder maize (8.94 %) and rice bean (18.93) was also observed under sole crop followed by 2:1 row ratio (8.79 % and 18.24 %) receiving 100 % RDF of NPK. Likewise, Tamta *et al.* (2019) and Asangla (2015) reported that the higher crude protein of maize under high nutrient application. Similarly, Krishna *et al.* (2022) also reported that application of NPK @ 120:50:40 kg ha⁻¹ registered the highest crude protein content (7.8 %) of fodder maize. Dhamodharan *et al.* (2021) studied the different levels of nutrients on maize with cowpea intercropping system. In this research, the highest crude protein content of fodder maize and cowpea was observed under the application of nutrients at 100 % RDF than 75 % RDF and 50 % RDF.

The interaction result (Table 34b) revealed that both factors (different row ratio and nutrient management) caused significantly a wide variation in crude protein content of fodder maize, fodder cowpea and fodder rice bean. The treatment combinations receiving higher levels of nutrients produced higher content of crude protein. Among all the treatment interactions, the higher and comparable crude protein content in fodder maize was recorded at C₆F₂ (11.78 %) and C₇F₂ (11.11 %), while the lowest crude protein content was obtained at C₁F₀ (6.82 %) and C₄F₀ (6.68 %) respectively. Where, for fodder cowpea, the highest crude protein content in fodder cowpea was observed at C₂F₂ (19.90 %), which was statistically on par with C₄F₂ (19.82 %) and then followed by C₈F₂ (19.53 %) and C₆F₂ (19.52 %). The lowest crude protein content was recorded at C₆F₀ (12.84 %). The crude protein content in fodder rice bean was found to be highest at C₃F₂ (20.37 %) followed by C₃F₁ (18.90 %), C₅F₂ (18.31 %) and C₇F₂ (18.12 %), while the lowest crude protein content was recorded at C₉F₀ (12.22 %) respectively. Rundani *et al.* (2023) also observed that the higher crude protein content of fodder rice bean from sole crop, which received 100 % RDF nutrient

application. Similarly, Asangla (2015) also proved the higher crude protein content of fodder maize and cowpea under higher nutrient management practices.

4.3.2 Crude protein yield (q ha⁻¹)

The data pertaining to crude protein yield of fodder maize, fodder cowpea and fodder rice bean was significantly influenced by both different row ratio and nutrient management and are presented in Table 35a. With respect to different row ratio, the highest crude protein yield of fodder maize (10.28 q ha⁻¹), fodder cowpea (8.70 q ha⁻¹) and fodder rice bean (6.83 q ha⁻¹) was recorded at sole plot *i.e.*, C₁, C₂ and C₃ respectively and followed by C₇ (8.02 q ha⁻¹), C₈ (4.65 q ha⁻¹) and C₉ (3.02 q ha⁻¹). Likewise, the lowest crude protein yield of fodder maize, fodder cowpea and fodder rice bean were recorded at C₅ (6.51 q ha⁻¹), C₆ (3.03 q ha⁻¹) and C₇ (2.10 q ha⁻¹). Similarly, the highest crude protein yield of fodder maize and fodder cowpea was recorded from sole crop and then at 2:1 row ratio (Yadav, 2022a). Sharma (2008) also reported that the higher crude protein yield of fodder maize and cowpea under sole crop followed by 2:2 row ratio. Tamta *et al.* (2019) also observed that the highest crude protein yield of fodder maize and fodder cowpea at 2:1 and 1:2 row ratio.

The nutrient management approaches showed that the crude protein yield of fodder maize, fodder cowpea and fodder rice bean was significantly improved with application of nutrients (Table 35a). The applications of nutrient @ 100 % RDF (F₂) recorded the highest crude protein yield of the fodder maize (10.51 q ha⁻¹), fodder cowpea (6.45 q ha⁻¹) and fodder rice bean (4.57 q ha⁻¹) in comparison to treatment F₁ and F₀ (control) . Similarly, the lowest crude protein yield of fodder maize (4.72 q ha⁻¹), fodder cowpea (3.87 q ha⁻¹) and fodder rice bean (2.85 q ha⁻¹) was observed at F₀. Similarly, the highest crude protein yield of fodder maize and fodder cowpea was observed at treatment receiving NPK @ 125 % RDF in compared to 75 % RDF and 100 % RDF (Dhamodharan *et al.*, 2021). Crude protein yield of fodder and fodder cowpea was found to increase with increase in nutrient levels. Yadahalli *et al.* (2022) also reported that application of NPK @ 200-50-40 kg ha⁻¹ produced the higher crude protein yield of fodder maize as compared to control.

The interaction result (Table 35b) indicated that both different row ratio and nutrient management practices caused a significant variation in crude protein yield of fodder crops. The crude protein yield was found increase with increase in nutrient levels. Among all the treatment combinations, the highest crude protein yield of fodder maize (14.40 q ha⁻¹), fodder cowpea (10.10 q ha⁻¹) and fodder rice bean (7.74 q ha⁻¹) was registered from treatments C₁F₂, C₂F₂ and C₃F₂ respectively. Subsequently, among all the treatments, the lower and comparable crude protein yield of fodder maize, fodder cowpea and fodder rice bean were observed at C₈F₀ (4.06 q ha⁻¹), C₆F₀ (2.01 q ha⁻¹) and C₇F₀ (1.69 q ha⁻¹).

4.3.3 Crude fibre (%)

The result (36a) suggested that differed row ratio did not cause much variation in the crude fibre content of fodder crops. Among all the treatments of different row ratio, the highest crude fibre content of fodder maize was recorded at sole crop (C₁- 24.09 %) and the lowest was registered at C₅ (21.73 %) and C₈ (21.86 %). Incase of fodder cowpea and fodder rice bean, the highest crude fibre content was recorded at sole plot (C₂- 22.72 %) and C₃ (23.00 %). The lowest crude fibre content of fodder cowpea and fodder rice bean was observed at C₆ (21.03 %) and C₇ (21.77 %) and which were statistically on par with other treatments respectively. This finding was in comparable with the findings of Asangla (2015), who reported the higher crude fibre content of fodder cowpea at sole crop followed by 1:1 row ratio. The higher crude fibre content of fodder maize and fodder cowpea was observed under sole crop. Similarly, Azim *et al.* (2000) also reported the higher crude fibre content of fodder maize at sole crop.

Among all the nutrient management approaches, the result (Table 36a) revealed that crude fibre content in fodder crops was significantly influenced by nutrient application. The crude fibre content increase with increasing the level of nutrient applications. The highest crude fibre content of fodder maize (27.18 %), fodder cowpea (25.56 %) and fodder rice bean (26.07 %) was registered at treatment receiving 100 % RDF (F₂). Eventually, the lowest crude fibre content for fodder maize fodder (16.61 %), fodder cowpea (17.41 %) and fodder rice bean (18.63 %) was recorded at control (F₀). Ayub *et al.* (2002) studied the different levels (160-80, 160-60, 160-40,

120-80, 120-60, 120-40 and control) of N and P on nutrient quality of maize. He reported that application of NP @ 160:80 kg ha⁻¹ registered the highest crude fibre (34.17 %) content of maize as compared to other treatments. Yadahalli *et al.* (2022) also reported that crude fibre content in fodder maize was increase with increase in nutrient applications. Application of NP @ 150-60 kg ha⁻¹ produced the highest crude fibre content (27.31 %) of fodder maize (Panwar *et al.*, 2020).

The interaction effect of different row ratio and nutrient management practices on crude fibre content of fodder maize, fodder cowpea and fodder rice bean were found statistically significant (Table 36b). Among all the treatment combinations, fodder maize (28.00 %), fodder cowpea (26.54 %) and fodder rice bean (27.14 %) planted under sole stand with application of 100 % RDF of NPK (F₂) recorded the highest crude fibre content as compared to other treatments. In contrast to this, the lower and comparable crude fibre of fodder maize was observed at C₅F₀ (15.67 %), C₈F₀ (15.67 %) and C₆F₀ (15.93 %). For fodder cowpea it was registered from C₆F₀ (16.71 %). Incase of fodder rice bean, intercropping of fodder maize with fodder rice bean (1:1, 1:2, 2:2) with no application of nutrients registered the lowest fibre content in fodder rice bean with compared to other treatments.

4.3.4 Ash content (%)

The ash content in fodder crops was significantly influenced by different row ratio of fodder maize with fodder legume (Table 37a). Regarding the different row ratio, the results revealed that the highest ash content of fodder maize was recorded at C₅ (8.77 %), which was significantly followed by treatments C₈ (8.56 %), C₄ (8.50 %) and C₉ (8.40 %). The lowest was recorded at sole maize C₁ (7.57 %). Incase of fodder legume, sole grown fodder cowpea (19.60 %) and fodder rice bean (13.83 %) recorded the highest ash content when compared with other treatments and the lowest ash content was observed at C₆ (14.66 %) and C₇ (12.15 %) respectively. This finding was substantiating by Prasanthi and Venkate (2014). They observed that the highest ash content of cowpea under sole crop (10.22 % and 15.88 %) followed by 2:2 row ratio (10.2 % and 15.81 %). The highest ash content of maize was observed at 2:2 row ratio followed by sole crop (10.55 % and 10.22 %). The least content was observed at 1:1 row ratio. Ginwal *et al.* (2019a): Tamta *et al.* (2019) also observed that under different

row ratio, the highest ash content of fodder maize and fodder cowpea was seen at 1:2 row ratio followed 1:1 row ratio. Runda *et al.* (2023) reported that the higher ash content on fodder maize and rice bean under sole crop and 1:1 in comparison to 2:1 row ratio. Kussie *et al.* (2024) studied the intercropping effect on nutritional values of maize and cowpea. They recorded the higher ash content of maize and cowpea under 2:2 row ratio as compared to 1:1 row ratio and sole crop. Similarly, Manoj *et al.* (2021) also reported that the lower ash content of maize grown under sole stand.

With regard to nutrient management practices, the data presented in the Table 37a showed that the ash content in fodder crops was found to increase with increase in nutrient applications. The application of nutrients at 100 % RDF (F_2 - 60-30-30 NPK kg ha⁻¹) recorded the highest ash content of fodder maize (9.52 %), fodder cowpea (23.66 %) and fodder rice bean (17.10 %) as compared to other treatments and subsequently the lowest ash content of fodder maize (6.86 %), fodder cowpea (11.01 %) and fodder rice bean (8.69 %) was recorded at F_0 (control). Similar finding of higher ash content of fodder maize and fodder cowpea was recorded in treatment receiving 120 kg ha⁻¹ N (Asangla, 2015). Ayub *et al.* (2002) also reported the increase in crude protein content with increase in nutrients application. They observed the highest ash content of fodder maize (34.17 %) under high nutrient application of N:P @ 160-80 kg ha⁻¹ than control, 120-40, 120-60 and 160-40 NP kg ha⁻¹. However, the highest ash content of fodder maize (8.94 %) and rice bean (18.93 %) was observed under sole crop followed by 2:1 row ratio (8.79 % and 18.24 %) receiving 100 % RDF of NPK.

The interaction result (Table 37b) indicated that different row ratio and nutrient management practices had a significant effect on ash content of fodder maize, fodder cowpea and fodder rice bean. Among all the treatments, fodder maize, fodder cowpea and fodder rice bean sown under sole stand along with applications of 100 % RDF (F_2) registered the highest ash content of fodder maize (10.23 %), fodder cowpea (27.08 %) and fodder rice bean (18.59 %), eventually the highest and comparable ash content of fodder maize was seen at when maize was grown at different row ratio *i.e.*, 1:1, 2:1 and 2:2 with application of NPK at 60-30-30 kg ha⁻¹. Similarly, the higher and similar trend of ash content in fodder cowpea and fodder rice bean was observed when both the crops were grown with maize at different row ratio along with applications 60-

30-30 NPK kg ha⁻¹. Eventually, the control treatment (F₀- zero nutrient application) registered the lowest ash content as compared to other treatment. Similarly, interaction of 1:1 row ratio with 100 % RDF produced the higher ash content on fodder maize and rice bean (Runda *et al.*, 2023).

Table 34a. Effect of row ratio and nutrient management on crude protein content of maize, cowpea and rice bean

Treatments	Crude protein content (%)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	8.45	8.99	8.72	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	17.84	18.24	18.04	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	18.20	19.04	18.62
C ₄ - M + C (1:1)	8.55	9.14	8.84	14.45	18.74	16.60	-	-	-
C ₅ - M + R (1:1)	8.47	9.11	8.79	-	-	-	15.80	15.90	15.85
C ₆ - M + C (2:1)	9.31	9.38	9.35	16.46	15.86	16.16	-	-	-
C ₇ - M + R (2:1)	9.36	9.89	9.63	-	-	-	15.81	16.14	15.97
C ₈ - M + C (2:2)	8.57	9.36	8.97	15.65	17.19	16.42	-	-	-
C ₉ - M + R (2:2)	8.55	9.28	8.91	-	-	-	14.51	15.45	14.98
SEm±	0.10	0.10	0.07	0.15	0.18	0.12	0.15	0.14	0.10
CD (P=0.05)	0.27	0.28	0.19	0.44	0.52	0.33	0.43	0.39	0.29
2. Nutrient management									
F ₀ - Control	7.12	7.41	7.26	13.43	14.36	13.89	14.32	13.51	13.91
F ₁ - 50 % NPK	8.57	9.34	8.95	15.99	17.67	16.83	16.12	16.92	16.52
F ₂ - 100 % NPK	10.57	11.18	10.88	18.82	20.57	19.69	17.80	19.46	18.63
SEm±	0.06	0.06	0.04	0.09	0.10	0.07	0.09	0.08	0.06
CD (P=0.05)	0.16	0.16	0.11	0.25	0.30	0.19	0.25	0.22	0.16

Table 34b. Interaction effect of row ratio and nutrient management on crude protein content of maize, cowpea and rice bean

Interaction (C X F)	Crude protein content (%)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	6.78	6.85	6.82	-	-	-	-	-	-
C ₁ F ₁	8.27	9.06	8.66	-	-	-	-	-	-
C ₁ F ₂	10.31	11.08	10.69	-	-	-	-	-	-
C ₂ F ₀	-	-	-	16.67	15.67	16.17	-	-	-
C ₂ F ₁	-	-	-	17.73	18.42	18.07	-	-	-
C ₂ F ₂	-	-	-	19.13	20.67	19.90	-	-	-
C ₃ F ₀	-	-	-	-	-	-	16.61	16.57	16.59
C ₃ F ₁	-	-	-	-	-	-	18.53	19.28	18.90
C ₃ F ₂	-	-	-	-	-	-	19.48	21.27	20.37
C ₄ F ₀	6.78	6.95	6.86	12.51	13.63	13.07	-	-	-
C ₄ F ₁	8.21	9.21	8.71	15.99	17.82	16.90	-	-	-
C ₄ F ₂	10.66	11.27	10.96	18.19	21.46	19.82	-	-	-
C ₅ F ₀	7.24	7.23	7.23	-	-	-	14.10	12.37	13.23
C ₅ F ₁	8.17	9.75	8.96	-	-	-	15.79	16.23	16.01
C ₅ F ₂	10.01	10.37	10.19	-	-	-	17.52	19.11	18.31
C ₆ F ₀	7.76	6.99	7.38	11.85	13.82	12.84	-	-	-
C ₆ F ₁	9.17	8.61	8.89	15.05	17.16	16.10	-	-	-
C ₆ F ₂	11.02	12.54	11.78	19.27	19.76	19.52	-	-	-
C ₇ F ₀	8.01	8.68	8.34	-	-	-	13.65	13.58	13.62
C ₇ F ₁	8.93	9.92	9.43	-	-	-	15.72	16.66	16.19
C ₇ F ₂	11.13	11.09	11.11	-	-	-	18.06	18.18	18.12
C ₈ F ₀	6.50	7.87	7.18	12.67	14.33	13.50	-	-	-
C ₈ F ₁	8.58	9.37	8.97	15.19	17.29	16.24	-	-	-
C ₈ F ₂	10.64	10.86	10.75	18.67	20.38	19.53	-	-	-
C ₉ F ₀	6.75	7.33	7.04	-	-	-	12.93	11.52	12.22
C ₉ F ₁	8.68	9.44	9.06	-	-	-	14.45	15.53	14.99
C ₉ F ₂	10.23	11.06	10.64	-	-	-	16.14	19.30	17.72
SEm±	0.17	0.17	0.12	0.27	0.31	0.21	0.26	0.24	0.18
CD (P=0.05)	0.48	0.48	0.33	0.76	0.89	0.58	0.74	0.67	0.49

Table 35a. Effect of row ratio and nutrient management on crude protein yield of maize, cowpea and rice bean

Treatments	Crude protein yield (q ha ⁻¹)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	9.69	10.87	10.28	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	8.37	9.03	8.70	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	6.39	7.26	6.83
C ₄ - M + C (1:1)	6.60	7.02	6.81	3.21	4.91	4.06	-	-	-
C ₅ - M + R (1:1)	5.49	7.54	6.51	-	-	-	2.33	3.30	2.81
C ₆ - M + C (2:1)	7.56	7.93	7.75	3.09	2.98	3.03	-	-	-
C ₇ - M + R (2:1)	7.36	8.68	8.02	-	-	-	1.87	2.34	2.10
C ₈ - M + C (2:2)	6.00	7.49	6.74	4.29	5.00	4.65	-	-	-
C ₉ - M + R (2:2)	6.38	6.97	6.68	-	-	-	2.47	3.56	3.02
SEm±	0.11	0.12	0.08	0.04	0.04	0.03	0.02	0.03	0.02
CD (P=0.05)	0.31	0.35	0.23	0.11	0.10	0.07	0.05	0.07	0.04
2. Nutrient management									
F ₀ - Control	4.31	5.14	4.72	3.55	4.19	3.87	2.59	3.12	2.85
F ₁ - 50 % NPK	6.77	8.01	7.39	4.69	5.33	5.01	3.36	3.94	3.65
F ₂ - 100 % NPK	9.95	11.07	10.51	5.99	6.91	6.45	3.85	5.29	4.57
SEm±	0.06	0.07	0.05	0.02	0.02	0.02	0.01	0.01	0.01
CD (P=0.05)	0.18	0.20	0.13	0.06	0.06	0.04	0.03	0.04	0.02

Table 35b. Interaction effect of row ratio and nutrient management on crude protein yield of maize, cowpea and rice bean

Interaction (C X F)	Crude protein yield (q ha ⁻¹)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	5.45	6.69	6.07	-	-	-	-	-	-
C ₁ F ₁	9.75	10.99	10.37	-	-	-	-	-	-
C ₁ F ₂	13.86	14.94	14.40	-	-	-	-	-	-
C ₂ F ₀	-	-	-	7.37	7.39	7.38	-	-	-
C ₂ F ₁	-	-	-	8.49	8.74	8.61	-	-	-
C ₂ F ₂	-	-	-	9.25	10.94	10.10	-	-	-
C ₃ F ₀	-	-	-	-	-	-	5.34	6.32	5.83
C ₃ F ₁	-	-	-	-	-	-	6.58	7.24	6.91
C ₃ F ₂	-	-	-	-	-	-	7.25	8.23	7.74
C ₄ F ₀	4.22	4.13	4.18	2.25	3.00	2.62	-	-	-
C ₄ F ₁	6.21	7.08	6.65	3.28	4.85	4.06	-	-	-
C ₄ F ₂	9.38	9.85	9.61	4.10	6.87	5.49	-	-	-
C ₅ F ₀	3.68	4.58	4.13	-	-	-	1.54	2.04	1.79
C ₅ F ₁	5.12	8.07	6.59	-	-	-	2.36	3.13	2.74
C ₅ F ₂	7.66	9.98	8.82	-	-	-	3.09	4.72	3.91
C ₆ F ₀	4.80	4.58	4.69	1.53	2.48	2.01	-	-	-
C ₆ F ₁	7.23	6.99	7.11	2.91	3.09	3.00	-	-	-
C ₆ F ₂	10.66	12.23	11.45	4.83	3.36	4.09	-	-	-
C ₇ F ₀	4.52	6.77	5.64	-	-	-	1.61	1.77	1.69
C ₇ F ₁	7.04	8.40	7.72	-	-	-	1.96	2.10	2.03
C ₇ F ₂	10.52	10.87	10.69	-	-	-	2.03	3.14	2.59
C ₈ F ₀	3.60	4.53	4.06	3.03	3.89	3.46	-	-	-
C ₈ F ₁	5.95	7.60	6.77	4.08	4.66	4.37	-	-	-
C ₈ F ₂	8.45	10.34	9.39	5.77	6.46	6.11	-	-	-
C ₉ F ₀	3.88	4.71	4.29	-	-	-	1.87	2.35	2.11
C ₉ F ₁	6.11	6.96	6.54	-	-	-	2.52	3.28	2.90
C ₉ F ₂	9.16	9.25	9.20	-	-	-	3.03	5.06	4.04
SEm±	0.19	0.22	0.14	0.07	0.06	0.05	0.03	0.04	0.03
CD (P=0.05)	0.53	0.61	0.40	0.19	0.18	0.13	0.08	0.12	0.07

Table 36a. Effect of row ratio and nutrient management on crude fibre content of maize, cowpea and rice bean

Treatments	Crude fibre (%)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	23.48	24.70	24.09	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	22.33	23.10	22.72	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	22.64	23.36	23.00
C ₄ - M + C (1:1)	21.89	23.12	22.51	21.41	22.12	21.77	-	-	-
C ₅ - M + R (1:1)	21.56	21.90	21.73	-	-	-	22.36	22.58	22.47
C ₆ - M + C (2:1)	21.55	22.69	22.12	20.96	21.09	21.03	-	-	-
C ₇ - M + R (2:1)	22.08	22.23	22.16	-	-	-	21.69	21.85	21.77
C ₈ - M + C (2:2)	21.86	21.87	21.86	21.25	22.22	21.74	-	-	-
C ₉ - M + R (2:2)	22.11	23.68	22.89	-	-	-	22.16	22.61	22.39
SEm±	0.17	0.12	0.10	0.11	0.08	0.07	0.13	0.10	0.08
CD (P=0.05)	0.47	0.35	0.29	0.30	0.21	0.18	0.37	0.27	0.23
2. Nutrient management									
F ₀ - Control	16.17	17.05	16.61	17.08	17.73	17.41	18.46	18.80	18.63
F ₁ - 50 % NPK	23.22	24.08	23.65	22.08	22.84	22.46	22.23	22.82	22.52
F ₂ - 100 % NPK	26.83	27.53	27.18	25.31	25.82	25.56	25.94	26.19	26.07
SEm±	0.10	0.07	0.06	0.06	0.04	0.04	0.08	0.06	0.05
CD (P=0.05)	0.27	0.20	0.17	0.18	0.12	0.11	0.21	0.16	0.13

Table 36b. Interaction effect of row ratio and nutrient management on crude fibre content of maize, cowpea and rice bean

Interaction (C X F)	Crude fibre (%)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	18.00	18.67	18.33	-	-	-	-	-	-
C ₁ F ₁	25.10	26.77	25.93	-	-	-	-	-	-
C ₁ F ₂	27.33	28.67	28.00	-	-	-	-	-	-
C ₂ F ₀	-	-	-	17.71	18.45	18.08	-	-	-
C ₂ F ₁	-	-	-	23.15	23.90	23.53	-	-	-
C ₂ F ₂	-	-	-	26.12	26.96	26.54	-	-	-
C ₃ F ₀	-	-	-	-	-	-	18.55	19.22	18.89
C ₃ F ₁	-	-	-	-	-	-	22.47	23.47	22.97
C ₃ F ₂	-	-	-	-	-	-	26.89	27.39	27.14
C ₄ F ₀	16.33	18.00	17.17	16.73	17.60	17.17	-	-	-
C ₄ F ₁	22.77	23.77	23.27	22.07	22.81	22.44	-	-	-
C ₄ F ₂	26.57	27.60	27.08	25.43	25.95	25.69	-	-	-
C ₅ F ₀	15.67	15.67	15.67	-	-	-	18.43	18.77	18.60
C ₅ F ₁	22.20	23.10	22.65	-	-	-	22.50	22.79	22.64
C ₅ F ₂	26.80	26.93	26.87	-	-	-	26.13	26.20	26.17
C ₆ F ₀	15.20	16.67	15.93	16.71	16.71	16.71	-	-	-
C ₆ F ₁	22.87	23.93	23.40	21.45	21.81	21.63	-	-	-
C ₆ F ₂	26.59	27.47	27.03	24.73	24.73	24.73	-	-	-
C ₇ F ₀	16.00	16.33	16.17	-	-	-	18.43	18.43	18.43
C ₇ F ₁	23.43	23.43	23.43	-	-	-	21.50	21.62	21.56
C ₇ F ₂	26.80	26.93	26.87	-	-	-	25.14	25.51	25.32
C ₈ F ₀	15.67	15.67	15.67	17.18	18.17	17.68	-	-	-
C ₈ F ₁	23.10	23.10	23.10	21.65	22.83	22.24	-	-	-
C ₈ F ₂	26.80	26.83	26.82	24.93	25.66	25.30	-	-	-
C ₉ F ₀	16.33	18.33	17.33	-	-	-	18.43	18.77	18.60
C ₉ F ₁	23.10	24.43	23.77	-	-	-	22.45	23.39	22.92
C ₉ F ₂	26.90	28.27	27.58	-	-	-	25.60	25.67	25.63
SEm±	0.29	0.21	0.18	0.19	0.13	0.11	0.23	0.17	0.14
CD (P=0.05)	0.81	0.60	0.50	0.53	0.37	0.32	0.64	0.47	0.39

Table 37a. Effect of row ratio and nutrient management on ash content of maize, cowpea and rice bean

Treatments	Ash content (%)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	7.48	7.67	7.57	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	16.26	22.94	19.60	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	13.14	14.53	13.83
C ₄ - M + C (1:1)	8.49	8.52	8.50	14.65	18.93	16.79	-	-	-
C ₅ - M + R (1:1)	8.54	8.99	8.77	-	-	-	12.15	13.94	13.04
C ₆ - M + C (2:1)	7.89	8.01	7.95	11.87	17.44	14.66	-	-	-
C ₇ - M + R (2:1)	7.92	8.37	8.15	-	-	-	10.24	14.05	12.15
C ₈ - M + C (2:2)	8.41	8.71	8.56	15.62	20.77	18.19	-	-	-
C ₉ - M + R (2:2)	8.28	8.53	8.40	-	-	-	11.96	14.24	13.10
SEm±	0.11	0.11	0.08	0.09	0.14	0.09	0.06	0.09	0.05
CD (P=0.05)	0.32	0.30	0.22	0.26	0.41	0.24	0.16	0.25	0.14
2. Nutrient management									
F ₀ - Control	6.63	7.08	6.86	10.02	12.01	11.01	8.38	9.00	8.69
F ₁ - 50 % NPK	8.33	8.55	8.44	14.32	20.19	17.26	12.07	14.53	13.30
F ₂ - 100 % NPK	9.47	9.56	9.52	19.46	27.86	23.66	15.17	19.04	17.10
SEm±	0.06	0.06	0.04	0.05	0.08	0.05	0.03	0.05	0.03
CD (P=0.05)	0.18	0.18	0.13	0.15	0.23	0.14	0.09	0.14	0.08

Table 37b. Interaction effect of row ratio and nutrient management on ash content of maize, cowpea and rice bean

Interaction (C X F)	Ash (%)								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	6.12	6.35	6.23	-	-	-	-	-	-
C ₁ F ₁	7.49	7.98	7.73	-	-	-	-	-	-
C ₁ F ₂	8.83	8.68	8.76	-	-	-	-	-	-
C ₂ F ₀	-	-	-	11.19	15.17	13.18	-	-	-
C ₂ F ₁	-	-	-	15.70	21.41	18.55	-	-	-
C ₂ F ₂	-	-	-	21.91	32.25	27.08	-	-	-
C ₃ F ₀	-	-	-	-	-	-	8.32	9.44	8.88
C ₃ F ₁	-	-	-	-	-	-	13.47	14.60	14.04
C ₃ F ₂	-	-	-	-	-	-	17.62	19.55	18.59
C ₄ F ₀	7.16	7.17	7.17	10.76	12.05	11.41	-	-	-
C ₄ F ₁	8.40	8.61	8.51	14.63	18.93	16.78	-	-	-
C ₄ F ₂	9.91	9.77	9.84	18.56	25.80	22.18	-	-	-
C ₅ F ₀	6.99	7.68	7.34	-	-	-	8.53	9.04	8.78
C ₅ F ₁	9.00	8.90	8.95	-	-	-	12.90	14.15	13.53
C ₅ F ₂	9.63	10.40	10.02	-	-	-	15.02	18.63	16.83
C ₆ F ₀	6.38	6.66	6.52	7.85	10.37	9.11	-	-	-
C ₆ F ₁	8.00	8.14	8.07	11.28	17.90	14.59	-	-	-
C ₆ F ₂	9.30	9.22	9.26	16.47	24.07	20.27	-	-	-
C ₇ F ₀	6.37	6.97	6.67	-	-	-	7.70	8.38	8.04
C ₇ F ₁	8.20	8.55	8.38	-	-	-	9.86	14.88	12.37
C ₇ F ₂	9.20	9.59	9.40	-	-	-	13.17	18.89	16.03
C ₈ F ₀	6.96	7.68	7.32	10.27	10.44	10.36	-	-	-
C ₈ F ₁	8.66	8.78	8.72	15.69	22.53	19.11	-	-	-
C ₈ F ₂	9.59	9.68	9.64	20.90	29.33	25.11	-	-	-
C ₉ F ₀	6.47	7.08	6.78	-	-	-	8.97	9.13	9.05
C ₉ F ₁	8.54	8.90	8.72	-	-	-	12.05	14.49	13.27
C ₉ F ₂	9.84	9.60	9.72	-	-	-	14.86	19.10	16.98
SEm±	0.19	0.19	0.13	0.16	0.25	0.15	0.10	0.15	0.09
CD (P=0.05)	0.55	0.53	0.38	0.46	0.70	0.41	0.27	0.43	0.25



Fig.8. Effect of row ratio and nutrient management on crude protein content of maize

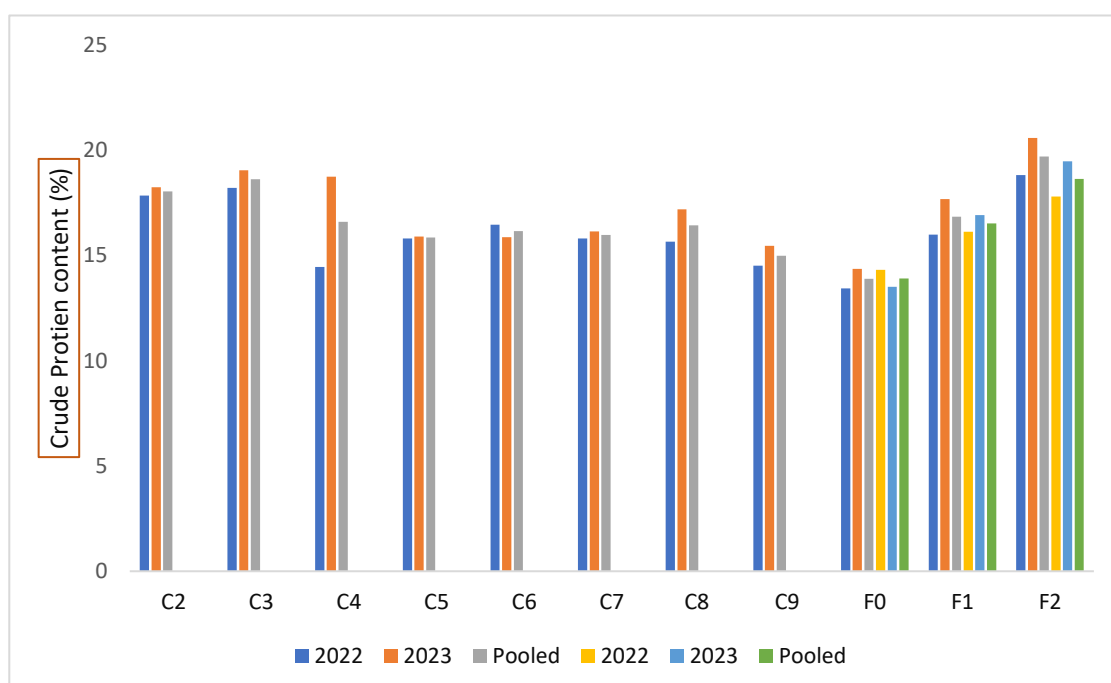


Fig.9. Effect of row ratio and nutrient management on crude protein content of cowpea and rice bean

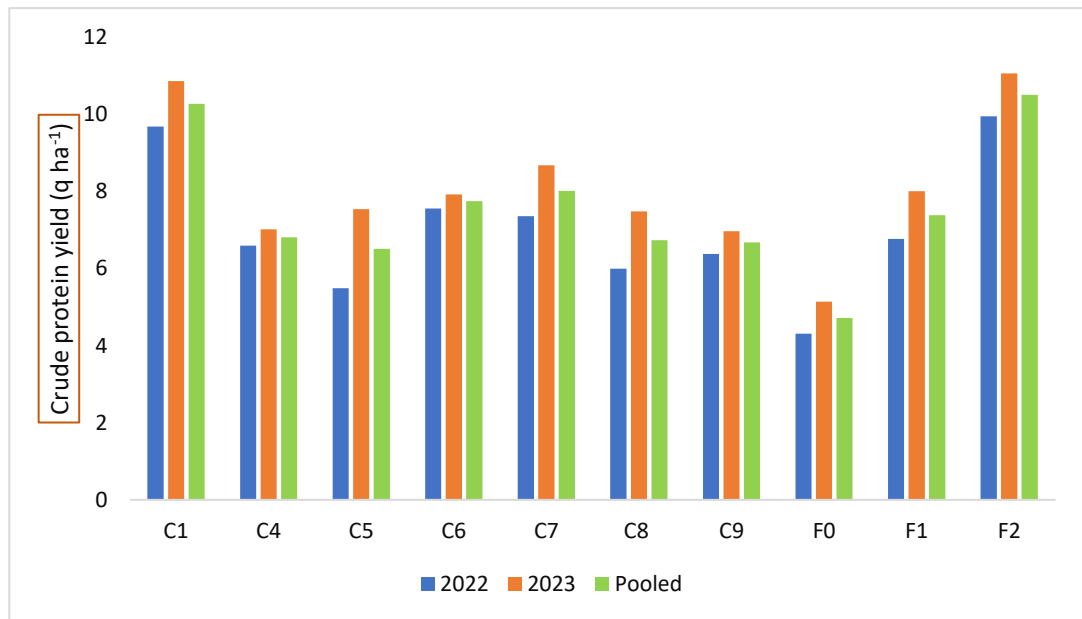


Fig.10. Effect of row ratio and nutrient management on crude protein yield of maize

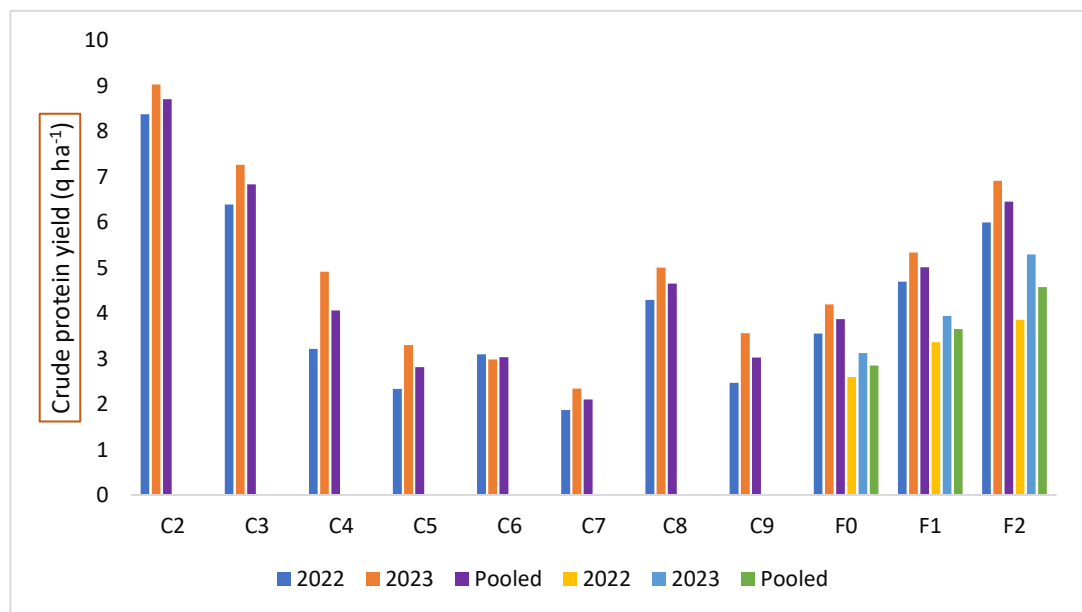


Fig.11. Effect of row ratio and nutrient management on crude protein yield of cowpea and rice bean

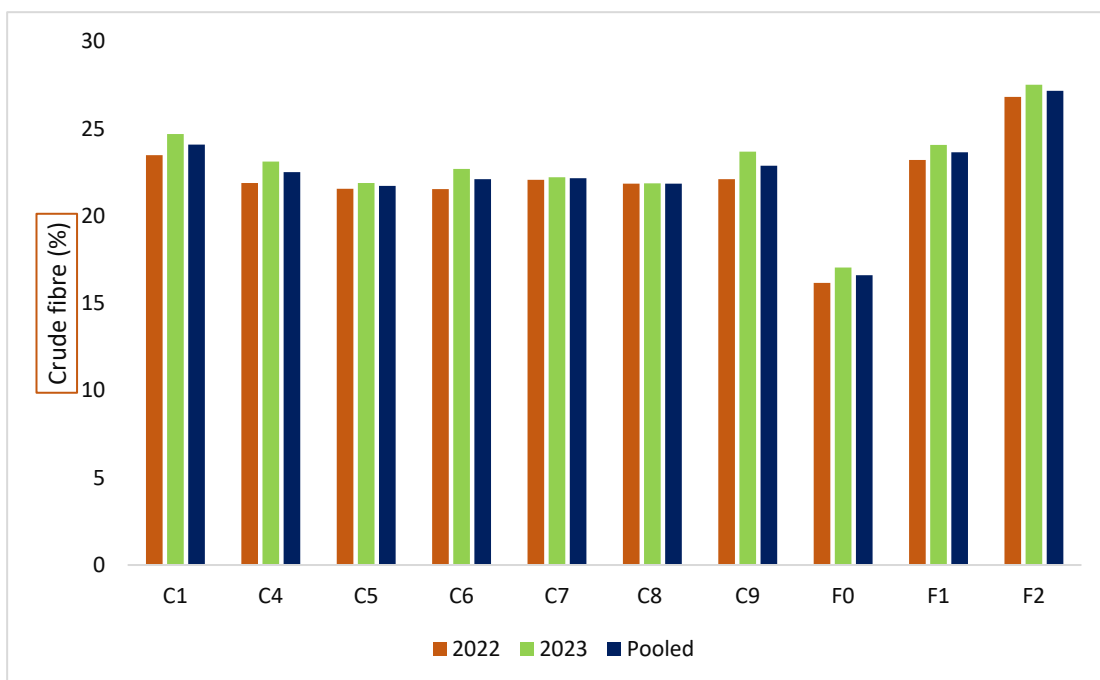


Fig.12. Effect of row ratio and nutrient management on crude fibre content of maize

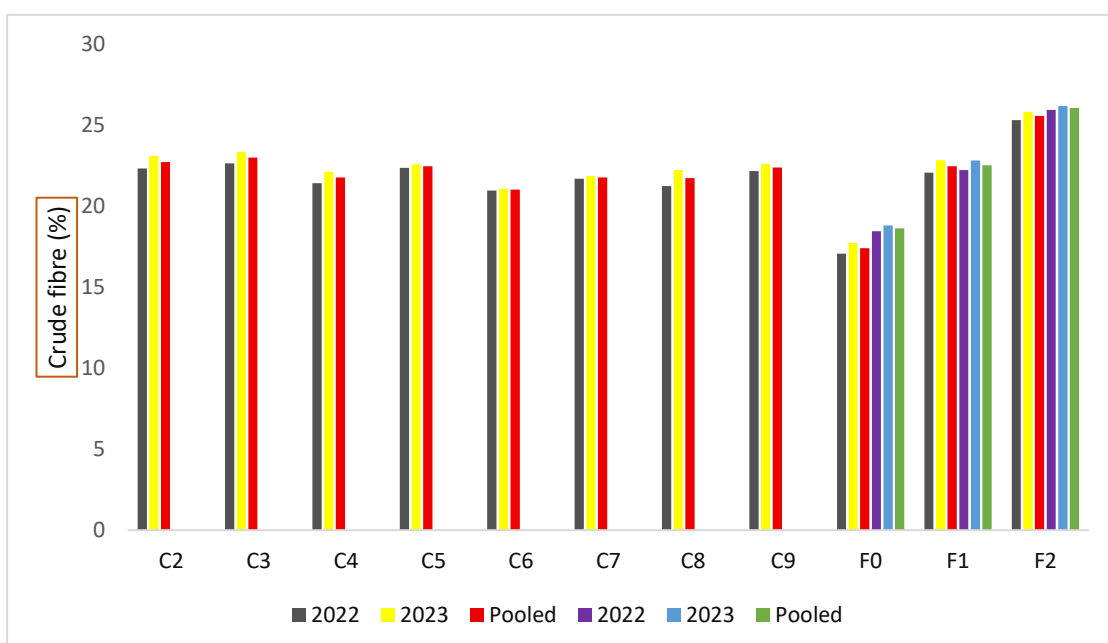


Fig.13. Effect of row ratio and nutrient management on crude fibre content of cowpea and rice bean

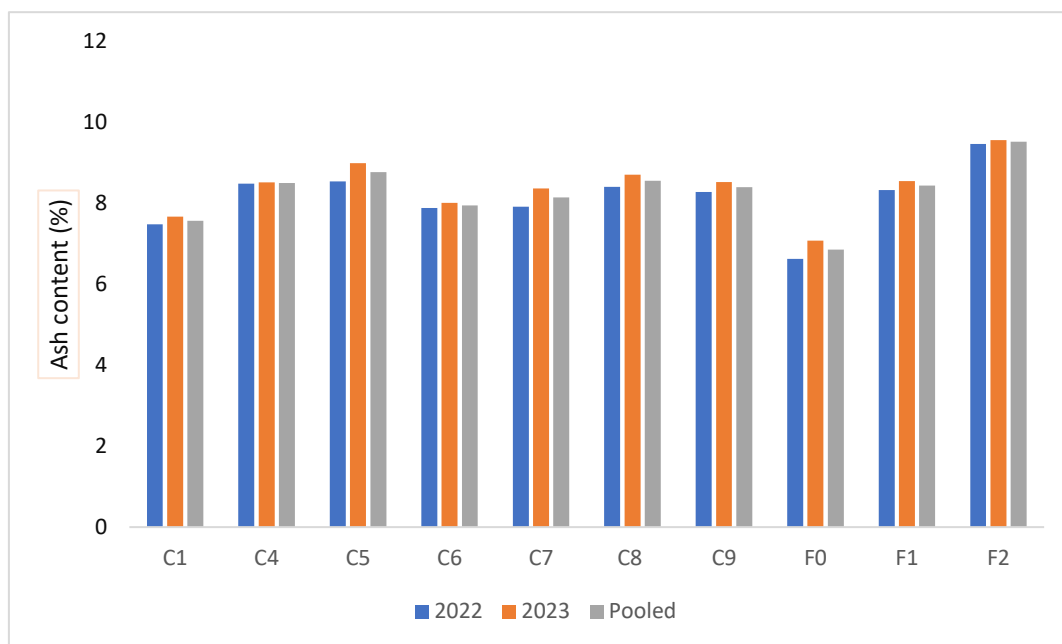


Fig.14. Effect of row ratio and nutrient management on ash content of maize

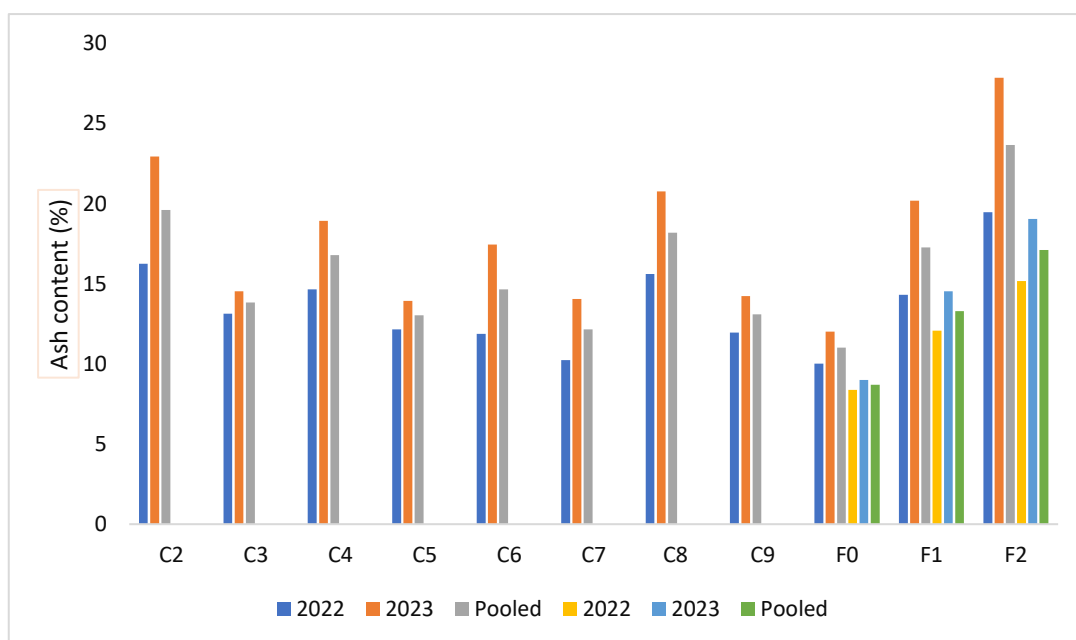


Fig.15. Effect of row ratio and nutrient management on ash content of cowpea and rice bean

4.4 Intercropping studies

4.4.1 Crop growth rate ($\text{g m}^{-2} \text{ day}^{-1}$)

The data presented in the Table 38a showed that crop growth rate was significant in both studied factors. Among the different row ratio, treatment C₄ ($15.73 \text{ g m}^{-2} \text{ day}^{-1}$) followed by C₅ ($14.87 \text{ g m}^{-2} \text{ day}^{-1}$) and C₉ ($14.58 \text{ g m}^{-2} \text{ day}^{-1}$) recorded the highest crop growth rate at 20-40 DAS, where the lowest crop growth rate was recorded at C₁ ($12.55 \text{ g m}^{-2} \text{ day}^{-1}$) and then followed by C₈ ($12.74 \text{ g m}^{-2} \text{ day}^{-1}$). At 40-60 DAS, the higher and comparable crop growth rate of fodder maize was registered at treatments C₄ ($38.19 \text{ g m}^{-2} \text{ day}^{-1}$) and C₅ ($37.57 \text{ g m}^{-2} \text{ day}^{-1}$). The lowest crop growth rate was observed at C₉ ($34.74 \text{ g m}^{-2} \text{ day}^{-1}$) followed by C₆ ($35.05 \text{ g m}^{-2} \text{ day}^{-1}$), C₇ ($35.56 \text{ g m}^{-2} \text{ day}^{-1}$), C₁ ($35.93 \text{ g m}^{-2} \text{ day}^{-1}$) and C₈ ($35.98 \text{ g m}^{-2} \text{ day}^{-1}$) respectively. Pandey *et al.* (2019) also reported the higher crop growth rate at 1:1 row ratio and the lower crop growth rate at sole crop.

With respect to nutrient management practices, crop growth rate of fodder maize was significantly influenced by application of nutrients (Table 38a). At 20-40 DAS, the treatments F₂ ($17.69 \text{ g m}^{-2} \text{ day}^{-1}$) and F₁ ($13.68 \text{ g m}^{-2} \text{ day}^{-1}$) recorded significantly higher crop growth rate of fodder maize in compared to F₀ ($10.49 \text{ g m}^{-2} \text{ day}^{-1}$). The crop growth rate of fodder maize was found increase with increase in nutrient levels. The observation at 40-60 DAS, the highest crop growth rate of fodder maize was registered at F₂ ($42.55 \text{ g m}^{-2} \text{ day}^{-1}$) as compared to other treatments F₁ ($34.66 \text{ g m}^{-2} \text{ day}^{-1}$) and F₀ ($31.23 \text{ g m}^{-2} \text{ day}^{-1}$) respectively. Nisar *et al.* (2024) also registered that application of $180 \text{ kg ha}^{-1} \text{ N}$ produced the highest crop growth rate of maize. Similarly, application of NPK @ $100\text{-}75\text{-}40 \text{ kg ha}^{-1}$ recorded the highest crop growth rate of maize as compared to control (Kumar *et al.*, 2024). Likewise, Bahuguna *et al.* (2020) also reported the highest crop growth rate of maize was obtained under application of NPK @ $180\text{-}60\text{-}40 \text{ kg ha}^{-1}$. Panwar *et al.* (2020) evaluated the effect of different level of N and P on performance of maize. The result revealed that application of $150\text{-}60 \text{ kg ha}^{-1}$ registered higher crop growth rate of maize.

The interaction result (Table 38b) revealed that both studied factors had a wide variation in crop growth rate of fodder maize. Among all the treatment combinations, the treatment C₄F₂ (20.02 g m⁻² day⁻¹) recorded the highest crop growth rate of fodder maize and then on followed by C₅F₂ (19.48 g m⁻² day⁻¹), C₈F₂ (18.71 g m⁻² day⁻¹), C₆F₂ (18.10 g m⁻² day⁻¹) and C₄F₂ (55.84 g m⁻² day⁻¹) respectively. Likewise, the lowest crop growth rate of fodder maize was recorded at C₇F₀ (9.79 g m⁻² day⁻¹) and followed by C₁F₀ (9.82 g m⁻² day⁻¹), C₈F₀ (10.04 g m⁻² day⁻¹) and C₉F₀ (10.83 m⁻² day⁻¹) at 20-40 DAS. However, the observation at 40-60 DAS, the highest crop growth rate of fodder maize was observed at treatments C₄F₂ (47.50 g m⁻² day⁻¹) and C₅F₂ (46.37 g m⁻² day⁻¹). Similarly, the lower and comparable crop growth rate of fodder maize was registered at C₆F₀ (30.58) and C₈F₀ (30.94) respectively. This finding was in confirmatory with finding of higher crop growth rate of maize under 1:1 row ratio which received NPK @ 150-100-100 kg ha⁻¹ (Iqbal *et al.*, 2006). Sairam *et al.* (2024) studied the impact of different levels of NKP on vegetative growth of maize. The higher crop growth rate of maize at 20-40 DAS, 40-60 DAS and 60-80 DAS was registered at T₃ (150-75-75).

Regarding the fodder cowpea and fodder rice bean, the crop growth rate found to be significant with both factors (Table 39a). Among all the treatments, the higher crop growth rate of fodder cowpea was recorded at C₂ at 20-40 DAS (13.89 g m⁻² day⁻¹) and 40-60 DAS (29.68 g m⁻² day⁻¹). Likewise, the lowest crop growth rate was registered at C₈ (8.96 m⁻² day⁻¹) and C₈ (21.96 m⁻² day⁻¹) at 20-40 DAS and 40-60 DAS respectively. Incase of fodder rice bean (Table 40a), the treatment C₃ significantly maintained the highest crop growth rate of fodder rice bean at 20-40 DAS (2.41 g m⁻² day⁻¹) and 40-60 DAS (6.59 g m⁻² day⁻¹). Subsequently, the lowest crop growth rate fodder rice bean at 20-40 DAS was observed at C₉ (1.96 g m⁻² day⁻¹), while C₅ (3.76 g m⁻² day⁻¹) and C₇ (3.79 m⁻² day⁻¹) registered the lowest crop growth rate at 40-60 DAS respectively.

The crop growth rate of fodder cowpea and rice bean was significantly influenced by nutrient management approaches. With respect to fodder cowpea, the crop growth rate was significantly influence by nutrient applications (Table 39a). The highest crop growth rate of fodder cowpea at 20-40 DAS and 40-60 DAS was recorded

at treatment F₂ (16.47 g m⁻² day⁻¹) and (37.21 g m⁻² day⁻¹) and while the lowest crop growth rate among the treatments was observed at F₀ (6.37 g m⁻² day⁻¹, 13.62 g m⁻² day⁻¹). Similarly, the crop growth rate of fodder rice bean was increase with increase in nutrient levels (Table 40a). The highest crop growth rate of fodder rice bean was registered at F₂ (3.12 g m⁻² day⁻¹ and 7.51 g m⁻² day⁻¹) at 20-40 DAS and 40-60 DAS as compared to F₁ (2.10 g m⁻² day⁻¹ and 4.65 g m⁻² day⁻¹) and F₀ (1.28 g m⁻² day⁻¹ and 2.47 g m⁻² day⁻¹) respectively.

The interaction result (Table 39b & 40b) of fodder legume showed that both factors caused a wide variation in crop growth rate. Within the treatment combinations, the crop growth rate of different row ratio along with nutrient management was significantly improved. The highest crop growth rate of fodder cowpea at 20-40 DAS was significantly registered at C₂F₂ (20.24 g m⁻² day⁻¹) followed by C₄F₂ (17.81 g m⁻² day⁻¹), while the lowest crop growth rate of fodder cowpea was recorded at C₈F₀ (4.95 g m⁻² day⁻¹) followed by C₆F₀ (5.70 g m⁻² day⁻¹). The highest crop growth rate of fodder cowpea at 40-60 DAS was recorded at C₂F₂ (45.51 g m⁻² day⁻¹) and the lowest crop growth rate was recorded at C₈F₀ (11.59 g m⁻² day⁻¹). Correspondingly, for fodder rice bean C₃F₂ recorded the highest crop growth rate at 20-40 DAS (3.63 g m⁻² day⁻¹) and 40-60 DAS (9.91 g m⁻² day⁻¹) followed by C₇F₂ (3.03 g m⁻² day⁻¹) at 20-40 DAS and while C₉F₂ recorded the second highest at 40-60 DAS (8.19 g m⁻² day⁻¹). The lowest crop growth rate of fodder rice bean at 20-40 DAS was recorded in C₉F₀ (1.19 g m⁻² day⁻¹), while C₇F₀ (1.72 g m⁻² day⁻¹) and C₅F₀ (1.82 g m⁻² day⁻¹) observed at 40-60 DAS.

Table 38a. Effect of row ratio and nutrient management on crop growth rate of maize

Treatments	Crop growth rate (g m ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	12.08	13.02	12.55	33.77	38.10	35.93
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-
C ₄ - M + C (1:1)	14.72	16.74	15.73	36.72	39.65	38.19
C ₅ - M + R (1:1)	14.29	15.45	14.87	37.09	38.05	37.57
C ₆ - M + C (2:1)	13.59	13.97	13.78	32.35	37.74	35.05
C ₇ - M + R (2:1)	12.32	14.54	13.43	33.42	37.69	35.56
C ₈ - M + C (2:2)	12.13	13.35	12.74	33.93	38.03	35.98
C ₉ - M + R (2:2)	13.76	15.40	14.58	32.70	36.77	34.74
SEm±	0.10	0.10	0.07	0.31	0.39	0.25
CD (P=0.05)	0.27	0.28	0.19	0.87	1.09	0.69
2. Nutrient management						
F ₀ - Control	9.86	11.12	10.49	30.24	32.21	31.23
F ₁ - 50 % NPK	13.00	14.37	13.68	32.99	36.33	34.66
F ₂ - 100 % NPK	16.95	18.43	17.69	39.62	45.47	42.55
SEm±	0.05	0.06	0.04	0.18	0.22	0.14
CD (P=0.05)	0.16	0.16	0.11	0.50	0.63	0.40

Table 38b. Interaction effect of row ratio and nutrient management on crop growth rate of maize

Interaction (C X F)	Crop growth rate (g m ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	9.55	10.10	9.82	30.60	31.64	31.12
C ₁ F ₁	12.36	13.31	12.84	33.31	37.45	35.38
C ₁ F ₂	14.35	15.66	15.00	37.39	45.20	41.29
C ₂ F ₀	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-
C ₄ F ₀	10.86	12.67	11.77	29.54	33.13	31.34
C ₄ F ₁	13.94	16.86	15.40	35.56	35.92	35.74
C ₄ F ₂	19.35	20.69	20.02	45.08	49.91	47.50
C ₅ F ₀	11.28	11.04	11.16	28.69	33.42	31.05
C ₅ F ₁	13.88	14.07	13.97	32.52	38.06	35.29
C ₅ F ₂	17.71	21.26	19.48	50.05	42.68	46.37
C ₆ F ₀	9.56	10.51	10.03	30.52	30.64	30.58
C ₆ F ₁	13.41	13.02	13.22	32.27	35.66	33.96
C ₆ F ₂	17.81	18.39	18.10	34.25	46.93	40.59
C ₇ F ₀	8.64	10.94	9.79	31.41	33.60	32.50
C ₇ F ₁	11.89	14.56	13.22	32.05	36.72	34.39
C ₇ F ₂	16.42	18.14	17.28	36.81	42.74	39.78
C ₈ F ₀	9.14	10.94	10.04	30.73	31.16	30.94
C ₈ F ₁	12.20	13.69	12.94	33.06	33.89	33.47
C ₈ F ₂	15.04	15.41	15.23	38.01	49.05	43.53
C ₉ F ₀	9.98	11.68	10.83	30.18	31.92	31.05
C ₉ F ₁	13.33	15.05	14.19	32.17	36.59	34.38
C ₉ F ₂	17.97	19.46	18.71	35.77	41.80	38.78
SEm±	0.16	0.17	0.12	0.53	0.67	0.43
CD (P=0.05)	0.47	0.49	0.33	1.51	1.89	1.20

Table 39a. Effect of row ratio and nutrient management on crop growth rate of cowpea

Treatments	Crop growth rate (g m ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	11.20	16.57	13.89	31.12	28.24	29.68
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-
C ₄ - M + C (1:1)	11.98	12.76	12.37	22.95	23.92	23.44
C ₅ - M + R (1:1)	-	-	-	-	-	-
C ₆ - M + C (2:1)	9.77	10.26	10.01	22.53	26.70	24.62
C ₇ - M + R (2:1)	-	-	-	-	-	-
C ₈ - M + C (2:2)	8.71	9.21	8.96	20.29	23.63	21.96
C ₉ - M + R (2:2)	-	-	-	-	-	-
SEm±	0.06	0.08	0.05	0.29	0.30	0.21
CD (P=0.05)	0.17	0.24	0.15	0.81	0.87	0.59
2. Nutrient management						
F ₀ - Control	5.86	6.87	6.37	13.20	14.04	13.62
F ₁ - 50 % NPK	10.02	12.16	11.09	23.08	24.82	23.95
F ₂ - 100 % NPK	15.36	17.57	16.47	36.40	38.02	37.21
SEm±	0.04	0.05	0.03	0.17	0.18	0.12
CD (P=0.05)	0.10	0.14	0.08	0.47	0.50	0.34

Table 39b. Interaction effect of row ratio and nutrient management on crop growth rate of cowpea

Interaction (C X F)	Crop growth rate (g m ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-
C ₂ F ₀	6.41	9.09	7.75	16.91	14.75	15.83
C ₂ F ₁	10.87	16.46	13.67	28.78	26.61	27.69
C ₂ F ₂	16.32	24.17	20.24	47.67	43.36	45.51
C ₃ F ₀	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-
C ₄ F ₀	6.62	7.51	7.07	13.28	14.37	13.83
C ₄ F ₁	11.71	12.76	12.23	22.15	23.00	22.58
C ₄ F ₂	17.61	18.01	17.81	33.42	34.38	33.90
C ₅ F ₀	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-
C ₆ F ₀	5.49	5.90	5.70	12.22	14.21	13.22
C ₆ F ₁	8.91	10.78	9.84	22.72	25.34	24.03
C ₆ F ₂	14.91	14.10	14.50	32.66	40.56	36.61
C ₇ F ₀	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-
C ₈ F ₀	4.94	4.96	4.95	10.37	12.82	11.59
C ₈ F ₁	8.60	8.65	8.62	18.66	24.32	21.49
C ₈ F ₂	12.61	14.01	13.31	31.85	33.75	32.80
C ₉ F ₀	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-
SEm±	0.11	0.15	0.09	0.50	0.53	0.36
CD (P=0.05)	0.30	0.42	0.25	1.41	1.50	1.02

Table 40a. Effect of row ratio and nutrient management on crop growth rate of rice bean

Treatments	Crop growth rate (g m ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	1.90	2.91	2.41	6.98	6.20	6.59
C ₄ - M + C (1:1)	-	-	-	-	-	-
C ₅ - M + R (1:1)	1.83	2.41	2.12	3.90	3.61	3.76
C ₆ - M + C (2:1)	-	-	-	-	-	-
C ₇ - M + R (2:1)	1.88	2.48	2.18	3.83	3.75	3.79
C ₈ - M + C (2:2)	-	-	-	-	-	-
C ₉ - M + R (2:2)	1.43	2.49	1.96	5.47	5.28	5.38
SEm±	0.01	0.02	0.01	0.03	0.03	0.02
CD (P=0.05)	0.04	0.06	0.04	0.09	0.08	0.06
2. Nutrient management						
F ₀ - Control	1.00	1.55	1.28	2.60	2.34	2.47
F ₁ - 50 % NPK	1.68	2.53	2.10	4.89	4.42	4.65
F ₂ - 100 % NPK	2.59	3.65	3.12	7.64	7.38	7.51
SEm±	0.01	0.01	0.01	0.02	0.02	0.01
CD (P=0.05)	0.02	0.03	0.02	0.05	0.05	0.04

Table 40b. Interaction effect of row ratio and nutrient management on crop growth rate of rice bean

Interaction (C X F)	Crop growth rate (g m ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-
C ₃ F ₀	0.85	1.64	1.25	3.86	3.07	3.47
C ₃ F ₁	1.91	2.78	2.34	6.87	5.94	6.40
C ₃ F ₂	2.95	4.32	3.63	10.22	9.59	9.91
C ₄ F ₀	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-
C ₅ F ₀	1.22	1.52	1.37	1.83	1.80	1.82
C ₅ F ₁	1.76	2.40	2.08	3.79	3.34	3.56
C ₅ F ₂	2.49	3.30	2.90	6.09	5.71	5.90
C ₆ F ₀	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-
C ₇ F ₀	1.16	1.42	1.29	1.81	1.63	1.72
C ₇ F ₁	1.87	2.56	2.22	3.72	3.48	3.60
C ₇ F ₂	2.60	3.47	3.03	5.96	6.13	6.05
C ₈ F ₀	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-
C ₉ F ₀	0.78	1.61	1.19	2.92	2.85	2.88
C ₉ F ₁	1.17	2.37	1.77	5.19	4.91	5.05
C ₉ F ₂	2.33	3.50	2.92	8.29	8.09	8.19
SEm±	0.02	0.04	0.02	0.06	0.05	0.04
CD (P=0.05)	0.07	0.10	0.06	0.16	0.14	0.11

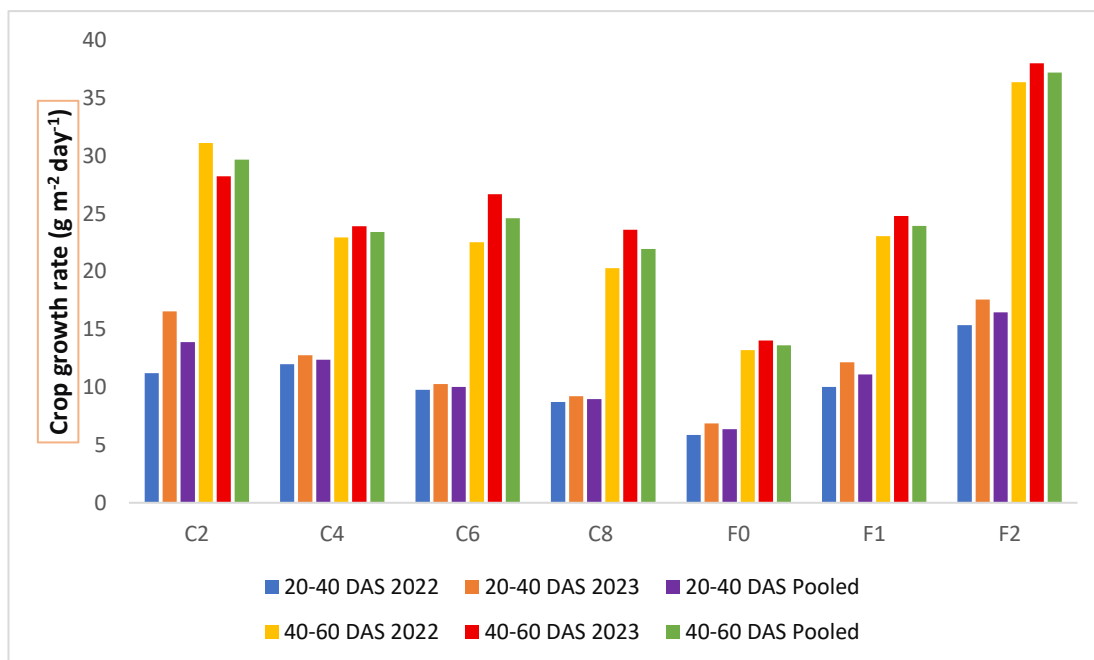


Fig.16. Effect of row ratio and nutrient management on crop growth rate of maize

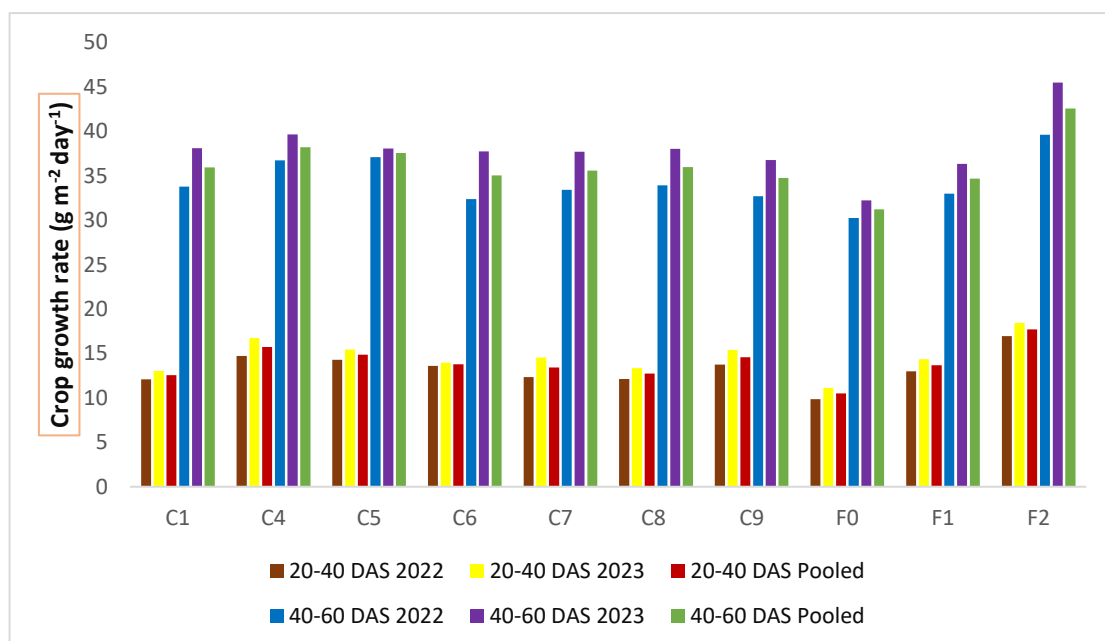


Fig.17. Effect of row ratio and nutrient management on crop growth rate of cowpea

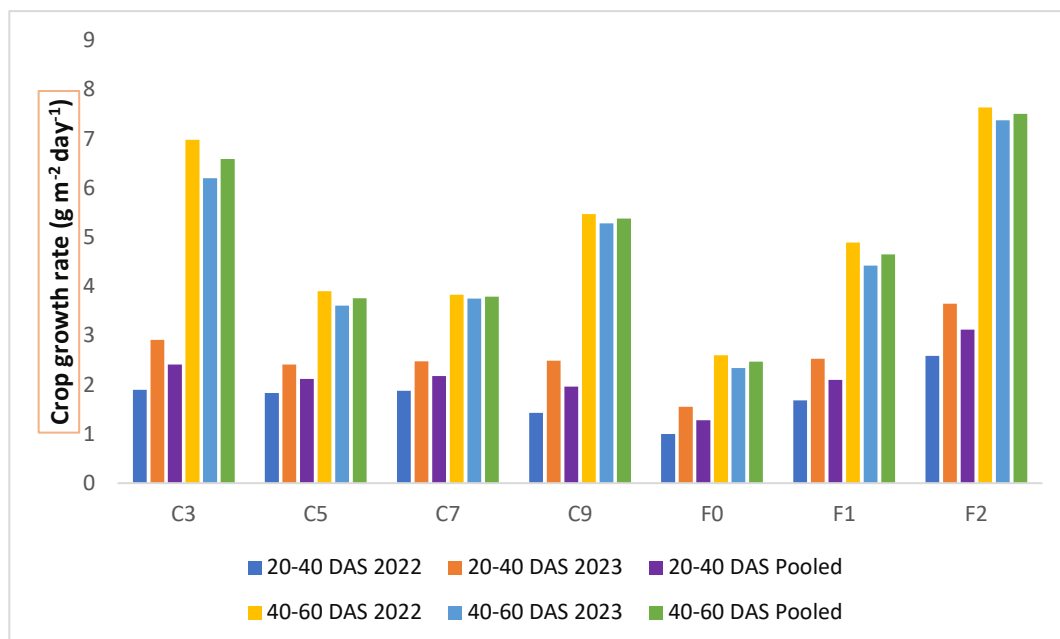


Fig.18. Effect of row ratio and nutrient management on crop growth rate of rice bean

4.4.2 Leaf area Index

The leaf area of fodder maize was significantly influenced by both different row ratio and nutrient management practices (Table 41a). Among the different row ratio, the highest leaf area index of fodder maize was registered at C₄ and C₅ DAS at 20 DAS (0.74, 0.73) and 40 DAS (1.45, 1.41). While the lower and comparable leaf area index were recorded from treatment C₇ (0.68), C₆ (0.69) at 20 DAS and C₁ (1.22) followed by C₆ (1.26) and C₇ (1.27) at 40 DAS respectively. Similarly, the highest leaf area index of fodder maize was observed at 1:1 row ratio as compared to 2:2 (Kumar, 2021). Gaikwad *et al.* (2022) also observed the highest leaf area index of maize under 1:1 followed by 2:1 and sole crop. However, Pandey *et al.* (2017) observed the highest leaf area index of maize at 2:2 row ratio. Nadeem *et al.* (2009) also reported the higher observation of 1:1 row ratio produced more leaf area index of maize as compared to sole crop.

Regarding the nutrient management approaches, the data presented in the Table 41a showed that application of nutrients at different levels lead to improve in leaf area index of fodder maize. The highest leaf area index at 20 DAS (0.84) and 40 DAS (1.61) was registered at F₂ (100 % RDF) as compared to treatments F₁ (0.73, 1.30) and F₀ (0.57, 1.09) respectively. Bahuguna *et al.* (2020) also reported the highest leaf area index of maize under the application of NPK @ 180:60:40 kg ha⁻¹. Similarly, applications of NPK @ 150-75-75 kg ha⁻¹ maintained the highest leaf area index of maize (Sairam *et al.*, 2024). Kumar (2024) also reported that applications of nutrient @ 150-75-40 kg ha⁻¹ registered the highest leaf area index of maize. Panwar *et al.* (2020) also recorded the highest leaf area of maize at 150:60 kg ha⁻¹ and likewise, Nisar *et al.* (2024) also reported that application of nitrogen at 180 kg ha⁻¹ produced the highest leaf area index of maize.

The interaction result (Table 41b) indicated that both factors had caused a variation in leaf area index of fodder maize. Among all the treatment combinations, the treatment C₄F₂ (0.88) recorded the highest leaf area index of fodder maize followed by treatments C₅F₂ (0.84), C₈F₂ (0.84) and which was on par with C₁F₂ (0.83), C₆F₂ (0.83) and C₉F₂ (0.83), while the lowest was observed at C₁F₀ (0.53) and C₆F₀ (0.54) at 20

DAS. Subsequently, the highest and lowest leaf area index of fodder maize at 40 DAS was registered at C₄F₂ (1.75), C₅F₂ (1.73) and C₁F₀ (0.99), C₆F₀ (1.00), C₇F₀ (1.08) respectively. Beremjungla (2015) also reported that sole crop receiving 100 % nutrients produced the highest leaf area index of maize. Application of NPK @ 120-60-40 kg ha⁻¹ recorded the highest leaf area index of maize as compared to control. Intercropping of maize with cowpea along with application of NPK @ 150-100-100 kg ha⁻¹ recorded the highest mixed leaf area index (Iqbal, 2006).

It is evident that different row ratio and nutrient management tactics had a significant effect in leaf area index fodder cowpea and fodder rice bean (Table 42a and 43a). The higher and comparable leaf area index of fodder cowpea at 20 DAS (0.2581) and 40 DAS (4.3836) was recorded at C₂, which was followed by C₈ (0.2455) at 20 DAS and C₄ (3.0904) at 40 DAS. The lowest leaf area of fodder cowpea was register at C₆ (0.2070) at 20 DAS and C₈ (2.4035) at 40 DAS respectively. Incase of fodder rice bean, the highest leaf area index was observed in C₃ at 20 DAS (0.2751) and 40 DAS (1.9585). Likewise, the lowest leaf area index at 20 DAS and 40 DAS was seen from C₇ (0.2100 and 1.5292) as compared to all other treatments. Gaidwak *et al.* (2022) also observed the highest leaf area index of cowpea at sole crop followed by 1:1 row ratio.

It is evident from the result (Table 42a and 43a) that leaf area index of fodder cowpea and fodder rice bean was significantly influenced by nutrient management practices. Among all the treatments, for both fodder cowpea and fodder rice bean, significantly the highest leaf area index was recorded when nutrients were applied at 100 % RDF in both in stages of the observation *i.e.*, 20 DAS (0.3639 and 0.3441) and 40 DAS (5.1885 and 2.7215) as compared to treatments F₁ and F₀. Likewise, the lowest leaf area index of fodder cowpea and fodder rice bean were registered at F₀ in both 20 DAS (0.1218 and 0.1261) and 40 DAS (1.5673 and 0.9579) respectively.

The interaction data showed that combinations of both different row ratio and nutrient management practices caused a significant impact on leaf area index of fodder cowpea (Table 42b) and fodder rice bean (Table 43b). In all the treatment combinations, it was observed that application of nutrient at different levels caused variation in leaf area index of the fodder legume. The highest leaf area index of fodder

cowpea at 20 DAS was obtained at C₂F₂ (0.4101) and then at C₈F₂ (0.3787). At 40 DAS, the higher and comparable leaf area index of fodder cowpea was registered from the treatments C₂F₂ (6.7884) and C₆F₂ (5.3092). The lowest leaf area index was obtained at 20 DAS was observed in C₂F₀ (0.1167) and C₄F₀ (0.1185), while C₆F₀ (0.9321) and C₈F₀ (1.1349) registered the lowest leaf area index at 40 DAS. Similarly, in all the treatment combinations, which does not receive nutrient applications recorded the similar trend of the lowest leaf area index at both 20 DAS and 40 DAS. With regards to fodder rice bean, the highest leaf area index at 20 DAS was registered from treatment C₃F₂ (0.3906) and C₅F₀ (0.3520), while lowest leaf area index was observed at C₇F₀ (0.1135), C₅F₀ (0.1191) and C₉F₀ (0.1197). Subsequently, the highest leaf area index at 40 DAS was observed at C₉F₂ (3.0946) which was followed by treatment C₃F₂ (2.9980). Likewise, the lowest and comparable leaf area index of fodder rice bean was obtained at treatment C₇F₀ (0.8391), C₉F₀ (0.9569) and C₅F₀ (0.9710) which did not receive nutrients (control).

Table 41a. Effect of row ratio and nutrient management on leaf area index of maize

Treatments	Leaf area index					
	20 DAS			40 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	0.642	0.756	0.699	1.023	1.427	1.225
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-
C ₄ - M + C (1:1)	0.698	0.787	0.742	1.394	1.514	1.454
C ₅ - M + R (1:1)	0.678	0.774	0.726	1.317	1.494	1.405
C ₆ - M + C (2:1)	0.670	0.714	0.692	1.062	1.463	1.262
C ₇ - M + R (2:1)	0.625	0.743	0.684	1.095	1.436	1.265
C ₈ - M + C (2:2)	0.671	0.753	0.712	1.272	1.444	1.358
C ₉ - M + R (2:2)	0.669	0.761	0.715	1.208	1.470	1.339
SEm±	0.006	0.006	0.004	0.007	0.008	0.005
CD (P=0.05)	0.018	0.017	0.012	0.020	0.023	0.015
2. Nutrient management						
F ₀ - Control	0.531	0.601	0.566	0.989	1.186	1.088
F ₁ - 50 % NPK	0.668	0.788	0.728	1.157	1.437	1.297
F ₂ - 100 % NPK	0.795	0.877	0.836	1.441	1.769	1.605
SEm±	0.004	0.004	0.003	0.004	0.005	0.003
CD (P=0.05)	0.011	0.010	0.007	0.011	0.013	0.009

Table 41b. Interaction effect of row ratio and nutrient management on leaf area index of maize

Interaction (C X F)	Leaf area index					
	20 DAS			40 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	0.514	0.552	0.533	0.889	1.082	0.986
C ₁ F ₁	0.663	0.801	0.732	0.894	1.403	1.149
C ₁ F ₂	0.749	0.915	0.832	1.286	1.794	1.540
C ₂ F ₀	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-
C ₄ F ₀	0.570	0.603	0.587	1.120	1.220	1.170
C ₄ F ₁	0.706	0.815	0.760	1.369	1.522	1.446
C ₄ F ₂	0.818	0.942	0.880	1.692	1.800	1.746
C ₅ F ₀	0.571	0.613	0.592	1.041	1.180	1.110
C ₅ F ₁	0.681	0.802	0.742	1.254	1.500	1.377
C ₅ F ₂	0.782	0.908	0.845	1.656	1.802	1.729
C ₆ F ₀	0.509	0.575	0.542	0.841	1.167	1.004
C ₆ F ₁	0.662	0.747	0.704	1.071	1.421	1.246
C ₆ F ₂	0.839	0.820	0.830	1.272	1.801	1.537
C ₇ F ₀	0.491	0.607	0.549	0.955	1.205	1.080
C ₇ F ₁	0.622	0.782	0.702	1.038	1.405	1.221
C ₇ F ₂	0.760	0.839	0.800	1.291	1.697	1.494
C ₈ F ₀	0.537	0.622	0.579	1.105	1.224	1.164
C ₈ F ₁	0.657	0.775	0.716	1.240	1.369	1.305
C ₈ F ₂	0.821	0.863	0.842	1.472	1.739	1.606
C ₉ F ₀	0.525	0.638	0.581	0.975	1.224	1.099
C ₉ F ₁	0.685	0.791	0.738	1.232	1.439	1.336
C ₉ F ₂	0.797	0.853	0.825	1.418	1.748	1.583
SEm±	0.011	0.011	0.008	0.012	0.014	0.009
CD (P=0.05)	0.032	0.030	0.022	0.034	0.040	0.026

Table 42a. Effect of row ratio and nutrient management on leaf area index of cowpea

Treatments	Leaf area index					
	20 DAS			40 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	0.2417	0.2745	0.2581	2.6049	6.1622	4.3836
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-
C ₄ - M + C (1:1)	0.2177	0.2570	0.2374	2.5435	3.6373	3.0904
C ₅ - M + R (1:1)	-	-	-	-	-	-
C ₆ - M + C (2:1)	0.1671	0.2469	0.2070	2.6146	3.2599	2.9373
C ₇ - M + R (2:1)	-	-	-	-	-	-
C ₈ - M + C (2:2)	0.1493	0.3416	0.2455	2.0740	2.7330	2.4035
C ₉ - M + R (2:2)	-	-	-	-	-	-
SEm±	0.0042	0.0024	0.0024	0.0277	0.0305	0.0206
CD (P=0.05)	0.0119	0.0067	0.0068	0.0785	0.0867	0.0578
2. Nutrient management						
F ₀ - Control	0.0856	0.1580	0.1218	1.0430	1.5673	1.3052
F ₁ - 50 % NPK	0.1892	0.2612	0.2252	2.3459	3.8888	3.1174
F ₂ - 100 % NPK	0.3071	0.4208	0.3639	3.9889	6.3882	5.1885
SEm±	0.0024	0.0014	0.0014	0.0160	0.0176	0.0119
CD (P=0.05)	0.0069	0.0039	0.0039	0.0453	0.0500	0.0334

Table 42b. Interaction effect of row ratio and nutrient management on leaf area index of cowpea

Interaction (C X F)	Leaf area index					
	20 DAS			40 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-
C ₂ F ₀	0.0927	0.1408	0.1167	1.0686	2.7384	1.9035
C ₂ F ₁	0.2403	0.2545	0.2474	2.6521	6.2656	4.4589
C ₂ F ₂	0.3920	0.4282	0.4101	4.0940	9.4827	6.7884
C ₃ F ₀	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-
C ₄ F ₀	0.0857	0.1513	0.1185	1.1697	1.3308	1.2502
C ₄ F ₁	0.2052	0.2631	0.2341	2.5748	3.4663	3.0206
C ₄ F ₂	0.3623	0.3567	0.3595	3.8860	6.1149	5.0004
C ₅ F ₀	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-
C ₆ F ₀	0.0865	0.1551	0.1208	0.9194	0.9448	0.9321
C ₆ F ₁	0.1519	0.2339	0.1929	2.1979	2.9430	2.5705
C ₆ F ₂	0.2630	0.3518	0.3074	4.7266	5.8918	5.3092
C ₇ F ₀	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-
C ₈ F ₀	0.0776	0.1850	0.1313	1.0144	1.2553	1.1349
C ₈ F ₁	0.1594	0.2935	0.2265	1.9586	2.8803	2.4195
C ₈ F ₂	0.2110	0.5464	0.3787	3.2490	4.0634	3.6562
C ₉ F ₀	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-
SEm±	0.0073	0.0041	0.0042	0.0479	0.0529	0.0357
CD (P=0.05)	0.0207	0.0117	0.0117	0.1360	0.1501	0.1001

Table 43a. Effect of row ratio and nutrient management on leaf area index of rice bean

Treatments	Leaf area index					
	20 DAS			40 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	0.1866	0.3636	0.2751	1.2280	2.6891	1.9585
C ₄ - M + C (1:1)	-	-	-	-	-	-
C ₅ - M + R (1:1)	0.1933	0.2648	0.2290	1.2046	2.1488	1.6767
C ₆ - M + C (2:1)	-	-	-	-	-	-
C ₇ - M + R (2:1)	0.2133	0.2066	0.2100	1.1018	1.9566	1.5292
C ₈ - M + C (2:2)	-	-	-	-	-	-
C ₉ - M + R (2:2)	0.1529	0.2721	0.2125	1.1403	2.7135	1.9269
SEm±	0.0021	0.0021	0.0015	0.0116	0.0164	0.0101
CD (P=0.05)	0.0059	0.0059	0.0041	0.0330	0.0466	0.0282
2. Nutrient management						
F ₀ - Control	0.1046	0.1476	0.1261	0.7034	1.2124	0.9579
F ₁ - 50 % NPK	0.1784	0.2711	0.2247	1.0789	2.1992	1.6391
F ₂ - 100 % NPK	0.2766	0.4116	0.3441	1.7237	3.7194	2.7215
SEm±	0.0012	0.0012	0.0008	0.0067	0.0095	0.0058
CD (P=0.05)	0.0034	0.0034	0.0024	0.0190	0.0269	0.0163

Table 43b. Interaction effect of row ratio and nutrient management on leaf area index of rice bean

Interaction (C X F)	Leaf area index					
	20 DAS			40 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-
C ₃ F ₀	0.1045	0.1999	0.1522	0.8182	1.3109	1.0646
C ₃ F ₁	0.1879	0.3770	0.2825	1.1889	2.4372	1.8130
C ₃ F ₂	0.2674	0.5139	0.3906	1.6768	4.3192	2.9980
C ₄ F ₀	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-
C ₅ F ₀	0.1012	0.1371	0.1191	0.7088	1.2333	0.9710
C ₅ F ₁	0.1831	0.2489	0.2160	1.0394	2.0224	1.5309
C ₅ F ₂	0.2957	0.4084	0.3520	1.8657	3.1909	2.5283
C ₆ F ₀	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-
C ₇ F ₀	0.1190	0.1081	0.1135	0.6621	1.0161	0.8391
C ₇ F ₁	0.1972	0.1867	0.1919	1.1000	1.8666	1.4833
C ₇ F ₂	0.3237	0.3251	0.3244	1.5434	2.9871	2.2652
C ₈ F ₀	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-
C ₉ F ₀	0.0939	0.1454	0.1197	0.6243	1.2895	0.9569
C ₉ F ₁	0.1453	0.2717	0.2085	0.9875	2.4706	1.7291
C ₉ F ₂	0.2195	0.3991	0.3093	1.8090	4.3803	3.0946
SEm±	0.0036	0.0036	0.0025	0.0201	0.0284	0.0174
CD (P=0.05)	0.0103	0.0102	0.0071	0.0571	0.0807	0.0489

4.4.3 Land equivalent ratio

The data presented in Table 44a provides the influence of different row ratio and nutrient management on land equivalent ratio of fodder maize, fodder cowpea and fodder rice bean. Regarding the different row ratio, the highest land equivalent ratio of the system was recorded at 2:2 followed by 2:1 row ratio. The higher and comparable land equivalent ratio of the system was observed from C₈ (1.263), C₇ (1.231), C₉ (1.219) and C₆ (1.218). The lowest land equivalent ratio of the system was obtained from treatments C₄ (1.70) and C₅ (1.174). The land equivalent ratio of the individual crop was found to be vary from each treatment. The highest land equivalent ratio of fodder maize was recorded at C₇ (0.859) and then followed by C₆ (0.847), while the lowest land equivalent ratio was observed at C₅ (0.661) and C₉ (0.663). In relation to fodder cowpea and fodder rice bean, the highest land equivalent ratio among all the treatments was registered at C₈ (0.582) and C₉ (0.556), while the lowest land equivalent ratio was obtained at treatments C₆ (0.372) and C₇ (0.372) respectively. This finding was in collateral with Arif (2024). They observed the highest land equivalent ratio at 2:1 followed by 2:2 and 1:1 row ratio. Similarly, Telkar *et al.* (2018) also observed the highest land equivalent ratio of the system at 2:2 row ratio. The higher leaf equivalent ratio of the system was observed at 2:1 and 2:2 row ratio than sole crop (Dudge *et al.*, 2022). Sharma *et al.* (2008) reported the higher land equivalent ratio of maize with cowpea and maize with rice bean intercropping was observed at 2:2 followed by 1:2 and 1:1 row ratio as compared to sole crop.

With respect to nutrient management approaches, the land equivalent ratio of the system and each crop were found to be significantly influenced by nutrient applications (Table 44a). The data presented in the table revealed that with increase in nutrient applications, the land equivalent ratio of the system and each crop was also found to be increase. Among all the treatments, the highest land equivalent ratio of the system (1.287) and for each crop *i.e.*, fodder maize (0.754), fodder cowpea (0.544) and fodder rice bean (0.522) were registered from F₂ (100 % RDF) and the treatment F₀ (control) recorded the lowest land equivalent ratio for the system and each crop (1.145, 0.710, 0.431 and 0.439) when compared to others treatments. Similarly, Beremjungla

(2015) also reported that application of nutrient at 100 % RDF recorded the higher land equivalent ratio of the system.

The interaction result (Table 44b) showed that both factors caused a variation in land equivalent ratio of fodder maize, fodder cowpea and fodder rice bean. Among all the treatment combinations, the highest land equivalent ratio of the system was registered at C₈F₂ (1.338) and which was followed by treatment C₉F₂ (1.312), while the lowest and comparable land equivalent ratio of the system was obtained at C₅F₀ (1.079) and C₄F₀ (1.092). Similarly, for each fodder crop, the higher and comparable land equivalent ratio was recorded at C₆F₂ (0.870), C₈F₂ (0.638) and C₉F₂ (0.607), where the lowest land equivalent ratio for fodder maize, fodder cowpea and fodder rice bean were seen at C₅F₀ (0.607), C₆F₀ (0.322) and then at C₇F₀ (0.335). respectively. Likewise, Amanullah *et al.* (2020) also registered the higher land equivalent ratio of the system under intercropping of maize with cowpea along application of 150 % RDF.

4.4.4 Land use efficiency (%)

The fodder maize was grown for fodder purposes, so the harvesting was done at 50 % silking stage. As the crop was harvested at silking stage the land use efficiency of the fodder maize was found to be 23.28 %.

Table 44a. Effect of row ratio and nutrient management on land equivalent ratio

Treatments	Land equivalent ratio											
	LER of the individual crop									LER of the system		
	Maize			Cowpea			Rice bean					
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	0.675	0.685	0.680	0.478	0.502	0.490	-	-	-	1.154	1.187	1.170
C ₅ - M + R (1:1)	0.660	0.662	0.661	-	-	-	0.506	0.520	0.513	1.166	1.182	1.174
C ₆ - M + C (2:1)	0.843	0.850	0.847	0.368	0.375	0.372	-	-	-	1.211	1.226	1.218
C ₇ - M + R (2:1)	0.853	0.864	0.859	-	-	-	0.358	0.387	0.372	1.212	1.251	1.231
C ₈ - M + C (2:2)	0.673	0.688	0.681	0.582	0.583	0.582	-	-	-	1.254	1.271	1.263
C ₉ - M + R (2:2)	0.653	0.673	0.663	-	-	-	0.543	0.569	0.556	1.196	1.241	1.219
SEm±	0.004	0.004	0.003	0.003	0.003	0.002	0.004	0.004	0.003	0.007	0.010	0.006
CD (P=0.05)	0.011	0.012	0.008	0.008	0.008	0.006	0.011	0.010	0.007	0.019	0.027	0.016
2. Nutrient management												
F ₀ - Control	0.705	0.715	0.710	0.439	0.423	0.431	0.431	0.448	0.439	1.140	1.151	1.145
F ₁ - 50 % NPK	0.723	0.739	0.731	0.474	0.466	0.470	0.466	0.494	0.480	1.193	1.219	1.206
F ₂ - 100 % NPK	0.751	0.757	0.754	0.515	0.572	0.544	0.511	0.533	0.522	1.264	1.310	1.287
SEm±	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.004	0.006	0.003
CD (P=0.05)	0.006	0.007	0.005	0.004	0.005	0.003	0.007	0.006	0.004	0.011	0.016	0.010

Table 44b. Interaction effect of row ratio and nutrient management on land equivalent ratio

Interaction (C X F)	LER of the individual crop									LER system		
	Maize			Cowpea			Rice bean					
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	0.658	0.675	0.666	0.435	0.416	0.426	-	-	-	1.092	1.092	1.092
C ₄ F ₁	0.683	0.686	0.684	0.485	0.456	0.471	-	-	-	1.168	1.142	1.155
C ₄ F ₂	0.685	0.695	0.690	0.515	0.633	0.574	-	-	-	1.200	1.328	1.264
C ₅ F ₀	0.606	0.609	0.607	-	-	-	0.464	0.479	0.472	1.070	1.088	1.079
C ₅ F ₁	0.673	0.682	0.677	-	-	-	0.505	0.519	0.512	1.178	1.201	1.189
C ₅ F ₂	0.700	0.697	0.698	-	-	-	0.549	0.562	0.556	1.249	1.259	1.254
C ₆ F ₀	0.833	0.846	0.839	0.323	0.322	0.322	-	-	-	1.156	1.167	1.162
C ₆ F ₁	0.829	0.833	0.831	0.366	0.383	0.375	-	-	-	1.195	1.216	1.206
C ₆ F ₂	0.867	0.872	0.870	0.416	0.421	0.418	-	-	-	1.283	1.293	1.288
C ₇ F ₀	0.854	0.865	0.860	-	-	-	0.319	0.350	0.335	1.173	1.215	1.194
C ₇ F ₁	0.850	0.861	0.856	-	-	-	0.358	0.400	0.379	1.208	1.261	1.235
C ₇ F ₂	0.856	0.867	0.861	-	-	-	0.398	0.410	0.404	1.253	1.277	1.265
C ₈ F ₀	0.667	0.660	0.664	0.560	0.529	0.545	-	-	-	1.227	1.190	1.208
C ₈ F ₁	0.660	0.698	0.679	0.570	0.558	0.564	-	-	-	1.230	1.255	1.243
C ₈ F ₂	0.691	0.707	0.699	0.615	0.662	0.638	-	-	-	1.306	1.370	1.338
C ₉ F ₀	0.611	0.638	0.624	-	-	-	0.508	0.515	0.512	1.119	1.153	1.136
C ₉ F ₁	0.644	0.676	0.660	-	-	-	0.534	0.563	0.548	1.178	1.239	1.209
C ₉ F ₂	0.705	0.705	0.705	-	-	-	0.586	0.627	0.607	1.291	1.332	1.312
SEm±	0.007	0.007	0.005	0.005	0.005	0.003	0.007	0.006	0.005	0.012	0.017	0.010
CD (P=0.05)	0.019	0.021	0.014	0.013	0.014	0.010	0.020	0.017	0.013	0.033	0.047	0.029

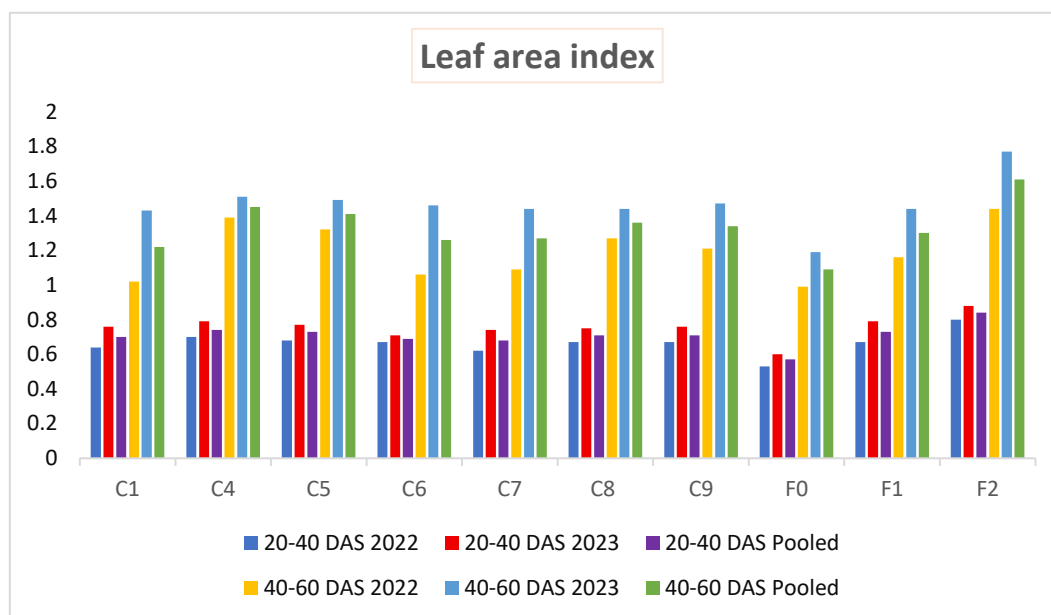


Fig.19. Effect of row ratio and nutrient management on leaf area index of maize

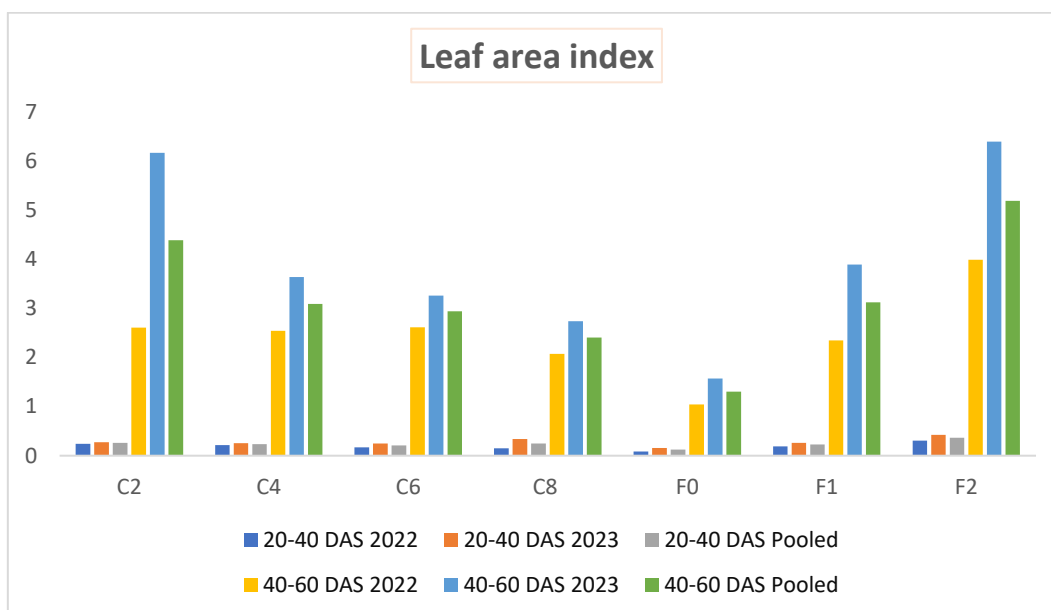


Fig.20. Effect of row ratio and nutrient management on leaf area index of cowpea

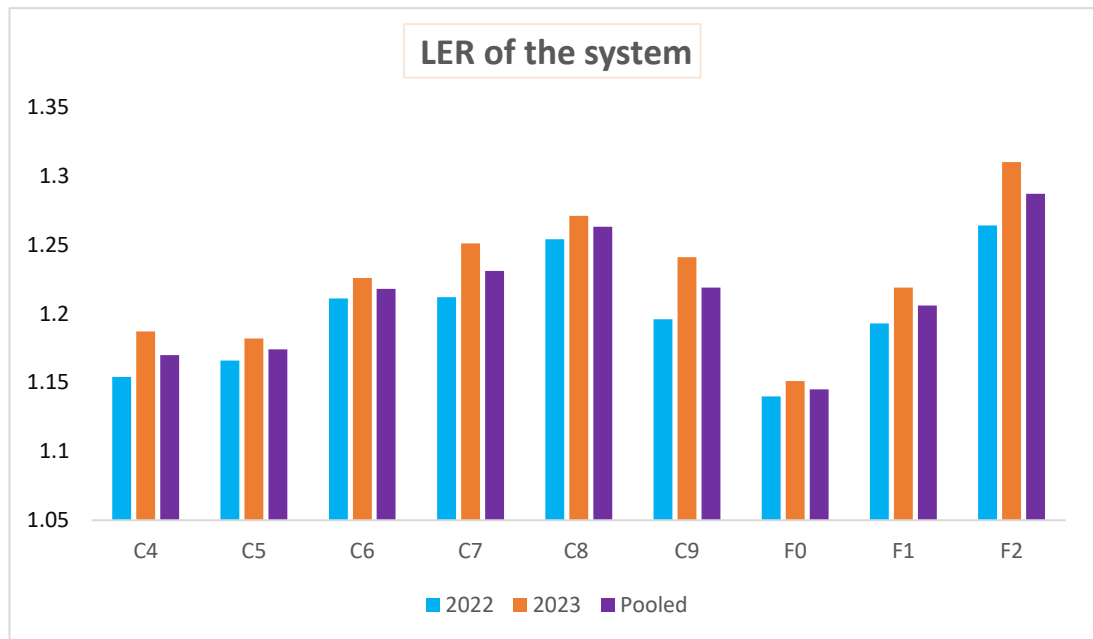


Fig.21. Effect of row ratio and nutrient management on leaf area index of rice bean

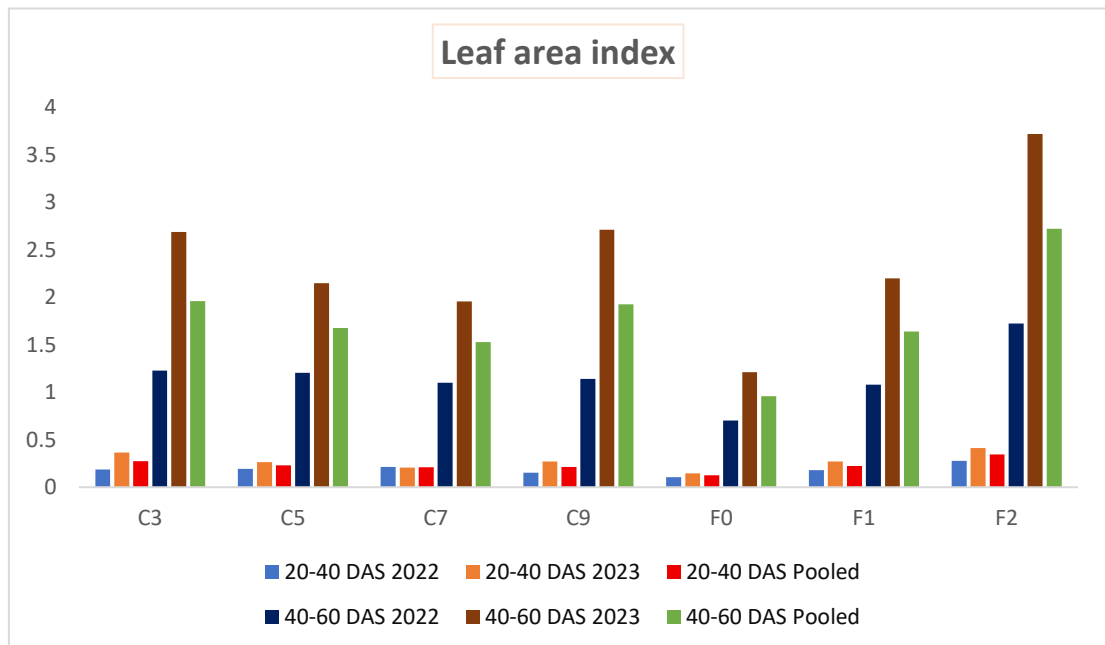


Fig.22. Effect of row ratio and nutrient management on land equivalent ratio of the system

4.4.5 Net assimilation rate ($\text{g cm}^{-2} \text{ day}^{-1}$)

The study revealed that different row ratio had significant effect on net assimilation ratio of fodder maize, the data presented in the Table 45a showed that treatment C₁ recorded the highest net assimilation rate ($0.00233 \text{ g cm}^{-2} \text{ day}^{-1}$) of fodder maize followed by C₇ ($0.00202 \text{ g cm}^{-2} \text{ day}^{-1}$), while C₄ ($0.00170 \text{ g cm}^{-2} \text{ day}^{-1}$) and C₅ ($0.00175 \text{ g cm}^{-2} \text{ day}^{-1}$) recorded the lowest net assimilation rate of fodder maize at 20-40 DAS. However, at 40-60 DAS, though net assimilation rate was found to be significant, the variation among the all treatments was not much different. The higher and comparable net assimilation rate of fodder maize was observed at treatments C₁ ($0.00336 \text{ g cm}^{-2} \text{ day}^{-1}$), C₆ ($0.00325 \text{ g cm}^{-2} \text{ day}^{-1}$), C₉ ($0.00308 \text{ g cm}^{-2} \text{ day}^{-1}$) and C₇ ($0.00307 \text{ g cm}^{-2} \text{ day}^{-1}$). Similarly, the lower net assimilation rate of fodder maize was recorded at C₄ ($0.00282 \text{ g cm}^{-2} \text{ day}^{-1}$) which was on par with treatment C₅ ($0.00285 \text{ g cm}^{-2} \text{ day}^{-1}$). Pandey *et al.* (2019) also reported the higher observation of net assimilation rate of maize under sole crop and 2:2 row ratio.

In regard to nutrient management practices, the net assimilation rate of fodder maize was found significantly increase with increase in nutrient applications (Table 45a). Among all the treatments, the highest net assimilation rate of fodder maize was found at F₂ in both 20-40 DAS ($0.00214 \text{ g cm}^{-2} \text{ day}^{-1}$) and 40-60 DAS ($0.00351 \text{ g cm}^{-2} \text{ day}^{-1}$), while the lowest were recorded at F₀ at 20-40 DAS ($0.00172 \text{ g cm}^{-2} \text{ day}^{-1}$) and 40-60 DAS ($0.00267 \text{ g cm}^{-2} \text{ day}^{-1}$) respectively. Sairam *et al.* (2024) observed the highest net assimilation rate of maize under the application of NPK @ 150:75:75 kg ha⁻¹. Dhamodharam *et al.* (2023) studied different levels of NPK at 0 %, 75 %, 100 % and 125 % RDF (60-40-20 kg ha⁻¹). From this research, net assimilation rate of maize was found increase with increase in nutrient applications. The highest net assimilation rate was registered under 125 % RDF followed by 100 % RDF. Similarly, Nisar *et al.* (2024) and Jassal *et al.* (2017) also claimed that net assimilation rate of maize was increase with increase in nitrogen levels (180 kg ha⁻¹ N, 150 kg ha⁻¹ N)

The interaction result (Table 45b) showed that combinations of both different row ratio and nutrient management practices caused a significant influence on net assimilation of fodder maize. Among all the treatment combinations, the higher and

comparable net assimilation rate of fodder maize at 20-40 DAS was registered at C₁F₂ (0.00264 g cm⁻² day⁻¹) followed by C₇F₂ (0.00231 g cm⁻² day⁻¹) and C₉ (0.00217 g cm⁻² day⁻¹). The lowest net assimilation rate was recorded at C₄F₀ (0.00156 g cm⁻² day⁻¹) which was in the same trends with treatment C₅F₀ (0.00157 g cm⁻² day⁻¹). The next observation at 40-60 DAS, treatment C₁F₂ (0.00388 g cm⁻² day⁻¹) registered the highest net assimilation rate which was followed by treatments C₉F₂ (0.00362 g cm⁻² day⁻¹) and C₇F₂ (0.00357 g cm⁻² day⁻¹). Likewise, the treatment C₅F₀ (0.00241 g cm⁻² day⁻¹) followed by C₄F₀ (0.00247 g cm⁻² day⁻¹) maintained the lowest net assimilation rate as compared to all other treatments.

The net assimilation rate of fodder cowpea and fodder rice bean was found to be significantly influenced by both factors (Table 46a & 47a). Regarding the different row ratio, the highest net assimilation rate of fodder cowpea was recorded at C₂ at both 20-40 DAS (0.01932 g cm⁻² day⁻¹) and 40-60 DAS (0.01849 g cm⁻² day⁻¹) followed by C₈ (0.01616 g cm⁻² day⁻¹) and C₆ (0.01616 g cm⁻² day⁻¹). The lowest net assimilation rate was registered at C₈ (0.01252 g cm⁻² day⁻¹) at 20-40 DAS and treatment C₄ (0.01123 g cm⁻² day⁻¹) maintained the lowest net assimilation rate at 40-60 DAS. The results (Table 47a) showed that net assimilation rate of fodder rice bean was significantly influenced when it was grown as intercrop with fodder maize at different row ratio. The higher net assimilation rate of fodder rice bean at 20-40 DAS was registered at C₇ (0.00318 g cm⁻² day⁻¹) and then followed by C₃ (0.00300 g cm⁻² day⁻¹) and C₅ (0.00288 g cm⁻² day⁻¹), while the lowest net assimilation rate among the all treatment was obtained at C₉ (0.0267 g cm⁻² day⁻¹). The net assimilation rate at 40-60 DAS was found to be highest at treatment C₃ (0.0405 g cm⁻² day⁻¹) and then at C₉ (0.00343 g cm⁻² day⁻¹). The lowest net assimilation rate was observed C₇ (0.00243 g cm⁻² day⁻¹) followed by C₅ (0.00251 g cm⁻² day⁻¹).

With respect to nutrient management approaches (Table 46a), the highest net assimilation rate of fodder cowpea was registered at F₂ (100 % RDF) in both 20-40 DAS (0.01702 g cm⁻² day⁻¹) and 40-60 DAS (0.01819 g cm⁻² day⁻¹) as compared to treatment F₁ (0.01603 g cm⁻² day⁻¹ and 0.01524 g cm⁻² day⁻¹) and F₀ (0.01509 g cm⁻² day⁻¹ and 0.01302 g cm⁻² day⁻¹) respectively. The net assimilation rate was found increase with increase in nutrient levels. It is evident (Table 47a) that net assimilation

rate of fodder rice bean was varied due to nutrient management approaches. Among all the treatments, the highest net assimilation rate of fodder rice bean was recorded at F₂ in both stages of the observation *i.e.*, 20-40 DAS (0.00330 g cm⁻² day⁻¹) and 40-60 DAS (0.00395 g cm⁻² day⁻¹). The lowest net assimilation rate was observed at 20-40 DAS (0.00254 g cm⁻² day⁻¹) and 40-60 DAS (0.00222 g cm⁻² day⁻¹) was registered from treatment F₀ (control). Similarly, Dhamodharam *et al.* (2023) studied the effect of different levels of NPK at 0 %, 75 %, 100 % and 125 % RDF (100 % RDF @ 60-40-20 kg ha⁻¹) on growth rate of cowpea. In this research it was found that net assimilation rate of maize was increase with increase in nutrient application. Application of NPK @ 125 % RDF followed by 100 % RDF recorded the highest net assimilation rate of cowpea.

The interaction result (Table 46b) showed that net assimilation rate was influenced with combinations of row ratio and nutrient management approaches. Among all the treatment combinations, C₂F₂ (0.02054 g cm⁻² day⁻¹) followed by C₂F₂ (0.01912 g cm⁻² day⁻¹) recorded the highest net assimilation rate, while treatment C₈F₀ (0.01202 g cm⁻² day⁻¹) recorded the lower net assimilation rate at 20-40 DAS. The observation at 40-60 DAS, the highest net assimilation rate of fodder cowpea was recorded at C₂F₂ (0.02200 g cm⁻² day⁻¹) followed by C₈F₂ (0.01909 g cm⁻² day⁻¹) and the treatment C₄F₀ (0.00901 g cm⁻² day⁻¹) registered the lowest net assimilation rate among all the treatments.

It was seen from the interaction result (Table 47b) that both different row ratio and nutrient management had a huge impact on net assimilation rate of fodder rice bean. At 20-40 DAS, the highest net assimilation rate of fodder rice bean was seen in treatment C₃F₂ (0.00361 g cm⁻² day⁻¹) followed by C₇F₂ (0.00348 g cm⁻² day⁻¹), while the lowest net assimilation rate was recorded at C₃F₀ (0.00233 g cm⁻² day⁻¹) and C₉F₀ (0.00237 g cm⁻² day⁻¹). And thereon, treatment C₃F₂ (0.00500 g cm⁻² day⁻¹) continuously maintained the highest net assimilation rate of fodder rice bean at 40-60 DAS, which was followed by treatment C₉F₂ (0.00424 g cm⁻² day⁻¹). The lowest net assimilation rate of fodder rice bean was obtained at C₇F₀ (0.00156 g cm⁻² day⁻¹) and followed by C₅F₀ (0.00167 g cm⁻² day⁻¹) as compared to other treatments.

Table 45a. Effect of row ratio and nutrient management on net assimilation rate of maize

Treatments	Net assimilation rate (g cm ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	0.00249	0.00216	0.00233	0.00351	0.00320	0.00336
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-
C ₄ - M + C (1:1)	0.00177	0.00164	0.00170	0.00280	0.00285	0.00282
C ₅ - M + R (1:1)	0.00166	0.00184	0.00175	0.00296	0.00275	0.00285
C ₆ - M + C (2:1)	0.00187	0.00171	0.00179	0.00339	0.00311	0.00325
C ₇ - M + R (2:1)	0.00210	0.00195	0.00202	0.00314	0.00301	0.00307
C ₈ - M + C (2:2)	0.00180	0.00178	0.00179	0.00301	0.00294	0.00297
C ₉ - M + R (2:2)	0.00208	0.00179	0.00193	0.00319	0.00297	0.00308
SEm±	0.00002	0.00002	0.00001	0.00003	0.00002	0.00002
CD (P=0.05)	0.00006	0.00005	0.00004	0.00007	0.00006	0.00005
2. Nutrient management						
F ₀ - Control	0.00176	0.00168	0.00172	0.00272	0.00261	0.00267
F ₁ - 50 % NPK	0.00195	0.00175	0.00185	0.00310	0.00289	0.00300
F ₂ - 100 % NPK	0.00219	0.00209	0.00214	0.00360	0.00342	0.00351
SEm±	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
CD (P=0.05)	0.00004	0.00003	0.00002	0.00004	0.00004	0.00003

Table 45b. Interaction effect of row ratio and nutrient management on net assimilation rate of maize

Interaction (C X F)	Net assimilation rate (g cm ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	0.00211	0.00207	0.00209	0.00296	0.00297	0.00297
C ₁ F ₁	0.00245	0.00206	0.00225	0.00341	0.00306	0.00323
C ₁ F ₂	0.00292	0.00236	0.00264	0.00417	0.00358	0.00388
C ₂ F ₀	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-
C ₄ F ₀	0.00159	0.00154	0.00156	0.00247	0.00247	0.00247
C ₄ F ₁	0.00174	0.00152	0.00163	0.00274	0.00269	0.00272
C ₄ F ₂	0.00197	0.00187	0.00192	0.00319	0.00337	0.00328
C ₅ F ₀	0.00146	0.00168	0.00157	0.00250	0.00232	0.00241
C ₅ F ₁	0.00165	0.00167	0.00166	0.00305	0.00288	0.00296
C ₅ F ₂	0.00187	0.00217	0.00202	0.00333	0.00304	0.00318
C ₆ F ₀	0.00181	0.00157	0.00169	0.00311	0.00265	0.00288
C ₆ F ₁	0.00189	0.00165	0.00177	0.00348	0.00306	0.00327
C ₆ F ₂	0.00191	0.00192	0.00192	0.00357	0.00362	0.00359
C ₇ F ₀	0.00178	0.00173	0.00175	0.00256	0.00274	0.00265
C ₇ F ₁	0.00215	0.00186	0.00201	0.00316	0.00283	0.00300
C ₇ F ₂	0.00236	0.00226	0.00231	0.00370	0.00344	0.00357
C ₈ F ₀	0.00157	0.00160	0.00159	0.00276	0.00255	0.00265
C ₈ F ₁	0.00178	0.00171	0.00175	0.00284	0.00280	0.00282
C ₈ F ₂	0.00203	0.00203	0.00203	0.00341	0.00348	0.00345
C ₉ F ₀	0.00199	0.00156	0.00177	0.00268	0.00260	0.00264
C ₉ F ₁	0.00197	0.00174	0.00185	0.00304	0.00291	0.00298
C ₉ F ₂	0.00228	0.00206	0.00217	0.00383	0.00341	0.00362
SEm±	0.00004	0.00003	0.00002	0.00004	0.00004	0.00003
CD (P=0.05)	0.00011	0.00008	0.00007	0.00013	0.00011	0.00008

Table 46a. Effect of row ratio and nutrient management on net assimilation rate of cowpea

Treatments	Net assimilation rate (g cm ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	0.01663	0.02202	0.01932	0.02068	0.01631	0.01849
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-
C ₄ - M + C (1:1)	0.01796	0.01805	0.01801	0.01152	0.01094	0.01123
C ₅ - M + R (1:1)	-	-	-	-	-	-
C ₆ - M + C (2:1)	0.01471	0.01396	0.01434	0.01677	0.01534	0.01605
C ₇ - M + R (2:1)	-	-	-	-	-	-
C ₈ - M + C (2:2)	0.01358	0.01147	0.01252	0.01576	0.01655	0.01616
C ₉ - M + R (2:2)	-	-	-	-	-	-
SEm±	0.00014	0.00016	0.00010	0.00012	0.00013	0.00009
CD (P=0.05)	0.00038	0.00045	0.00029	0.00033	0.00037	0.00024
2. Nutrient management						
F ₀ - Control	0.01501	0.01518	0.01509	0.01349	0.01254	0.01302
F ₁ - 50 % NPK	0.01569	0.01637	0.01603	0.01610	0.01438	0.01524
F ₂ - 100 % NPK	0.01647	0.01758	0.01702	0.01896	0.01742	0.01819
SEm±	0.00008	0.00009	0.00006	0.00007	0.00008	0.00005
CD (P=0.05)	0.00022	0.00026	0.00017	0.00019	0.00021	0.00014

Table 46b. Interaction effect of row ratio and nutrient management on net assimilation rate of cowpea

Interaction (C X F)	Net assimilation rate (g cm ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-
C ₂ F ₀	0.01571	0.02113	0.01842	0.01776	0.01343	0.01560
C ₂ F ₁	0.01639	0.02163	0.01901	0.02058	0.01518	0.01788
C ₂ F ₂	0.01779	0.02329	0.02054	0.02369	0.02032	0.02200
C ₃ F ₀	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-
C ₄ F ₀	0.01699	0.01662	0.01681	0.00947	0.00854	0.00901
C ₄ F ₁	0.01823	0.01797	0.01810	0.01127	0.01170	0.01149
C ₄ F ₂	0.01867	0.01957	0.01912	0.01382	0.01258	0.01320
C ₅ F ₀	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-
C ₆ F ₀	0.01405	0.01217	0.01311	0.01410	0.01390	0.01400
C ₆ F ₁	0.01453	0.01453	0.01453	0.01720	0.01416	0.01568
C ₆ F ₂	0.01555	0.01517	0.01536	0.01901	0.01795	0.01848
C ₇ F ₀	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-
C ₈ F ₀	0.01327	0.01078	0.01202	0.01263	0.01430	0.01347
C ₈ F ₁	0.01361	0.01135	0.01248	0.01532	0.01649	0.01591
C ₈ F ₂	0.01384	0.01227	0.01306	0.01934	0.01885	0.01909
C ₉ F ₀	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-
SEm±	0.00023	0.00027	0.00018	0.00020	0.00023	0.00015
CD (P=0.05)	0.00067	0.00078	0.00051	0.00057	0.00064	0.00042

Table 47a. Effect of row ratio and nutrient management on net assimilation rate of rice bean

Treatments	Net assimilation rate (g cm ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	0.00251	0.00348	0.00300	0.00448	0.00362	0.00405
C ₄ - M + C (1:1)	-	-	-	-	-	-
C ₅ - M + R (1:1)	0.00255	0.00321	0.00288	0.00273	0.00228	0.00251
C ₆ - M + C (2:1)	-	-	-	-	-	-
C ₇ - M + R (2:1)	0.00280	0.00356	0.00318	0.00261	0.00225	0.00243
C ₈ - M + C (2:2)	-	-	-	-	-	-
C ₉ - M + R (2:2)	0.00211	0.00323	0.00267	0.00366	0.00320	0.00343
SEm±	0.00003	0.00003	0.00002	0.00003	0.00002	0.00002
CD (P=0.05)	0.00007	0.00009	0.00006	0.00009	0.00006	0.00005
1. Nutrient management						
F ₀ - Control	0.00209	0.00298	0.00254	0.00245	0.00200	0.00222
F ₁ - 50 % NPK	0.00249	0.00342	0.00296	0.00342	0.00286	0.00314
F ₂ - 100 % NPK	0.00290	0.00370	0.00330	0.00424	0.00366	0.00395
SEm±	0.00002	0.00002	0.00001	0.00002	0.00001	0.00001
CD (P=0.05)	0.00004	0.00005	0.00003	0.00005	0.00003	0.00003

Table 47b. Interaction effect of row ratio and nutrient management on net assimilation rate of rice bean

Interaction (C X F)	Net assimilation rate (g cm ⁻² day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-
C ₃ F ₀	0.00173	0.00293	0.00233	0.00352	0.00247	0.00300
C ₃ F ₁	0.00264	0.00346	0.00305	0.00451	0.00379	0.00415
C ₃ F ₂	0.00316	0.00407	0.00361	0.00541	0.00459	0.00500
C ₄ F ₀	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-
C ₅ F ₀	0.00246	0.00303	0.00274	0.00175	0.00160	0.00167
C ₅ F ₁	0.00256	0.00324	0.00290	0.00283	0.00226	0.00255
C ₅ F ₂	0.00264	0.00336	0.00300	0.00360	0.00300	0.00330
C ₆ F ₀	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-
C ₇ F ₀	0.00250	0.00293	0.00271	0.00176	0.00136	0.00156
C ₇ F ₁	0.00288	0.00380	0.00334	0.00265	0.00228	0.00246
C ₇ F ₂	0.00302	0.00394	0.00348	0.00342	0.00311	0.00326
C ₈ F ₀	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-
C ₉ F ₀	0.00169	0.00305	0.00237	0.00277	0.00255	0.00266
C ₉ F ₁	0.00186	0.00320	0.00253	0.00367	0.00313	0.00340
C ₉ F ₂	0.00279	0.00345	0.00312	0.00455	0.00393	0.00424
SEm±	0.00005	0.00006	0.00004	0.00005	0.00004	0.00003
CD (P=0.05)	0.00013	0.00016	0.00010	0.00016	0.00010	0.00009

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

The data presented in the Table 48a, revealed that the relative growth rate of fodder maize was significantly affected by different row ratio and nutrient management practices. In regard with different row ratio, the highest relative growth rate of fodder maize at 20-40 DAS was found at C_1 ($0.04932 \text{ g g}^{-1} \text{ day}^{-1}$), which was followed by treatments C_7 ($0.04882 \text{ g g}^{-1} \text{ day}^{-1}$) and C_5 ($0.04802 \text{ g g}^{-1} \text{ day}^{-1}$), then the lowest was recorded at C_9 ($0.04528 \text{ g g}^{-1} \text{ day}^{-1}$). However, at 40-60 DAS, the highest relative growth rate of fodder maize was observed at treatment C_6 ($0.02796 \text{ g g}^{-1} \text{ day}^{-1}$) and then at C_5 ($0.02670 \text{ g g}^{-1} \text{ day}^{-1}$). Among all the treatments, the lowest relative growth rate of fodder maize was registered at C_1 ($0.02468 \text{ g g}^{-1} \text{ day}^{-1}$) followed by C_7 ($0.02569 \text{ g g}^{-1} \text{ day}^{-1}$) respectively. Yavas and Unay (2016) also reported the highest relative growth rate of maize at sole crop than 1:1 row ratio. Pandey *et al.* (2019) also reported the highest relative growth rate of maize was found at sole crop, which was followed by 1:1 at 45-60 DAS, while 2:2 row ratio managed at 60 DAS to harvest.

The nutrient management practices significantly influenced the relative growth rate of fodder maize (Table 48a). The relative growth rate was increase with application of nutrient at different level as compared to control treatment. The highest relative growth rate was observed at F_2 at 20-40 DAS ($0.04926 \text{ g g}^{-1} \text{ day}^{-1}$) and 40-60 DAS ($0.02682 \text{ g g}^{-1} \text{ day}^{-1}$). The lowest relative growth rate was registered at F_0 in both 20-40 DAS ($0.04509 \text{ g g}^{-1} \text{ da}^{-1}$) and 40-60 DAS ($0.02591 \text{ g g}^{-1} \text{ da}^{-1}$). This finding was in collateral with Nisar *et al.* (2024) and Jassal *et al.* (2018). They also observed the higher relative growth rate of maize under the application of nitrogen at 180 kg ha^{-1} and 150 kg ha^{-1} . Kumar *et al.* (2024) also claimed that application NPK @ 150-75-40 registered the higher relative growth rate of maize as compared to control. Panwar *et al.* (2020) evaluated the different level of NP (90-30, 110-40, 130-50 and $150-60 \text{ kg ha}^{-1}$) on growth performance of maize. From the results, it was observed that the relative growth rate of the maize was increased up to $150-50 \text{ kg ha}^{-1}$. However, further increase in NP leads to decrease in relative growth rate of maize. Among all the treatments, the highest relative growth rate of maize was recorded under application of N and P at $130-50 \text{ kg ha}^{-1}$. Similarly, Bahuguna *et al.* (2020) also observed the highest relative growth rate of

maize in the application of NPK @ 180-60-40 kg ha⁻¹ than control at 25 DAS to 45 DAS and 45 DAS to harvest.

The interaction result (Table 48b) showed that relative growth rate of fodder maize was impressed by combinations of both factors. The highest relative growth rate of fodder maize was found in treatment C₁F₂ (0.05154 g g⁻¹ day⁻¹) followed by C₇F₂ (0.05085 g g⁻¹ day⁻¹), C₁F₁ (0.05059 g g⁻¹ day⁻¹) and C₅F₂ (0.05033 g g⁻¹ day⁻¹). The lowest relative growth rate was recorded at C₉F₀ (0.04374 g g⁻¹ day⁻¹) and C₈F₀ (0.04479 g g⁻¹ day⁻¹) among the treatment combinations at 20-40 DAS. However, at 40-60 DAS the highest relative growth rate of fodder maize was seen at C₆F₂ (0.02811 g g⁻¹ day⁻¹) and C₆F₁ (0.02851 g g⁻¹ day⁻¹). The lowest relative growth rate of fodder maize was seen in control treatment C₁F₀ (0.02436 g g⁻¹ day⁻¹) and C₁F₁ (0.0270 g g⁻¹ day⁻¹) respectively.

The data (Table 49a) revealed that relative growth rate of fodder cowpea was significantly influence when it was growing together with fodder maize as intercrop with nutrient management approaches. Among the different row ratio, the highest relative growth rate of fodder cowpea was observed in treatments C₂ (0.04585 g g⁻¹ day⁻¹) and C₆ (0.04425 g g⁻¹ day⁻¹), where the lowest was obtained from C₈ (0.03790 g g⁻¹ day⁻¹) at 20-40 DAS. However, at 40-60 DAS, the highest relative growth rate was observed at C₈ (0.02620 g g⁻¹ day⁻¹) and C₆ (0.02587 g g⁻¹ day⁻¹). The lowest growth was registered at C₄ (0.01728 g g⁻¹ day⁻¹) as compared to other treatments.

The relative growth rate of fodder cowpea was found increase with increase in nutrient application (Table 49a). Among all the treatments, F₂ registered the highest relative growth rate of fodder cowpea at 20-40 DAS (0.04751 g g⁻¹ day⁻¹) and 40-60 DAS (0.02408 g g⁻¹ day⁻¹) when compared to other treatments F₁ (0.04207 g g⁻¹ day⁻¹ and 0.02294 g g⁻¹ day⁻¹) and F₀ (0.03698 and 0.02210 g g⁻¹ day⁻¹) respectively. Dhamodharam *et al.* (2023) investigated the different level of NPK (75 %, 100 % and 125 % RDF) on growth of maize. The recommended dose of NPK was 60-40-20 kg ha⁻¹. The results revealed that application NPK @ 125 % produced the highest relative growth rate of cowpea.

Results (Table 49b) showed that interaction of both factors had significant influence on relative growth rate of fodder cowpea (Table 48b). The highest growth rate of fodder cowpea at 20-40 DAS and 40-60 DAS was observed from C₆F₂ (0.05096 g g⁻¹ day⁻¹), C₂F₂ (0.04944 g g⁻¹ day⁻¹) and C₈F₂ (0.02672 g g⁻¹ day⁻¹), C₈F₁ (0.02654 g g⁻¹ day⁻¹). The lowest growth rate among the treatment combinations was observed at C₈F₀ (0.03384 g g⁻¹ day⁻¹) and C₄F₀ (0.01590 g g⁻¹ day⁻¹) at 20-40 DAS and 40-60 DAS respectively.

The data related to relative growth rate of fodder rice bean (Table 50a) revealed that both factors have a significant effect on relative growth rate of fodder rice bean. Among the different row ratio, the highest and the lowest relative growth rate was obtained from treatments C₇ (0.0352 g g⁻¹ day⁻¹) and C₅ (0.0300 g g⁻¹ day⁻¹) at 20-40 DAS. At 40-60 DAS, treatments C₉ (0.0236 g g⁻¹ day⁻¹) and C₃ (0.0234 g g⁻¹ day⁻¹) registered the highest relative growth rate, while the treatment C₅ (0.0179 g g⁻¹ day⁻¹) produced the lowest relative growth rate of fodder rice bean.

It is proved that nutrient management practice holds a significant effect on relative growth rate of fodder rice bean (Table 50a). The highest relative growth rate of fodder rice bean was seen at treatment F₂ in both the stages of observations *i.e.*, 20-40 DAS (0.0325 g g⁻¹ day⁻¹) and 40-60 DAS (0.0229 g g⁻¹ day⁻¹) respectively. The lowest relative growth rate was seen in F₀ at 20-40 DAS (0.0257 g g⁻¹ day⁻¹) and 40-60 DAS (0.0188 g g⁻¹ day⁻¹) as compared to other treatments.

The result revealed that both different row ratio and nutrient management approaches caused a significant effect on relative growth rate of fodder rice bean (Table 50b). Among all the treatment combinations, the highest relative growth rate was observed from treatments receiving higher doses of nutrient applications. At 20-40 DAS, the highest relative growth rate was recorded at C₇F₂ (0.0368 g g⁻¹ day⁻¹) and C₇F₁ (0.0354 g g⁻¹ day⁻¹) and the lowest was seen at C₃F₀ (0.0198 g g⁻¹ day⁻¹). Likewise, the highest relative growth rate of fodder rice bean at 40-60 DAS was registered at C₉F₂ (0.0250 g g⁻¹ day⁻¹) followed by C₉F₁ (0.0245 g g⁻¹ day⁻¹) and C₃F₂ (0.0244 g g⁻¹ day⁻¹) respectively. The lowest relative growth rate of fodder rice bean was recorded from treatments C₅F₀ (0.0147 g g⁻¹ day⁻¹) and C₇F₀ (0.0156 g g⁻¹ day⁻¹).

Table 48a. Effect of row ratio and nutrient management on relative growth rate of maize

Treatments	Relative growth rate (g g ⁻¹ day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	0.04888	0.04976	0.04932	0.02478	0.02459	0.02468
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-
C ₄ - M + C (1:1)	0.04818	0.04678	0.04748	0.02599	0.02766	0.02682
C ₅ - M + R (1:1)	0.04723	0.04886	0.04805	0.02778	0.02562	0.02670
C ₆ - M + C (2:1)	0.04744	0.04627	0.04686	0.02809	0.02782	0.02796
C ₇ - M + R (2:1)	0.04852	0.04912	0.04882	0.02591	0.02547	0.02569
C ₈ - M + C (2:2)	0.04649	0.04727	0.04688	0.02664	0.02669	0.02666
C ₉ - M + R (2:2)	0.04367	0.04689	0.04528	0.02520	0.02699	0.02610
SEm±	0.00026	0.00019	0.00016	0.00014	0.00010	0.00009
CD (P=0.05)	0.00074	0.00053	0.00045	0.00040	0.00028	0.00024
2. Nutrient management						
F ₀ - Control	0.04451	0.04566	0.04509	0.02588	0.02593	0.02591
F ₁ - 50 % NPK	0.04784	0.04863	0.04823	0.02647	0.02631	0.02639
F ₂ - 100 % NPK	0.04926	0.04927	0.04926	0.02667	0.02697	0.02682
SEm±	0.00015	0.00011	0.00009	0.00008	0.00006	0.00005
CD (P=0.05)	0.00043	0.00030	0.00026	0.00023	0.00016	0.00014

Table 48b. Interaction effect of row ratio and nutrient management on relative growth rate of maize

Interaction (C X F)	Relative growth rate (g g ⁻¹ day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	0.04516	0.04650	0.04583	0.02444	0.02429	0.02436
C ₁ F ₁	0.04986	0.05131	0.05059	0.02490	0.02451	0.02470
C ₁ F ₂	0.05162	0.05147	0.05154	0.02499	0.02496	0.02498
C ₂ F ₀	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-
C ₄ F ₀	0.04526	0.04431	0.04479	0.02562	0.02683	0.02623
C ₄ F ₁	0.04865	0.04781	0.04823	0.02613	0.02779	0.02696
C ₄ F ₂	0.05064	0.04822	0.04943	0.02621	0.02835	0.02728
C ₅ F ₀	0.04428	0.04644	0.04536	0.02725	0.02530	0.02628
C ₅ F ₁	0.04756	0.04935	0.04846	0.02799	0.02518	0.02659
C ₅ F ₂	0.04986	0.05080	0.05033	0.02809	0.02638	0.02724
C ₆ F ₀	0.04437	0.04504	0.04471	0.02786	0.02698	0.02742
C ₆ F ₁	0.04840	0.04685	0.04762	0.02834	0.02787	0.02811
C ₆ F ₂	0.04955	0.04692	0.04824	0.02808	0.02860	0.02834
C ₇ F ₀	0.04423	0.04679	0.04551	0.02578	0.02516	0.02547
C ₇ F ₁	0.05012	0.05007	0.05010	0.02591	0.02540	0.02566
C ₇ F ₂	0.05120	0.05050	0.05085	0.02605	0.02584	0.02594
C ₈ F ₀	0.04525	0.04609	0.04567	0.02628	0.02617	0.02623
C ₈ F ₁	0.04674	0.04752	0.04713	0.02677	0.02658	0.02667
C ₈ F ₂	0.04750	0.04821	0.04785	0.02686	0.02732	0.02709
C ₉ F ₀	0.04303	0.04446	0.04374	0.02396	0.02678	0.02537
C ₉ F ₁	0.04355	0.04748	0.04552	0.02525	0.02687	0.02606
C ₉ F ₂	0.04442	0.04874	0.04658	0.02639	0.02733	0.02686
SEm±	0.00045	0.00032	0.00028	0.00024	0.00017	0.00015
CD (P=0.05)	0.00128	0.00091	0.00077	0.00069	0.00049	0.00042

Table 49a. Effect of row ratio and nutrient management on relative growth rate of cowpea

Treatments	Relative growth rate (g g ⁻¹ day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	0.04109	0.04585	0.04347	0.02602	0.01962	0.02282
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-
C ₄ - M + C (1:1)	0.04164	0.04132	0.04148	0.01667	0.01789	0.01728
C ₅ - M + R (1:1)	-	-	-	-	-	-
C ₆ - M + C (2:1)	0.04377	0.04425	0.04401	0.02589	0.02584	0.02587
C ₇ - M + R (2:1)	-	-	-	-	-	-
C ₈ - M + C (2:2)	0.03939	0.03790	0.03864	0.02540	0.02701	0.02620
C ₉ - M + R (2:2)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SEm±	0.00015	0.00021	0.00013	0.00019	0.00015	0.00012
CD (P=0.05)	0.00043	0.00059	0.00036	0.00053	0.00042	0.00033
2. Nutrient management						
F ₀ - Control	0.03625	0.03698	0.03662	0.02246	0.02174	0.02210
F ₁ - 50 % NPK	0.04109	0.04207	0.04158	0.02352	0.02237	0.02294
F ₂ - 100 % NPK	0.04708	0.04793	0.04751	0.02450	0.02366	0.02408
SEm±	0.00009	0.00012	0.00007	0.00011	0.00008	0.00007
CD (P=0.05)	0.00025	0.00034	0.00021	0.00031	0.00024	0.00019

Table 49b. Interaction effect of row ratio and nutrient management on relative growth rate of cowpea

Interaction (C X F)	Relative growth rate (g g ⁻¹ day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-
C ₂ F ₀	0.03672	0.03907	0.03790	0.02492	0.01861	0.02177
C ₂ F ₁	0.04007	0.04608	0.04308	0.02545	0.01922	0.02234
C ₂ F ₂	0.04648	0.05241	0.04944	0.02768	0.02103	0.02435
C ₃ F ₀	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-
C ₄ F ₀	0.03740	0.03780	0.03760	0.01563	0.01617	0.01590
C ₄ F ₁	0.04131	0.04037	0.04084	0.01609	0.01816	0.01713
C ₄ F ₂	0.04621	0.04578	0.04600	0.01829	0.01934	0.01881
C ₅ F ₀	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-
C ₆ F ₀	0.03633	0.03792	0.03712	0.02499	0.02580	0.02540
C ₆ F ₁	0.04311	0.04479	0.04395	0.02706	0.02447	0.02576
C ₆ F ₂	0.05189	0.05004	0.05096	0.02563	0.02724	0.02643
C ₇ F ₀	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-
C ₈ F ₀	0.03454	0.03315	0.03384	0.02431	0.02638	0.02534
C ₈ F ₁	0.03988	0.03705	0.03847	0.02548	0.02761	0.02654
C ₈ F ₂	0.04374	0.04350	0.04362	0.02640	0.02703	0.02672
C ₉ F ₀	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-
SEm±	0.00026	0.00036	0.00022	0.00032	0.00025	0.00021
CD (P=0.05)	0.00074	0.00103	0.00062	0.00092	0.00072	0.00058

Table 50a. Effect of row ratio and nutrient management on relative growth rate of rice bean

Treatments	Relative growth rate (g g ⁻¹ day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	0.0236	0.0263	0.0249	0.0273	0.0194	0.0234
C ₄ - M + C (1:1)	-	-	-	-	-	-
C ₅ - M + R (1:1)	0.0281	0.0320	0.0300	0.0197	0.0161	0.0179
C ₆ - M + C (2:1)	-	-	-	-	-	-
C ₇ - M + R (2:1)	0.0328	0.0376	0.0352	0.0200	0.0168	0.0184
C ₈ - M + C (2:2)	-	-	-	-	-	-
C ₉ - M + R (2:2)	0.0228	0.0292	0.0260	0.0273	0.0200	0.0236
SEm±	0.0002	0.0002	0.0001	0.0002	0.0001	0.0001
CD (P=0.05)	0.0005	0.0006	0.0004	0.0005	0.0003	0.0003
2. Nutrient management						
F ₀ - Control	0.0239	0.0276	0.0257	0.0215	0.0155	0.0185
F ₁ - 50 % NPK	0.0266	0.0313	0.0289	0.0241	0.0181	0.0211
F ₂ - 100 % NPK	0.0301	0.0348	0.0325	0.0251	0.0206	0.0229
SEm±	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
CD (P=0.05)	0.0003	0.0003	0.0002	0.0003	0.0002	0.0002

Table 50b. Interaction effect of row ratio and nutrient management on relative growth rate rice bean

Interaction (C X F)	Relative growth rate (g g ⁻¹ day ⁻¹)					
	20-40 DAS			40-60 DAS		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-
C ₃ F ₀	0.0179	0.0218	0.0198	0.0276	0.0170	0.0223
C ₃ F ₁	0.0245	0.0264	0.0255	0.0269	0.0199	0.0234
C ₃ F ₂	0.0284	0.0307	0.0295	0.0274	0.0214	0.0244
C ₄ F ₀	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-
C ₅ F ₀	0.0272	0.0276	0.0274	0.0160	0.0134	0.0147
C ₅ F ₁	0.0276	0.0316	0.0296	0.0204	0.0157	0.0181
C ₅ F ₂	0.0296	0.0366	0.0331	0.0226	0.0191	0.0208
C ₆ F ₀	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-
C ₇ F ₀	0.0309	0.0360	0.0334	0.0170	0.0143	0.0156
C ₇ F ₁	0.0332	0.0375	0.0354	0.0204	0.0163	0.0184
C ₇ F ₂	0.0344	0.0392	0.0368	0.0226	0.0197	0.0211
C ₈ F ₀	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-
C ₉ F ₀	0.0195	0.0252	0.0223	0.0254	0.0173	0.0213
C ₉ F ₁	0.0210	0.0296	0.0253	0.0287	0.0202	0.0245
C ₉ F ₂	0.0280	0.0329	0.0304	0.0276	0.0224	0.0250
SEM±	0.0003	0.0004	0.0002	0.0003	0.0002	0.0002
CD (P=0.05)	0.0009	0.0010	0.0007	0.0009	0.0006	0.0005

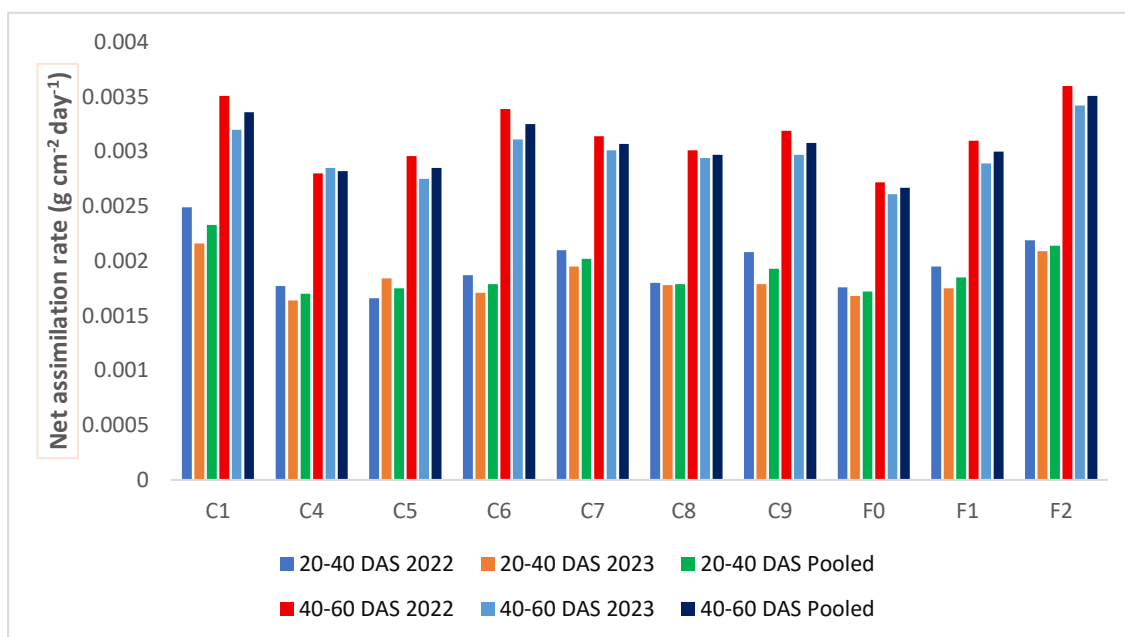


Fig.23. Effect of row ratio and nutrient management on net assimilation rate of maize

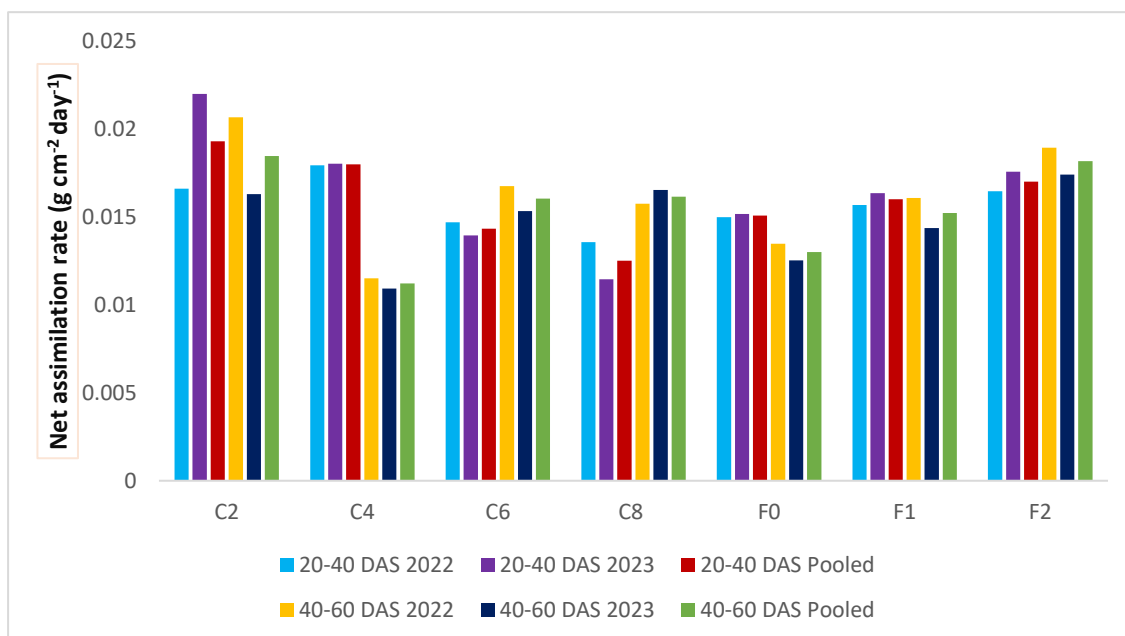


Fig.24. Effect of row ratio and nutrient management on net assimilation rate of cowpea

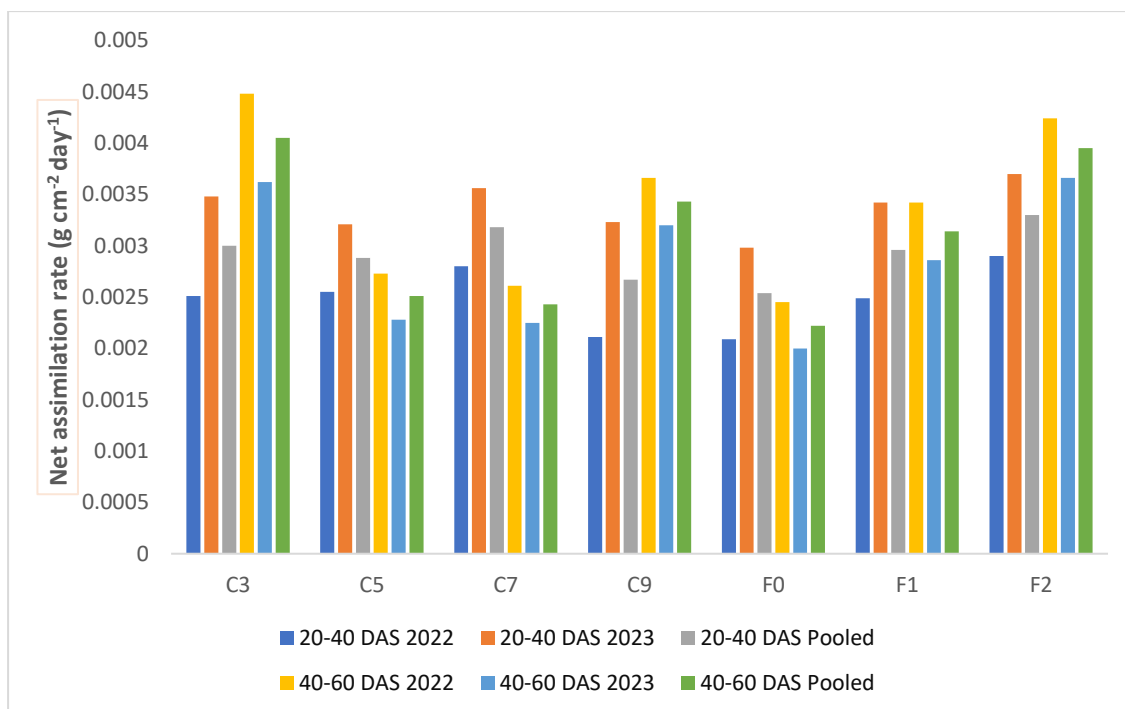


Fig.25. Effect of row ratio and nutrient management on net assimilation rate of rice bean

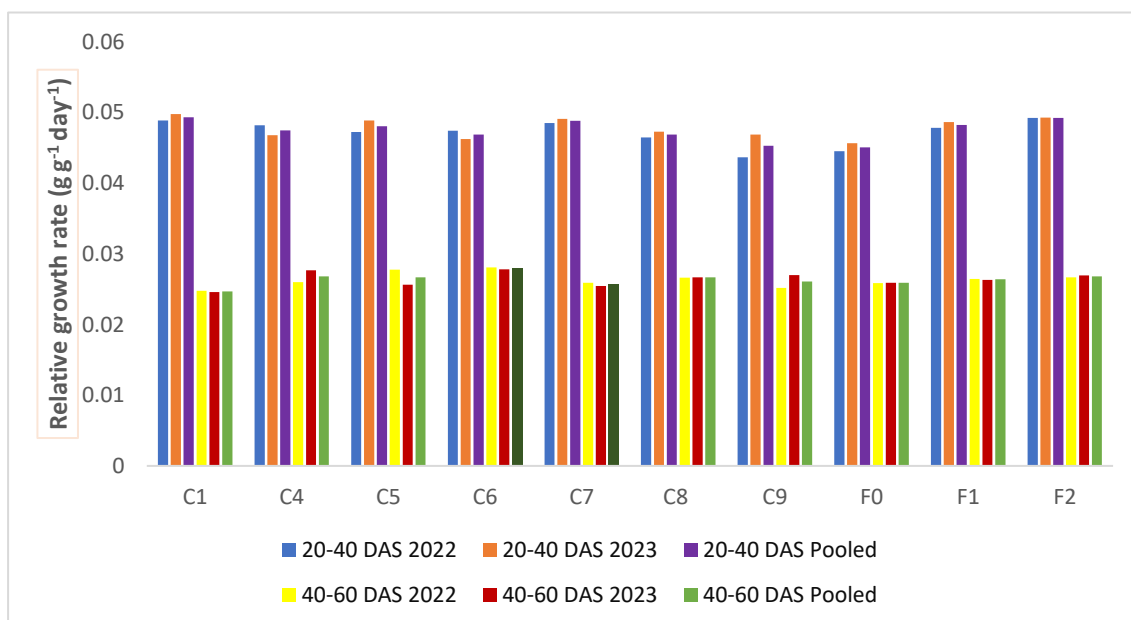


Fig.26. Effect of row ratio and nutrient management on relative growth rate of maize

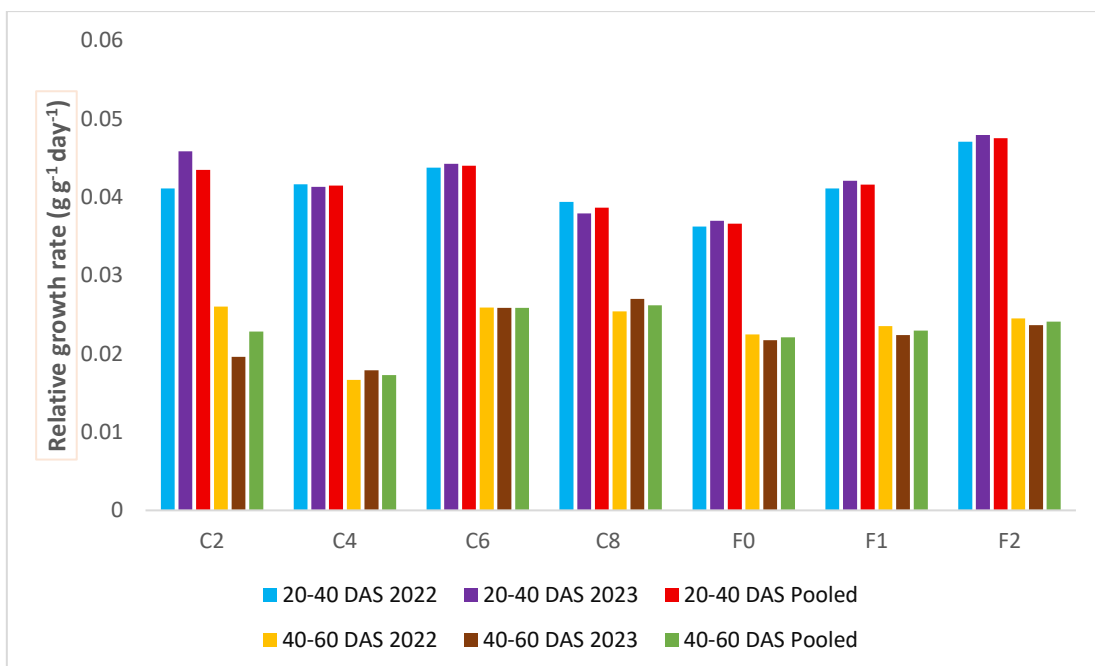


Fig.27. Effect of row ratio and nutrient management on relative growth rate of cowpea

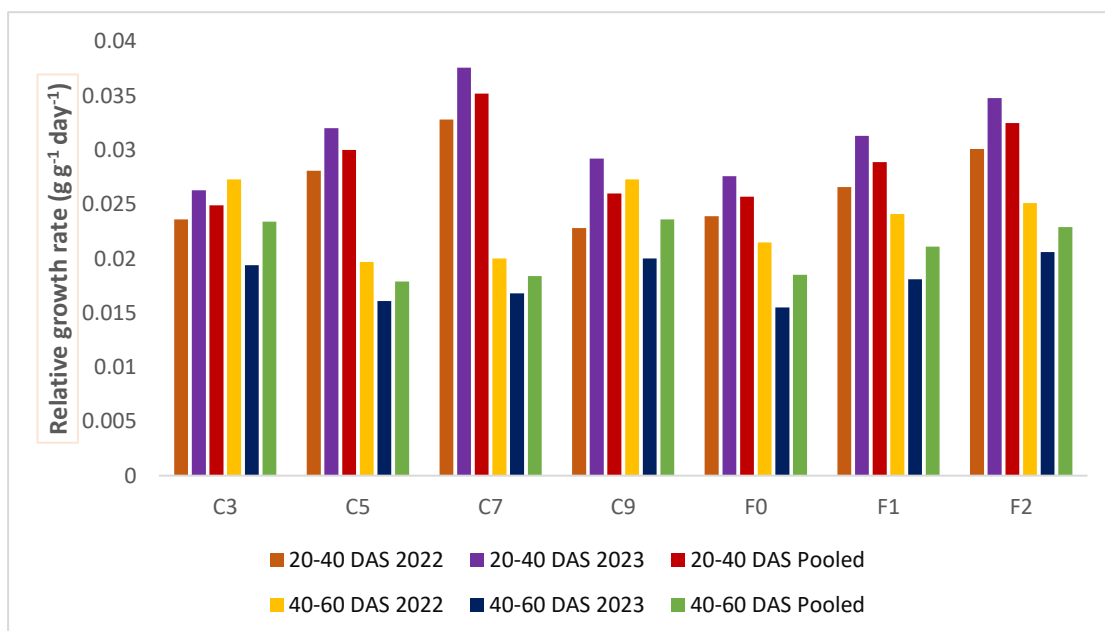


Fig.28. Effect of row ratio and nutrient management on relative growth rate of rice bean

4.4.7 Relative crowding co-efficient

The relative crowding co-efficient of fodder maize, fodder cowpea and fodder rice bean was significantly influenced by both factors (Table 51a). The highest relative crowding co-efficient of the system was observed at C₆ (3.467) and C₈ (3.108), while the lowest crowding co-efficient was recorded from C₇ (1.852) followed by C₅ (2.176) and C₄ (2.186). With regard to different row ratio, the highest relative crowding co-efficient for fodder maize was recorded at C₇ (3.113) and C₆ (2.846). Similarly, the lowest relative crowding co-efficient was registered at C₅ (1.994). The highest relative crowding co-efficient for fodder cowpea and fodder rice bean was recorded at C₈ (1.427) and C₉ (1.285), while C₄ (1.011) and C₇ (0.599) recorded the lowest relative crowding co-efficient for fodder cowpea and fodder rice bean. The relative crowding co-efficient values were greater than one in all the treatments, which indicating that the crops produced more than the expected yield. The intercropping of fodder maize with fodder cowpea and fodder rice bean proved to be significantly advantage over mono cropping. Similarly, Sharma (2008) also reported the highest relative crowding co-efficient under maize intercrop with cowpea at 2:2 row ratio followed by 1:2 row ratio and lowest was observed at 1:1 row ratio. Likewise, highest relative crowding co-efficient for cowpea and rice bean was registered under higher co-efficient was observed in 2:2 row ratio. The highest relative crowding co-efficient of maize and cowpea was recorded at 2:1 followed by 2:2 row ratio (Arif *et al.*, 2024). Beremjungla (2015) also reported the highest relative crowding co-efficient at 2:2 row ratio.

Incase of nutrient management practices, it was observed that the relative crowding co-efficient of the system and each crop was found increase with increase in nutrient management (Table 51a). Among the treatments, the F₂ (100 % RDF) recorded the highest relative crowding co-efficient for each crop *i.e.*, fodder maize (2.627), fodder cowpea (1.540), fodder rice bean (1.169) and the relative crowding co-efficient of the system (4.036). The lowest relative crowding co-efficient of the system (2.154) and each crop *i.e.*, fodder maize (2.180), fodder cowpea (0.996) fodder rice bean (0.820) was registered from treatment F₀ (control). Similarly, Beremjungla (2015)

reported that the application of nutrients @ 100 % RDF also recorded the highest relative crowding co-efficient of maize.

The interaction result (Table 51b) showed that the combinations of different row ratio and nutrient management caused a significant variation in relative crowding co-efficient of the fodder crops. Among all the treatment combinations, the highest relative crowding co-efficient of the system was found in treatment C₆F₂ (4.821) followed by C₈F₂ (4.165), while the lowest was observed at treatment C₅F₀ (1.389), C₄F₀ (1.492) and C₇F₀ (1.588). With regard to each crop, the highest relative crowding co-efficient of fodder maize was seen at C₆F₂ (3.349). Likewise, the lowest was observed at C₅F₀ (1.557) and C₉F₀ (1.669). For fodder cowpea, the highest crowding co-efficient was observed at C₈F₂ (1.784) and C₆F₂ (1.440), while the lowest was recorded at C₄F₀ (0.744) and C₆F₀ (0.952) as compared to all other treatments. In case of fodder rice bean, the highest and the lowest crowding co-efficient was registered at C₉F₂ (1.576) and C₇F₀ (0.506) among all the treatments.

Table 51a. Effect of row ratio and nutrient management on relative crowding co-efficient of maize, cowpea and rice bean

Treatments	Relative crowding co-efficient											
	Maize			Cowpea			Rice bean			RCC of the system		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system												
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	2.087	2.181	2.134	0.926	1.097	1.011	-	-	-	1.946	2.426	2.186
C ₅ - M + R (1:1)	1.983	2.005	1.994	-	-	-	1.042	1.096	1.069	2.101	2.250	2.176
C ₆ - M + C (2:1)	2.783	2.908	2.846	1.180	1.216	1.198	-	-	-	3.348	3.585	3.467
C ₇ - M + R (2:1)	3.004	3.221	3.113	-	-	-	0.564	0.634	0.599	1.665	2.039	1.852
C ₈ - M + C (2:2)	2.063	2.228	2.145	1.399	1.456	1.427	-	-	-	2.903	3.312	3.108
C ₉ - M + R (2:2)	1.925	2.086	2.005	-	-	-	1.205	1.364	1.285	2.369	2.913	2.641
SEm±	0.030	0.032	0.022	0.012	0.012	0.009	0.007	0.009	0.006	0.042	0.049	0.032
CD (P=0.05)	0.086	0.090	0.062	0.033	0.035	0.024	0.020	0.026	0.016	0.120	0.139	0.091
2. Nutrient management												
F ₀ - Control	2.120	2.240	2.180	0.999	0.933	0.966	0.795	0.845	0.820	2.173	2.135	2.154
F ₁ - 50 % NPK	2.229	2.394	2.311	1.144	1.117	1.130	0.911	1.017	0.964	2.504	2.636	2.570
F ₂ - 100 % NPK	2.573	2.680	2.627	1.361	1.718	1.540	1.105	1.233	1.169	3.520	4.552	4.036
SEm±	0.018	0.018	0.013	0.007	0.007	0.005	0.004	0.005	0.003	0.024	0.028	0.019
CD (P=0.05)	0.050	0.052	0.036	0.019	0.020	0.014	0.012	0.015	0.009	0.069	0.080	0.052

Table 51b. Interaction effect of row ratio and nutrient management on relative crowding co-efficient of maize, cowpea and rice bean

Interaction (C X F)	Relative crowding co-efficient											
	Maize			Cowpea			Rice bean			RCC of the system		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-	-	-	-
C ₄ F ₀	1.925	2.083	2.004	0.770	0.718	0.744	-	-	-	1.480	1.504	1.492
C ₄ F ₁	2.153	2.186	2.169	0.947	0.843	0.895	-	-	-	2.044	1.843	1.944
C ₄ F ₂	2.182	2.274	2.228	1.061	1.729	1.395	-	-	-	2.314	3.930	3.122
C ₅ F ₀	1.555	1.559	1.557	-	-	-	0.880	0.920	0.900	1.342	1.436	1.389
C ₅ F ₁	2.059	2.150	2.104	-	-	-	1.027	1.085	1.056	2.114	2.349	2.231
C ₅ F ₂	2.336	2.306	2.321	-	-	-	1.219	1.284	1.252	2.848	2.966	2.907
C ₆ F ₀	2.599	2.789	2.694	0.955	0.949	0.952	-	-	-	2.484	2.638	2.561
C ₆ F ₁	2.474	2.515	2.494	1.157	1.245	1.201	-	-	-	2.888	3.149	3.018
C ₆ F ₂	3.278	3.421	3.349	1.427	1.454	1.440	-	-	-	4.672	4.969	4.821
C ₇ F ₀	3.070	3.289	3.180	-	-	-	0.472	0.540	0.506	1.408	1.768	1.588
C ₇ F ₁	2.930	3.108	3.019	-	-	-	0.558	0.668	0.613	1.614	2.080	1.847
C ₇ F ₂	3.012	3.266	3.139	-	-	-	0.661	0.695	0.678	1.973	2.269	2.121
C ₈ F ₀	2.004	1.953	1.979	1.273	1.133	1.203	-	-	-	2.553	2.264	2.409
C ₈ F ₁	1.945	2.311	2.128	1.328	1.262	1.295	-	-	-	2.581	2.917	2.749
C ₈ F ₂	2.238	2.419	2.329	1.596	1.972	1.784	-	-	-	3.575	4.755	4.165
C ₉ F ₀	1.570	1.769	1.669	-	-	-	1.034	1.076	1.055	1.622	1.909	1.765
C ₉ F ₁	1.814	2.093	1.953	-	-	-	1.148	1.297	1.222	2.084	2.695	2.390
C ₉ F ₂	2.391	2.395	2.393	-	-	-	1.434	1.719	1.576	3.401	4.136	3.769
SEm±	0.053	0.055	0.038	0.020	0.021	0.015	0.012	0.016	0.010	0.073	0.085	0.056
CD (P=0.05)	0.150	0.155	0.107	0.058	0.061	0.041	0.035	0.045	0.028	0.208	0.241	0.157

4.4.8 Aggressivity

The analysis of data on aggressivity (A) are presented in Table (Table 52a). The data showed that aggressivity on different row ratio and nutrient management approaches revealed that aggressivity values were all positive in most of the treatments. Among all the treatments, the highest aggressivity was recorded in C₄ (0.393) followed by C₅ (0.296) and C₉ (0.215). The lowest aggressivity was observed in C₆ (0.150) and C₇ (0.171). In case of intercrop (fodder cowpea and fodder rice bean), the lowest aggressivity was observed from treatment C₄ (-0.393) and C₅ (-0.296). The highest aggressivity of fodder maize was obtained under 1:1 and 2:2 row ratio. The positive aggressivity of maize showed the dominant over the intercrop. While the negative aggressivity of intercrop revealed that the intercrop plant was dominated by the main crop. The finding of higher aggressivity under 1:1 row ratio was in similar with the findings reported by Arif *et al.* (2024). They also recorded the highest and lowest aggressivity of maize (0.24) and cowpea (-0.24) under 1:1 row ratio. Dudge *et al.* (2022) also observed the highest aggressivity of maize at 4:1 followed by 3:1 and 2:1 row ratio, while 1:1 and 2:2 registered the higher aggressivity of cowpea. Likewise, the higher aggressivity of maize intercrop with cowpea and rice bean was also observed at 1:1 row ratio (Sharma *et al.*, 2008).

With regard to nutrient management practices, the decrease in aggressivity was observed with increase in nutrient levels (Table 52a). The treatment F₀ (control) registered the highest aggressivity of fodder maize (0.299) followed by F₁ (0.250) and the lowest aggressivity of fodder maize was seen at F₂ (0.162). The higher aggressivity in control treatment was mainly due higher competition between the crops for resources like nutrients, moisture, spaces and sunlight.

The interaction result (Table 52b) showed that aggressivity of the fodder crops was affected by both factors. The higher aggressivity of the fodder maize was recorded at C₄F₀ (0.482) and C₄F₁ (0.447), while the lowest aggressivity was observed at C₆F₂ (0.036) and C₇F₂ (0.081) as compared to all other treatment combinations.

4.4.9 Competition ratio

The data analysis (Table 53a) on competition ratio showed that both factors had significant impact on competition ratio of the fodder maize. During both the years of investigations, the highest competition ratio of fodder maize under different row ratio was observed in C₄ (1.414) followed by C₅ (1.294) and the lowest competition ratio was seen at C₆ (1.151) and C₇ (1.167). In case of nutrient management, the competition ratio was found to decrease with increase in nutrient applications. The highest competition ratio for fodder maize was obtained at F₀ (1.319) as compared to F₁ (1.240) and F₂ (1.141) respectively. Correspondingly, the highest competition ratio of fodder maize intercrop with cowpea and rice bean was obtained at 2:2 row ratio followed by 1:1, the lowest was seen at 2:1 row ratio (Sharma, 2008). Identically Arif *et al.* (2024) also reported the highest competition ratio of maize under 1:1 and 2:2 row ratio. However, in contradiction to this, highest competition ratio of maize under 2:1 row ratio was reported by Dudge *et al.* (2022).

With reference to factors interaction (Table 53b), it was observed that treatments receiving lower levels of nutrients application produced higher competition ratio than those treatments which received higher levels of nutrients application. The highest competition ratio was recorded at C₄F₀ (1.571) and C₄F₁ (1.458), while the lowest competition ratio of fodder maize was registered at C₆F₂ (1.040), C₇F₂ (1.069) and C₈F₂ (1.097) respectively.

The analysis of data (Table 53a) on competition ratio of fodder cowpea was found to differ by both factors. The results revealed that highest competition ratio under different row ratio was observed at C₆ (0.878) and C₈ (0.846), while the lowest competition ratio was recorded at C₄ (0.719). Among the nutrient management operations, the treatment F₂ (0.902) recorded the highest competition ratio of fodder cowpea as compared to F₁ (0.807) and F₀ (0.743). The interaction results (Table 53b) revealed that both factors caused a significant variation on competition ratio of fodder cowpea. The highest competition ratio was obtained at C₆F₂ (0.962) followed by C₈F₂ (0.913), while the lowest was observed at C₄F₀ (0.639) as compared to other treatments. In the same way, observation of the highest competition ratio of fodder cowpea was

seen at 2:1 and 2:2 row ratio, while 1:1 registered the lowest competition ratio among the treatments (Arif *et al.*, 2024; Dudge *et al.*, 2022). Comparably, Sharma *et al.* (2008) also reported the highest competition ratio of cowpea at 2:1 and then 2:2 row ratio respectively.

Data related to competition ratio of fodder rice bean are presented in the Table 53a. Among all the treatment under different row ratio, the highest competition ratio was registered at C₇ (0.842) and the lowest was observed at C₅ (0.769). In response to nutrient management, the highest competition ratio was seen in treatment F₂ (0.861), while the lowest was observed at F₀ (0.793) and F₁ (0.824) respectively. Results (Table 53b) revealed that competition ratio of fodder rice bean was remarkable by both factors interaction. Among all the treatment combinations, the highest competition ratio of fodder rice bean was obtained at C₇F₂ (0.938) followed by C₇F₁ (0.886) and C₉F₂ (0.851), while the lowest competition ratio was recorded at C₅F₁ (0.756). Identically, Sharma *et al.* (2008) also reported the higher competition ratio of rice bean grown with maize at 2:1 row ratio followed by 2:2, while the least was observed at 1:1 row ratio. Similarly, Arif *et al.* (2024) and Dudge *et al.* (2022) also registered the highest competition ratio of rice bean under 2:1 and then at 2:2 row ratio.

4.4.10 Maize fodder equivalent yield (q ha⁻¹)

The appraisal of mean data presented in Table 54a revealed that maize fodder equivalent yield was significantly influenced due to different intercropping systems and nutrient management during the year 2022-2023 and 2023-24 and in pooled analysis. In comparison to sole fodder maize, all intercropping combinations produced higher maize fodder equivalent yield. Among the cropping system, the highest maize fodder equivalent yield was obtained from treatment C₈ (603.19 q ha⁻¹) which was followed by C₉ (584.31 q ha⁻¹) and C₇ (570.14 q ha⁻¹). However, the lowest maize fodder equivalent yield was obtained from C₆ (563.65 q ha⁻¹). The higher maize fodder equivalent yield from fodder maize + fodder legume was due to higher market price of fodder legume in comparison to fodder maize. The higher performance in fodder maize + fodder cowpea and fodder maize + fodder rice bean intercrop at 2:2, 2:1 and 1:1 row ratio might be due to accumulation of sufficient availability of solar radiation, nutrients and soil moisture. The increase in maize fodder equivalent yield under treatments C₈

and C₉ was mainly attributed to growth attributing parameters. These results are in conformity with findings of Baishya *et al.* (2021). Likewise, Patil *et al.* (2022) also obtained the highest maize equivalent yield under 1:1 and 2:2 row ratio in compared to sole maize. Mauriya *et al.* (2025) also reported the higher maize equivalent yield from intercropping of maize + pea than sole crop maize.

The result presented in the Table 54a showed that nutrient management practices significantly improved maize fodder equivalent yield. The data revealed that treatments receiving different levels of nutrient registered the higher maize fodder equivalent yield in comparison to control treatment. Among all the treatments, the highest maize fodder equivalent yield (691.57 q ha⁻¹) was recorded in treatment F₂ (100 % RDF) which was followed by F₁ (50 % RDF). The lowest maize fodder equivalent yield (446.44 q ha⁻¹) was registered at F₀ (control). The production of higher maize fodder equivalent yield under treatments receiving nutrients was mainly due to availability of sufficient nutrients to plant for their growth and development. Similar types of findings were also reported by Skekinah (2004).

With reference to factors interaction (Table 54b), it was observed that treatments receiving higher levels of nutrients produced higher maize fodder equivalent yield than those treatments which did not received nutrients. Among all the treatment combinations, the highest maize fodder equivalent yield was recorded at C₉F₂ (717.66 q ha⁻¹) and C₈F₂ (711.35 q ha⁻¹), while the lowest maize fodder equivalent yield of fodder maize was registered at C₅F₀ (413.81 q ha⁻¹), C₉F₀ (434.58 q ha⁻¹) and C₇F₀ (439.36 q ha⁻¹) respectively. The interaction of proper cropping system and nutrient management leads to maximum fodder yield, ensuring higher productivity and sustainability.

Table 52a. Effect of row ratio and nutrient management on aggressivity of maize, cowpea and rice bean

Treatments	Aggressivity					
	A _{Maize}			A _{Intercrop}		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-
C ₄ - M + C (1:1)	0.419	0.367	0.393	-0.419	-0.367	-0.393
C ₅ - M + R (1:1)	0.307	0.285	0.296	-0.307	-0.285	-0.296
C ₆ - M + C (2:1)	0.159	0.141	0.150	-0.159	-0.141	-0.150
C ₇ - M + R (2:1)	0.205	0.137	0.171	-0.205	-0.137	-0.171
C ₈ - M + C (2:2)	0.182	0.211	0.196	-0.182	-0.211	-0.196
C ₉ - M + R (2:2)	0.221	0.209	0.215	-0.221	-0.209	-0.215
SE _m ±	0.019	0.016	0.012	0.019	0.016	0.012
CD (P=0.05)	0.054	0.045	0.035	0.054	0.045	0.035
2. Nutrient management						
F ₀ - Control	0.292	0.306	0.299	0.292	0.306	0.299
F ₁ - 50 % NPK	0.253	0.247	0.250	0.253	0.247	0.250
F ₂ - 100 % NPK	0.202	0.121	0.162	0.202	0.121	0.162
SE _m ±	0.011	0.009	0.007	0.011	0.009	0.007
CD (P=0.05)	0.031	0.026	0.020	0.031	0.026	0.020

Table 52b. Interaction of row ratio and nutrient management on aggressivity of maize, cowpea and rice bean

Interaction (C X F)	Aggressivity					
	A _{Maize}			A _{Intercrop}		
	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-
C ₄ F ₀	0.446	0.518	0.482	-0.446	-0.518	-0.482
C ₄ F ₁	0.435	0.459	0.447	-0.435	-0.459	-0.447
C ₄ F ₂	0.378	0.123	0.250	-0.378	-0.123	-0.250
C ₅ F ₀	0.283	0.260	0.271	-0.283	-0.260	-0.271
C ₅ F ₁	0.336	0.326	0.331	-0.336	-0.326	-0.331
C ₅ F ₂	0.302	0.270	0.286	-0.302	-0.270	-0.286
C ₆ F ₀	0.281	0.303	0.292	-0.281	-0.303	-0.292
C ₆ F ₁	0.144	0.099	0.121	-0.144	-0.099	-0.121
C ₆ F ₂	0.052	0.020	0.036	-0.052	-0.020	-0.036
C ₇ F ₀	0.322	0.247	0.285	-0.322	-0.247	-0.285
C ₇ F ₁	0.202	0.092	0.147	-0.202	-0.092	-0.147
C ₇ F ₂	0.091	0.071	0.081	-0.091	-0.071	-0.081
C ₈ F ₀	0.214	0.262	0.238	-0.214	-0.262	-0.238
C ₈ F ₁	0.179	0.280	0.230	-0.179	-0.280	-0.230
C ₈ F ₂	0.153	0.090	0.121	-0.153	-0.090	-0.121
C ₉ F ₀	0.205	0.245	0.225	-0.205	-0.245	-0.225
C ₉ F ₁	0.221	0.225	0.223	-0.221	-0.225	-0.223
C ₉ F ₂	0.237	0.156	0.196	-0.237	-0.156	-0.196
SEm±	0.033	0.028	0.022	0.033	0.028	0.022
CD (P=0.05)	0.096	0.166	0.095	0.096	0.166	0.095

Table 53a. Effect of row ratio and nutrient management on competition ratio of maize, cowpea and rice bean

Treatments	Competition ratio								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	1.418	1.411	1.414	0.708	0.731	0.719	-	-	-
C ₅ - M + R (1:1)	1.312	1.276	1.294	-	-	-	0.769	0.785	0.777
C ₆ - M + C (2:1)	1.155	1.147	1.151	0.874	0.882	0.878	-	-	-
C ₇ - M + R (2:1)	1.208	1.126	1.167	-	-	-	0.842	0.895	0.868
C ₈ - M + C (2:2)	1.158	1.190	1.174	0.864	0.846	0.855	-	-	-
C ₉ - M + R (2:2)	1.206	1.192	1.199	-	-	-	0.831	0.837	0.834
SEm±	0.024	0.019	0.015	0.005	0.006	0.004	0.006	0.007	0.004
CD (P=0.05)	0.068	0.053	0.043	0.015	0.018	0.011	0.016	0.019	0.012
2. Nutrient management									
F ₀ - Control	1.312	1.325	1.319	0.759	0.726	0.743	0.785	0.802	0.793
F ₁ - 50 % NPK	1.239	1.241	1.240	0.820	0.795	0.807	0.807	0.841	0.824
F ₂ - 100 % NPK	1.177	1.105	1.141	0.867	0.938	0.902	0.849	0.874	0.861
SEm±	0.014	0.011	0.009	0.003	0.004	0.002	0.003	0.004	0.003
CD (P=0.05)	0.039	0.031	0.025	0.009	0.010	0.007	0.009	0.011	0.007

Table 53b. Interaction of row ratio and nutrient management on competition ratio of maize, cowpea and rice bean

Treatments	Competition ratio								
	Maize			Cowpea			Rice bean		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-
C ₄ F ₀	1.514	1.628	1.571	0.662	0.616	0.639	-	-	-
C ₄ F ₁	1.408	1.507	1.458	0.711	0.665	0.688	-	-	-
C ₄ F ₂	1.332	1.097	1.215	0.751	0.912	0.831	-	-	-
C ₅ F ₀	1.322	1.272	1.297	-	-	-	0.772	0.787	0.779
C ₅ F ₁	1.337	1.316	1.326	-	-	-	0.751	0.761	0.756
C ₅ F ₂	1.276	1.240	1.258	-	-	-	0.784	0.807	0.796
C ₆ F ₀	1.291	1.315	1.303	0.776	0.762	0.769	-	-	-
C ₆ F ₁	1.131	1.087	1.109	0.884	0.920	0.902	-	-	-
C ₆ F ₂	1.042	1.038	1.040	0.960	0.964	0.962	-	-	-
C ₇ F ₀	1.353	1.241	1.297	-	-	-	0.751	0.810	0.781
C ₇ F ₁	1.193	1.079	1.136	-	-	-	0.843	0.929	0.886
C ₇ F ₂	1.079	1.059	1.069	-	-	-	0.930	0.945	0.938
C ₈ F ₀	1.192	1.249	1.220	0.839	0.801	0.820	-	-	-
C ₈ F ₁	1.158	1.252	1.205	0.864	0.799	0.832	-	-	-
C ₈ F ₂	1.124	1.070	1.097	0.890	0.937	0.913	-	-	-
C ₉ F ₀	1.203	1.244	1.223	-	-	-	0.832	0.808	0.820
C ₉ F ₁	1.208	1.204	1.206	-	-	-	0.828	0.835	0.831
C ₉ F ₂	1.208	1.129	1.168	-	-	-	0.833	0.869	0.851
SEm±	0.042	0.033	0.026	0.009	0.011	0.007	0.010	0.012	0.008
CD (P=0.05)	0.118	0.093	0.074	0.026	0.030	0.020	0.028	0.033	0.021

Table 54a. Effect of row ratio and nutrient management on maize fodder equivalent yield

Treatments	Maize fodder equivalent yield (q ha ⁻¹)		
	2022	2023	Pooled
1. Cropping system			
C ₁ - Sole Maize (M)	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-
C ₄ - M + C (1:1)	544.53	583.28	563.91
C ₅ - M + R (1:1)	548.53	581.63	565.08
C ₆ - M + C (2:1)	548.72	578.58	563.65
C ₇ - M + R (2:1)	547.64	592.63	570.14
C ₈ - M + C (2:2)	586.28	620.11	603.19
C ₉ - M + R (2:2)	560.17	608.45	584.31
SEm±	2.77	4.28	2.55
CD (P=0.05)	7.86	12.14	7.14
2. Nutrient management			
F ₀ - Control	436.33	456.54	446.44
F ₁ - 50 % NPK	562.47	611.78	587.13
F ₂ - 100 % NPK	669.13	714.02	691.57
SEm±	1.60	2.47	1.47
CD (P=0.05)	4.54	7.01	4.12

Table 54b. Interaction of row ratio and nutrient management on maize fodder equivalent yield

Treatments	Maize fodder equivalent yield (q ha ⁻¹)		
	2022	2023	Pooled
C ₁ F ₀	-	-	-
C ₁ F ₁	-	-	-
C ₁ F ₂	-	-	-
C ₂ F ₀	-	-	-
C ₂ F ₁	-	-	-
C ₂ F ₂	-	-	-
C ₃ F ₀	-	-	-
C ₃ F ₁	-	-	-
C ₃ F ₂	-	-	-
C ₄ F ₀	440.33	458.96	449.65
C ₄ F ₁	554.17	577.65	565.91
C ₄ F ₂	639.08	713.25	676.17
C ₅ F ₀	404.08	423.54	413.81
C ₅ F ₁	570.00	615.83	592.92
C ₅ F ₂	671.50	705.52	688.51
C ₆ F ₀	435.42	457.25	446.33
C ₆ F ₁	543.83	591.23	567.53
C ₆ F ₂	666.92	687.25	677.08
C ₇ F ₀	424.92	453.81	439.36
C ₇ F ₁	560.25	624.50	592.38
C ₇ F ₂	657.75	699.58	678.67
C ₈ F ₀	492.25	497.52	494.89
C ₈ F ₁	578.33	628.35	603.34
C ₈ F ₂	688.25	734.46	711.35
C ₉ F ₀	421.00	448.17	434.58
C ₉ F ₁	568.25	633.13	600.69
C ₉ F ₂	691.25	744.06	717.66
SEm±	4.80	7.41	4.41
CD (P=0.05)	13.61	21.02	12.37

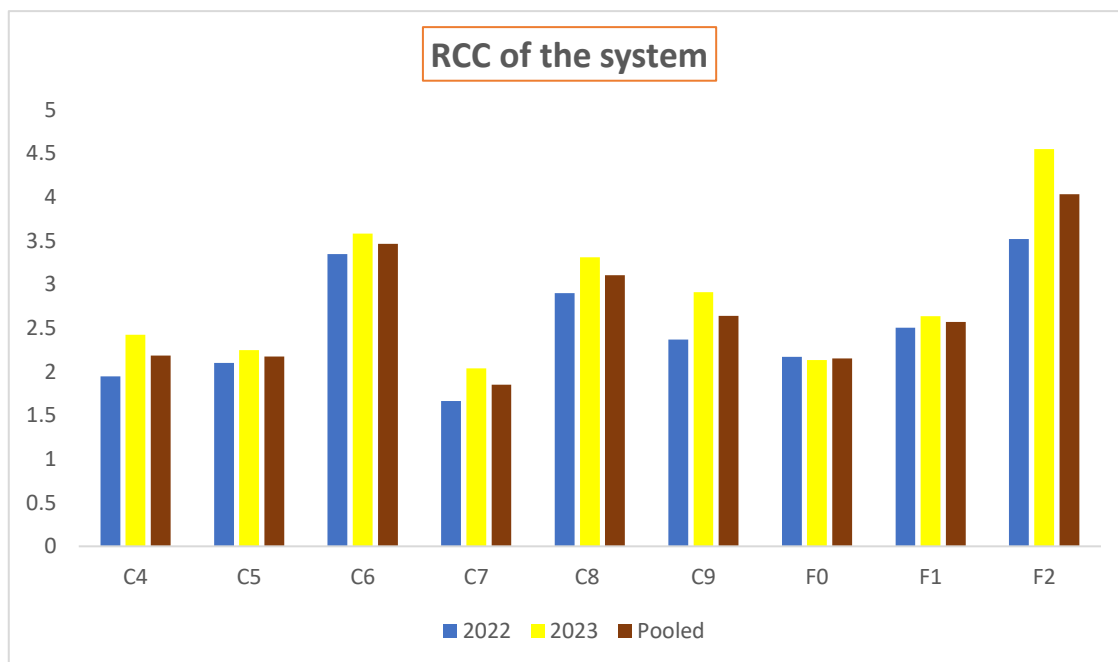


Fig.29. Effect of row ratio and nutrient management on relative crowding co-efficient of the system

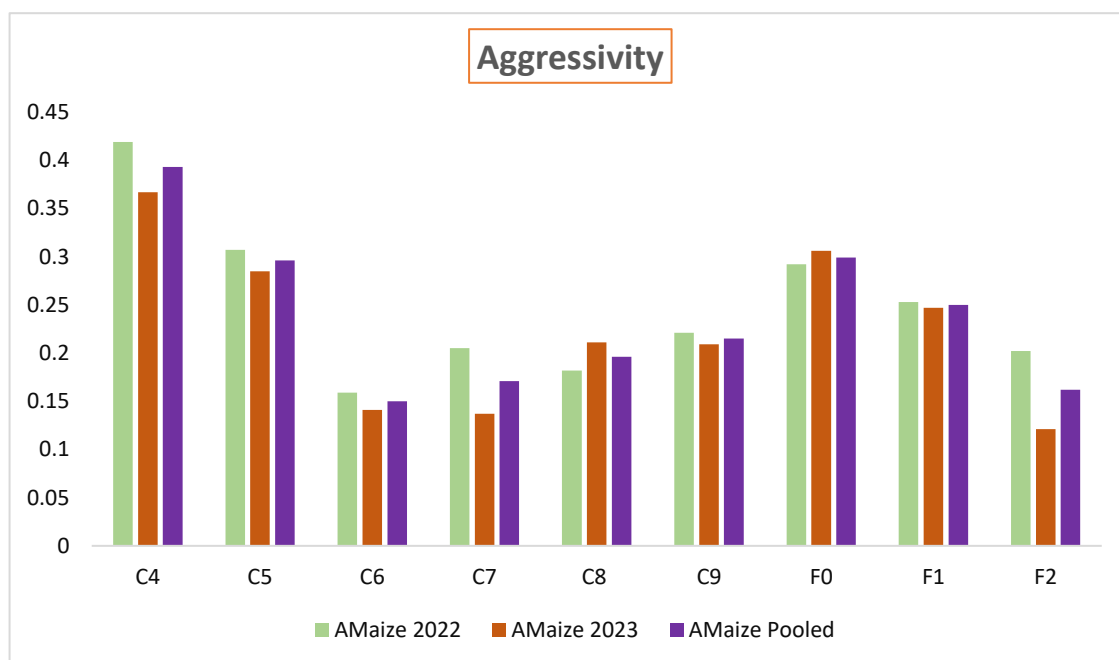


Fig.30. Effect of row ratio and nutrient management on aggressivity of maize

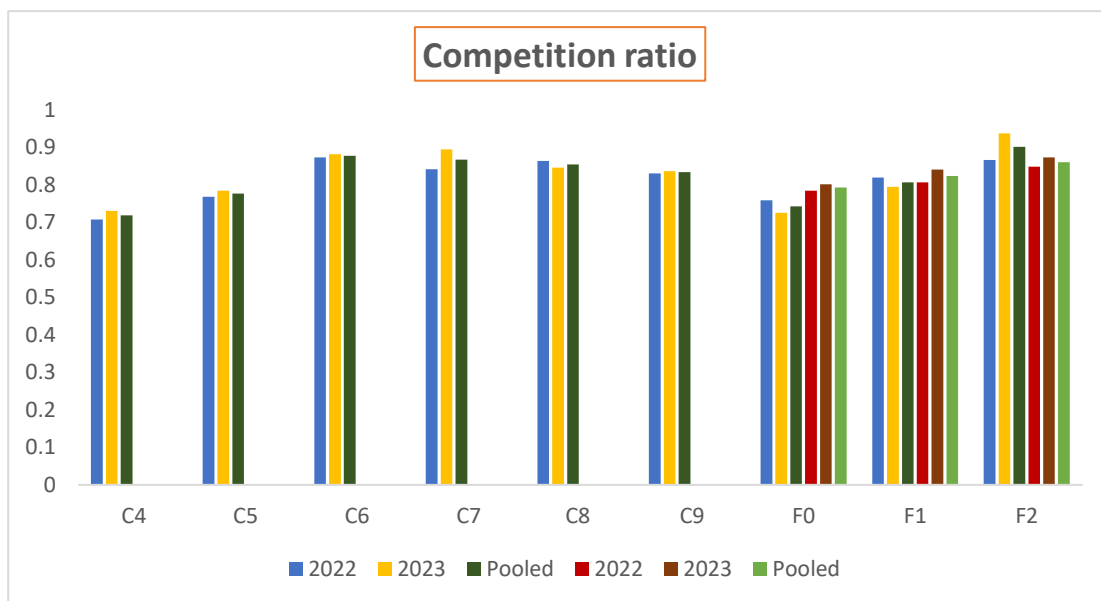


Fig.31. Effect of row ratio and nutrient management on competition ratio of maize

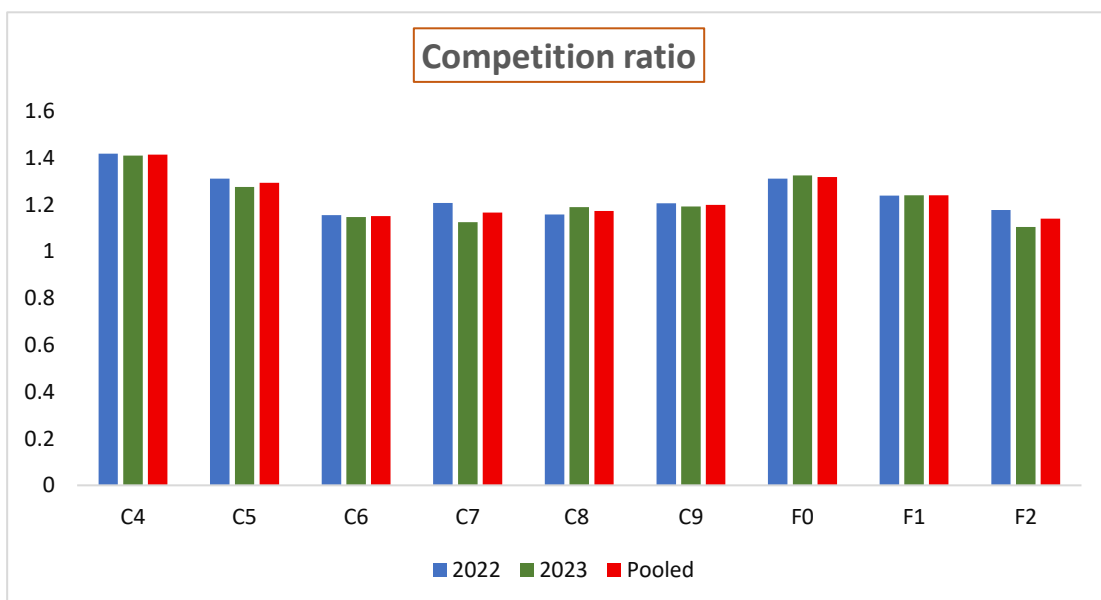


Fig.32. Effect of row ratio and nutrient management on competition ratio of cowpea and rice bean

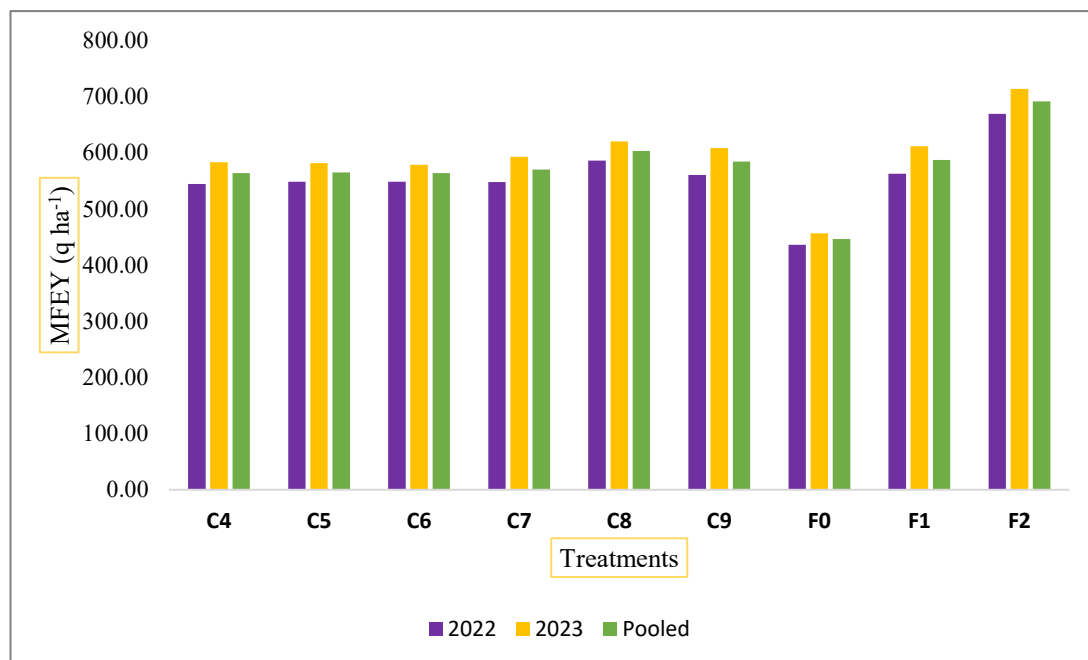


Fig.33. Effect of row ratio and nutrient management on maize fodder equivalent yield

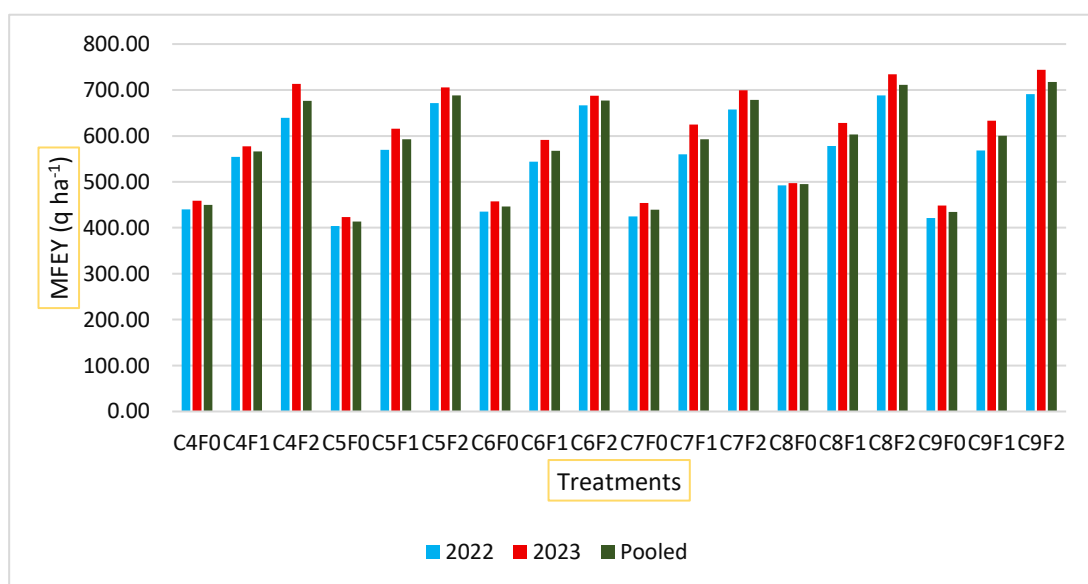


Fig.34. Interaction effect of row ratio and nutrient management on maize fodder equivalent yield

4.5. Chemicals analysis

4.5.1 Physiological properties of soil after harvesting

4.5.1.1 Soil pH and soil organic carbon (%)

The result (Table 55a) revealed that soil pH and soil organic carbon did not differ significantly due to both different row ratio and nutrient management. Among the different row ratio, soil pH ranged from 5.24 to 5.28, while the soil organic carbon was ranged from 1 % to 1.05 % and it was found that all the treatments were in the same trend. Similarly, with regard to nutrient management, the soil pH and soil organic carbon was also not significantly influenced by nutrient application.

4.5.1.2 Available nitrogen (kg ha^{-1})

The data on available nitrogen status of soil at harvest of fodder crop are presented in the table 56a. The available nitrogen in the soil after harvest was found to be significantly influenced by different row ratio and the available nitrogen ranged from 245.56 kg ha^{-1} to 280.54 kg ha^{-1} . Among the different row ratio, the highest available nitrogen presents in soil after harvest was recorded at sole stand crop C₃ (280.54 kg ha^{-1}) followed by C₂ (276.54 kg ha^{-1}) and the lowest was observed at C₁ (245.56 kg ha^{-1}) and C₇ (247.48 kg ha^{-1}). This finding was in closely with Dahmardeh *et al.* (2010). Similarly, Adeleke and Haruna (2012) also reported the increased in available nitrogen as compared to sole crop. Kumar and Faruqui (2010) evaluated the production potential and economics of food-forage based cropping system. They reported that intercropping of maize-berseem with legumes helps to improve the available nitrogen in soil compared to initial value.

With regard to nutrient management practices (Table 56a), the available nitrogen was increase with increase in nutrient levels. The highest available nitrogen present in the soil was observed from treatment F₂ (273.77 kg ha^{-1}) and while the lowest was seen at F₀ (247.87 kg ha^{-1}). The higher obtained of available nitrogen under the application of nutrient at 100 % RDF was might be due to sufficient supply of nutrients to the soil.

The interaction result showed that both different row ratio and nutrient management practices caused a significant variation in available nitrogen present in the soil (Table 56b). Among all the treatment combinations, the highest available nitrogen present in the soil was observed at treatment C₃F₂ (296.83 kg ha⁻¹) followed by C₂F₂ (292.84 kg ha⁻¹) and the lowest available nitrogen was recorded at C₇F₀ (230.43 kg ha⁻¹), C₁F₀ (237.64 kg ha⁻¹) and C₆F₀ (238.59 kg ha⁻¹) as compared to other treatments.

4.5.1.3 Available phosphorus (kg ha⁻¹)

Results (Table 56a) showed that available phosphorus present in the soil was significantly improved by both factor of different row ratio and nutrient management. The highest available phosphorus present in the soil was recorded under sole stand of fodder rice bean (C₃- 23.69 kg ha⁻¹) and fodder cowpea (C₂- 23.49 kg ha⁻¹), while the lowest available phosphorus in the soil was observed at C₁ (22.09 kg ha⁻¹). In case of nutrient management practices, the highest available phosphorus was obtained at F₂ (24.15 kg ha⁻¹) as compared to F₁ (22.89 kg ha⁻¹) and F₀ (21.62 kg ha⁻¹). Kumar and Faruqui (2010) evaluated the production potential and economics of food-forage based cropping system. They reported that intercropping of maize-berseem with legumes improve the available phosphorus after harvested. Similarly, Dahmardeh *et al.* (2010): Adeleke and Haruna (2012) also reported the increased in available phosphorus as compared to monocrop maize.

The interaction result (Table 56b) revealed that both factors had a significant impact on available phosphorus present in the soil. The interaction data showed that the crop grow at different row ratio along with higher doses of nutrient application recorded the highest available phosphorus present in the soil. Among all the treatment combinations, the highest available phosphorus was observed from C₂F₂ (25.90 kg ha⁻¹) and C₃F₂ (24.52 kg ha⁻¹). The lowest was obtained at C₁F₀ (20.47 kg ha⁻¹) as compared to all other treatments.

4.5.1.4 Available potassium (kg ha⁻¹)

It is evident from the results (Table 56a) that available potassium present in the soil was significantly influenced by both factors approaches. The available

potassium present in the soil ranged from 135.06 kg ha⁻¹ to 172.67 kg ha⁻¹. Among the different row ratio, wide range of available potassium was observed in all the treatments. The highest available potassium present in the soil was recorded at C₂ (172.67 kg ha⁻¹) and C₃ (169.37 kg ha⁻¹). The lowest available potassium was registered from treatments C₇ (135.06 kg ha⁻¹) and C₆ (136.20 kg ha⁻¹) in compared to other treatments. With regard to nutrient management approaches, the highest available potassium was registered at F₂ (156.45 kg ha⁻¹), while the lowest available potassium present in the soil was recorded at F₀ (139.29 kg ha⁻¹) and then at F₁ (146.50 kg ha⁻¹) respectively. This finding was in collateral with Dahmardeh *et al.* (2010); Adeleke and Haruna (2012). They also observed the increase in available potassium after harvest than initial value.

The interaction result (Table 56b) showed that sole stand of fodder cowpea and fodder rice bean which received nutrient @ 100 % RDF significantly recorded the highest available potassium present in the soil as compared to other treatment combinations. The treatment C₃F₂ (191.61 kg ha⁻¹) followed by C₂F₂ (186.01 kg ha⁻¹) recorded the highest available potassium among all the treatment combinations. The lowest available potassium was registered at C₇F₀ (128.71 kg ha⁻¹) followed by C₆F₀ (132.41 kg ha⁻¹) and C₁F₀ (132.99 kg ha⁻¹) respectively.

Table 55a. Physical properties of soil after field operation

Treatments	Soil pH			Organic Carbon (%)		
	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system						
C ₁ - Sole Maize (M)	5.27	5.29	5.28	0.99	1.00	1.00
C ₂ - Sole Cowpea (C)	5.28	5.22	5.25	1.03	1.04	1.03
C ₃ - Sole Rice bean (R)	5.26	5.24	5.25	1.03	1.05	1.04
C ₄ - M + C (1:1)	5.25	5.24	5.25	1.01	1.02	1.02
C ₅ - M + R (1:1)	5.28	5.27	5.28	1.04	1.05	1.05
C ₆ - M + C (2:1)	5.29	5.25	5.27	1.02	1.03	1.02
C ₇ - M + R (2:1)	5.26	5.22	5.24	1.01	1.02	1.02
C ₈ - M + C (2:2)	5.27	5.24	5.26	1.02	1.03	1.02
C ₉ - M + R (2:2)	5.27	5.25	5.26	1.01	1.03	1.02
SEm±	NS	NS	NS	NS	NS	NS
CD (P=0.05)	NS	NS	NS	NS	NS	NS
2. Nutrient management						
F ₀ - Control	5.29	5.27	5.28	0.97	0.92	0.94
F ₁ - 50 % NPK	5.27	5.24	5.26	1.01	1.00	1.01
F ₂ - 100 % NPK	5.24	5.24	5.24	1.07	1.17	1.12
SEm±	NS	NS	NS	NS	NS	NS
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Interaction (C x F)	NS	NS	NS	NS	NS	NS

Table 56a. Effect of row ratio and nutrient management on available NPK after harvest

Treatments	Available N (kg ha ⁻¹)			Available P ₂ O ₅ (kg ha ⁻¹)			Available K ₂ O (kg ha ⁻¹)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	242.69	248.42	245.56	21.70	22.48	22.09	137.30	141.00	139.15
C ₂ - Sole Cowpea (C)	274.98	278.09	276.54	22.92	24.06	23.49	169.89	175.45	172.67
C ₃ - Sole Rice bean (R)	278.32	282.76	280.54	23.08	24.30	23.69	164.88	173.86	169.37
C ₄ - M + C (1:1)	259.44	261.84	260.64	23.08	23.05	23.06	144.40	145.89	145.15
C ₅ - M + R (1:1)	265.42	271.58	268.50	22.84	23.60	23.22	150.90	142.16	146.53
C ₆ - M + C (2:1)	250.97	252.34	251.65	21.59	23.80	22.69	141.41	130.98	136.20
C ₇ - M + R (2:1)	245.94	249.02	247.48	23.40	22.28	22.84	138.41	131.71	135.06
C ₈ - M + C (2:2)	258.05	263.87	260.96	22.13	22.76	22.44	144.40	148.13	146.27
C ₉ - M + R (2:2)	253.76	258.13	255.95	22.40	22.56	22.48	139.17	133.55	136.36
SEm±	2.23	1.82	1.44	0.28	0.27	0.19	1.50	1.92	1.22
CD (P=0.05)	6.33	5.18	4.04	0.79	0.77	0.54	4.24	5.44	3.41
2. Nutrient management									
F ₀ - Control	246.55	249.19	247.87	21.15	22.08	21.62	139.65	138.93	139.29
F ₁ - 50 % NPK	258.55	263.37	260.96	22.45	23.34	22.89	146.88	146.13	146.50
F ₂ - 100 % NPK	271.42	276.13	273.77	24.10	24.20	24.15	157.06	155.84	156.45
SEm±	1.29	1.05	0.83	0.16	0.16	0.11	0.86	1.11	0.70
CD (P=0.05)	3.65	2.99	2.33	0.46	0.44	0.31	2.45	3.14	1.97

Table 55b. Interaction effect of row ratio and nutrient management on available NPK after harvest

Interaction (C X F)	Available N (kg ha ⁻¹)			Available P ₂ O ₅ (kg ha ⁻¹)			Available K ₂ O (kg ha ⁻¹)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	236.61	238.67	237.64	19.59	21.34	20.47	131.89	134.08	132.99
C ₁ F ₁	245.85	245.60	245.73	21.28	22.33	21.80	135.39	139.04	137.21
C ₁ F ₂	245.60	261.00	253.30	24.21	23.78	24.00	144.61	149.87	147.24
C ₂ F ₀	259.47	261.53	260.50	20.08	23.06	21.57	160.87	166.39	163.63
C ₂ F ₁	273.87	278.67	276.27	22.12	23.89	23.00	165.48	171.28	168.38
C ₂ F ₂	291.60	294.08	292.84	26.57	25.22	25.90	183.32	188.69	186.01
C ₃ F ₀	266.92	270.51	268.71	22.43	22.99	22.71	147.16	149.63	148.39
C ₃ F ₁	271.81	280.33	276.07	23.12	24.54	23.83	163.43	172.80	168.11
C ₃ F ₂	296.21	297.45	296.83	23.68	25.37	24.52	184.07	199.15	191.61
C ₄ F ₀	241.80	250.79	246.29	20.89	21.42	21.15	132.99	140.96	136.97
C ₄ F ₁	259.27	261.32	260.29	23.89	23.45	23.67	141.01	147.60	144.31
C ₄ F ₂	277.27	273.41	275.34	24.45	24.29	24.37	159.20	149.12	154.16
C ₅ F ₀	252.92	261.39	257.15	22.15	22.19	22.17	141.89	137.47	139.68
C ₅ F ₁	262.93	270.88	266.91	22.97	23.83	23.40	147.79	142.37	145.08
C ₅ F ₂	280.40	282.47	281.43	23.39	24.77	24.08	163.01	146.64	154.82
C ₆ F ₀	240.67	236.51	238.59	20.64	23.27	21.95	136.32	128.51	132.41
C ₆ F ₁	249.60	252.93	251.27	21.28	23.93	22.60	143.20	129.81	136.51
C ₆ F ₂	262.64	267.57	265.11	22.84	24.19	23.52	144.72	134.61	139.67
C ₇ F ₀	228.93	231.93	230.43	22.01	20.98	21.50	133.29	124.13	128.71
C ₇ F ₁	250.73	250.73	250.73	23.28	22.34	22.81	140.19	133.41	136.80
C ₇ F ₂	258.16	264.40	261.28	24.89	23.51	24.20	141.75	137.57	139.66
C ₈ F ₀	248.20	247.95	248.07	20.96	21.94	21.45	140.64	132.93	136.79
C ₈ F ₁	256.93	265.92	261.43	22.02	22.85	22.43	143.13	150.13	146.63
C ₈ F ₂	269.01	277.73	273.37	23.40	23.50	23.45	149.43	161.33	155.38
C ₉ F ₀	243.41	243.41	243.41	21.63	21.57	21.60	131.84	136.32	134.08
C ₉ F ₁	255.99	263.95	259.97	22.07	22.91	22.49	142.27	128.72	135.49
C ₉ F ₂	261.89	267.03	264.46	23.49	23.21	23.35	143.41	135.60	139.51
SEm±	3.86	3.16	2.49	0.48	0.47	0.34	2.59	3.32	2.11
CD (P=0.05)	10.96	8.96	7.00	1.37	1.33	0.94	7.35	9.42	5.91

4.5.2 Plant analysis

4.5.2.1 Nitrogen content (%)

The nitrogen content in fodder maize was ranged from 1.419 % to 1.507 % (Table 57a). Among the different row ratio, the highest nitrogen content in fodder maize was observed at C₉ (1.507 %) followed by C₈ (1.478 %). The lowest available nitrogen content was found in treatment C₁ (1.419 %). In response to nutrient management, the nitrogen content in fodder maize was increase with increasing the nutrient application rate. The highest nitrogen content was registered at F₂ (1.672 %) in comparison with F₁ (1.441 %) and F₀ (1.233 %). In a same way, the highest nitrogen content in maize was observed in 2:2 row ratio followed by 1:1 and 2:1 row ratio as compared to pure stand maize (Arif, 2024).

Result (Table 57b) showed that the combinations of different row ratio of fodder maize with fodder legume and nutrient management practices were differed significantly. Among all the treatment combinations, the highest nitrogen content in fodder maize was observed from treatment C₇F₂ (1.783 %) followed by C₆F₂ (1.778 %), C₈F₂ (1.708 %) and C₁F₂ (1.703 %). The lowest nitrogen content was registered from treatments C₇F₀ (1.022 %) and C₆F₀ (1.143 %) as compared to other treatment combinations. The higher nitrogen content in fodder maize was probably due to adequate application of nutrients and the contribution nitrogen from legume crops through fixation. Likewise, Singh *et al.* (2020) studied the different row ratio *i.e.*, sole crop, 1:1 and 2:1 with different nutrient levels *i.e.*, 50 %, 75 % and 100 % RDF. They observed the highest nitrogen content in maize at 2:1 and 1:1 row ratio which received 100 % RDF application as compared to sole crop.

Regarding the fodder legume crop, the result (Table 58a) revealed that nitrogen content in fodder cowpea was found to be significant by growing together with fodder maize at different row ratio along with nutrient management practices. The highest nitrogen content was observed at sole crop C₈ (2.487 %), while the lowest nitrogen content in fodder cowpea was recorded at C₂ (2.182 %). Incase of nutrient management approaches, the nitrogen content in fodder cowpea was observed to be

increase with increase in nutrient levels. Among the treatments, F₂ (3.316 %) recorded the highest nitrogen content than treatment F₁ (2.327 %) and F₀ (1.348 %) respectively. Similarly, Arif *et al.* (2024) also registered the higher nitrogen content in cowpea grown with maize at 2:2 row ratio and followed by 1:1 and 2:1 row ratio.

The interaction of different row ratio and nutrient management had a significant impact on nitrogen content in fodder cowpea (Table 58b). Among the treatment combinations, the highest nitrogen content in fodder cowpea was observed at C₈F₂ (3.402 %) followed by C₆F₂ (3.395 %), C₄F₂ (3.287 %) and C₁F₂ (3.178 %). This was in accordance with Singh (2020). The lowest content of nitrogen in fodder cowpea was registered at C₁F₀ (1.089 %) and C₆F₀ (1.267 %). The higher content was mainly due to higher doses of nutrients applied in the soil and the nitrogen fixation by the legume crop.

In case of fodder rice bean (Table 59a), the nitrogen content in fodder rice bean were ranged from 2.171 % to 2.304 %. The highest nitrogen content was recorded under sole stand C₅ (2.304 %) followed by C₉ (2.229 %), while the lowest nitrogen content was observed at C₃ (2.171 %) and C₇ (2.190 %) when compared to other treatments. Regarding the nutrient management practices, the treatment F₂ (2.540 %) registered the highest nitrogen content, while the treatment F₀ (1.888 %) maintained the lowest content of nitrogen in fodder rice bean. The higher nitrogen content in maize grown with cowpea at 2:2 row ratio followed by 1:1 and 2:1 row ratio as compared to sole crop was also reported by Arif *et al.* (2024).

The data presented in the Table 59b revealed that interaction of different row ratio and nutrient management approaches caused a significant impact in nitrogen content of fodder rice bean. The application of nutrient at different levels caused a variation in nitrogen content among the treatment combinations. The highest content of nitrogen in fodder rice bean was recorded from C₃F₂ (2.634 %) and then at C₇F₂ (2.583 %). Likewise, the least nitrogen content was recorded at C₇F₀ (1.709 %), C₃F₀ (1.859 %) and C₅F₀ (1.948 %) respectively. Singh *et al.* (2020) studied the different row ratio *i.e.*, sole crop, 1:1 and 2:1 with different nutrient levels *i.e.*, 50 %, 75 % and 100 %

RDF. They reported that application of 100 % RDF under 2:2 and 1:1 row ratio produced the highest nitrogen content in rice bean.

4.5.2.1 Phosphorus content (%)

The result (Table 57a) showed that phosphorus content in the fodder maize was found to be significant. Among the different row ratio, the highest phosphorus content in the fodder maize was recorded at C₉ (0.230 %) followed by C₆ (0.229 %) and C₈ (0.228 %). The lower and similar trend of phosphorus content in fodder maize was obtained at C₁ (0.215 %) and C₄ (0.217 %). Regarding the nutrient management approaches, the higher phosphorus content was observed at F₂ (0.237 %), while the lowest was observed at F₀ (0.213 %). This finding was in conformity with the findings reported by Arif *et al.* (2024). They observed the highest phosphorus content in cowpea grown with maize at 2:2 row ratio followed by 1:1 and 2:1 row ratio as compared to sole crop.

The interaction result (Table 57b) showed that the phosphorus content in fodder maize was differed in both the factors. The higher and comparable phosphorus content in fodder maize was seen at treatment C₉F₂ (0.247 %), C₄F₂ (0.244 %), C₆F₂ (0.239 %) and C₉F₂ (0.237 %). Among all the treatments, the lowest phosphorus content was observed at C₁F₀ (0.194 %) and then at C₄F₀ (0.209 %) respectively. Singh *et al.* (2020) studied the different row ratio and nutrient management interaction. They observed the highest phosphorus content in maize at 2:1 and 1:1 row ratio which received 100 % RDF application as compared to sole crop.

The phosphorus content (Table 58a) in fodder cowpea was found to be highest at C₈ (0.247 %) when it was grown together with fodder maize at 2:2 row ratio and the lowest phosphorus content was observed from C₂ (0.230 %). Regarding the nutrient management practices, the phosphorus content in fodder cowpea was not much differed from each other. The higher and comparable phosphorus content was observed at F₂ (0.249 %) and then at F₁ (0.237 %) and F₀ (0.225 %). Similarly, the higher phosphorus content in cowpea was recorded under growing with maize at 2:2 row ratio followed by 1:1 and 2:1 row ratio (Arif *et al.*, 2024).

The interaction result (Table 58b) reported that treatments receiving higher doses of nutrient applications maintained the higher phosphorus content in fodder cowpea than those treatment which received lower or did not receive nutrient applications. Among all the treatment combinations, the highest phosphorus content in fodder cowpea was registered at C₉F₂ (0.260 %) and followed by C₆F₂ (0.254 %). The lowest content was observed at treatment C₂F₀ (0.219 %).

The phosphorus content in fodder rice bean was found in similar trends (Table 59a). Among the different row ratio, the higher and comparable phosphorus content in fodder rice bean was recorded at C₉ (0.247 %) and C₅ (0.246 %), while the least content was obtained at C₃ (0.240 %). Similarly, the nutrient management practices did not cause much differed in the phosphorus content of fodder rice bean. The highest phosphorus content was observed at F₂ (0.249 %) followed by F₁ (0.244 %) and the lowest content of phosphorus in fodder rice bean was seen at F₀ (0.239 %) respectively. Likewise, the higher phosphorus content in cowpea was recorded under growing with maize at 2:2 row ratio followed by 1:1 and 2:1 row ratio (Arif *et al.*, 2024).

The interaction result (Table 59b) showed that both factors caused a differed in phosphorus content among the treatment combinations. Among the treatment combinations, the phosphorus content in fodder rice bean was increase with increase in nutrient doses. The higher and comparable phosphorus content in fodder rice bean was observed at C₇F₂ (0.253 %), C₅F₂ (0.251 %) and C₉F₂ (0.250 %) as compared to other treatment combinations. The lowest content of phosphorus in fodder rice bean was recorded from C₇F₀ (0.234 %) and C₃F₀ (0.237 %) respectively. In a same manner, Singh *et al.* (2020) also recorded the higher phosphorus content in rice bean under 2:1 and 1:1 row ratio with application of 100 % RDF.

4.5.2.1 Potassium content (%)

The results (Table 57a) revealed that potassium content in fodder maize was significantly influence with different row ratio and nutrient management practices. With regard to different row ratio, the highest potassium content in fodder maize was

registered at C₉ (1.736 %) and then at C₈ (1.702 %). The lowest potassium content in fodder maize was observed from C₁ (1.577 %), C₆ (1.624 %) and C₅ (1.627 %) as compared to other treatments. Among the nutrient management approaches, the highest potassium content in fodder maize was obtained at F₂ (1.948 %) in comparison with F₁ (1.648 %) and F₀ (1.367 %). This finding result was in same trends with the results findings reported by Arif *et al.* (2024).

Data presented in the Table 57b showed that combinations of both different row ratio and nutrient management had significant impact on potassium content in fodder maize. Among all the treatment combinations, the highest potassium content was registered at C₈F₂ (2.117 %) followed by C₉F₂ (2.043 %) and C₆F₂ (2.027 %). The similar lower trend of potassium content in fodder maize was recorded at C₇F₀ (1.357 %) followed by C₅F₀ (1.373 %), C₉F₀ (1.390 %), C₁F₀ (1.393 %) and C₈F₀ (1.393 %) respectively. Singh *et al.* (2020) also recorded the higher phosphorus content in rice bean under 2:1 and 1:1 with application of 100 % RDF.

The data (Table 58a) showed that potassium content in fodder cowpea was vary with response to different row ratio practices. Among all the treatments, the highest potassium content in fodder cowpea was recorded at C₈ (1.119 %) and the lowest potassium content was obtained at C₁ (1.011 %) as compared to remaining treatments. With regard to nutrient management practices, the potassium content in fodder cowpea was found to be highest in F₂ (1.191 %) when with F₁ (1.069 %) and F₀ (0.926 %). Identically, the higher potassium content in cowpea was observed at 2:2, 1:1 and 2:1 row ratio as compared to sole crop (Arif *et al.*, 2024).

The results (Table 58b) of factor interactions showed that potassium content in fodder cowpea was vary from each other. Among all the treatment combinations, the highest potassium content was observed from C₈F₂ (1.243 %) followed by C₄F₂ (1.207 %). Similarly, the lowest potassium content in fodder cowpea was recorded at C₄F₀ (0.887 %) and C₆F₀ (0.900 %). This finding was in accordance with Singh *et al.* (2020).

Results (Table 59a) showed that potassium content in fodder rice bean was in similar trends when it was grown with fodder maize at different row ratio. Among

the treatments, the higher and comparable potassium content in fodder rice bean was recorded at C₅ (1.090 %) and the lowest content was observed at C₃ (1.036 %) respectively. In response to nutrient management, the potassium content in fodder rice bean was found increase with increase in nutrient application. The higher potassium content was recorded at F₂ (1.248 %) as compared to treatments F₁ (1.088 %) and F₀ (0.866 %) respectively.

The interaction results (Table 59b) revealed that both different row ratio and nutrient management approaches caused a significant influenced on potassium content in fodder rice bean. Among all the treatment combinations, the highest potassium content in fodder rice bean was observed at C₅F₂ (1.267 %) followed by C₇F₂ (1.257 %) and C₉F₂ (1.257 %). The lowest content of potassium in fodder rice bean was registered at C₉F₀ (0.813 %) and C₃F₀ (0.833 %) respectively. The similar findings were also reported by Singh *et al.* (2020).

Table 57a. Effect of row ratio and nutrient management on nutrient content in maize

Treatments	Nutrient content (%)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	1.356	1.481	1.419	0.214	0.216	0.215	1.498	1.656	1.577
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	1.399	1.475	1.437	0.213	0.222	0.217	1.619	1.729	1.674
C ₅ - M + R (1:1)	1.440	1.456	1.448	0.224	0.226	0.225	1.664	1.622	1.643
C ₆ - M + C (2:1)	1.406	1.450	1.428	0.225	0.233	0.229	1.616	1.638	1.627
C ₇ - M + R (2:1)	1.384	1.468	1.426	0.223	0.228	0.225	1.571	1.677	1.624
C ₈ - M + C (2:2)	1.459	1.496	1.478	0.224	0.232	0.228	1.722	1.682	1.702
C ₉ - M + R (2:2)	1.487	1.528	1.507	0.230	0.231	0.230	1.751	1.720	1.736
SEm±	0.018	0.020	0.014	0.001	0.002	0.001	0.019	0.019	0.014
CD (P=0.05)	0.052	0.058	0.038	0.004	0.005	0.003	0.054	0.055	0.038
2. Nutrient management									
F ₀ - Control	1.197	1.269	1.233	0.210	0.217	0.213	1.400	1.334	1.367
F ₁ - 50 % NPK	1.404	1.479	1.441	0.220	0.225	0.223	1.663	1.634	1.648
F ₂ - 100 % NPK	1.655	1.689	1.672	0.235	0.238	0.237	1.840	2.056	1.948
SEm±	0.011	0.012	0.008	0.001	0.001	0.001	0.011	0.011	0.008
CD (P=0.05)	0.030	0.033	0.022	0.002	0.003	0.002	0.031	0.032	0.022

Table 57b. Interaction effect of row ratio and nutrient management on nutrient content in maize

Interaction (C X F)	Nutrient content (%)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	1.195	1.307	1.251	0.193	0.196	0.194	1.347	1.440	1.393
C ₁ F ₁	1.232	1.372	1.302	0.210	0.212	0.211	1.510	1.553	1.532
C ₁ F ₂	1.643	1.764	1.703	0.239	0.239	0.239	1.637	1.973	1.805
C ₂ F ₀	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-
C ₄ F ₀	1.213	1.307	1.260	0.192	0.209	0.200	1.407	1.440	1.423
C ₄ F ₁	1.419	1.531	1.475	0.207	0.214	0.210	1.637	1.767	1.702
C ₄ F ₂	1.564	1.587	1.575	0.239	0.244	0.242	1.813	1.980	1.897
C ₅ F ₀	1.251	1.363	1.307	0.216	0.218	0.217	1.433	1.313	1.373
C ₅ F ₁	1.503	1.493	1.498	0.222	0.226	0.224	1.707	1.593	1.650
C ₅ F ₂	1.568	1.512	1.540	0.234	0.234	0.234	1.853	1.960	1.907
C ₆ F ₀	1.092	1.195	1.143	0.214	0.231	0.223	1.433	1.047	1.240
C ₆ F ₁	1.325	1.400	1.363	0.230	0.232	0.231	1.633	1.593	1.613
C ₆ F ₂	1.801	1.755	1.778	0.231	0.238	0.234	1.780	2.273	2.027
C ₇ F ₀	1.017	1.027	1.022	0.217	0.217	0.217	1.333	1.380	1.357
C ₇ F ₁	1.428	1.521	1.475	0.228	0.233	0.231	1.667	1.677	1.672
C ₇ F ₂	1.708	1.857	1.783	0.224	0.232	0.228	1.713	1.973	1.843
C ₈ F ₀	1.223	1.232	1.227	0.211	0.231	0.221	1.473	1.313	1.393
C ₈ F ₁	1.465	1.531	1.498	0.222	0.230	0.226	1.680	1.513	1.597
C ₈ F ₂	1.689	1.727	1.708	0.240	0.234	0.237	2.013	2.220	2.117
C ₉ F ₀	1.391	1.456	1.423	0.225	0.217	0.221	1.373	1.407	1.390
C ₉ F ₁	1.456	1.503	1.479	0.224	0.228	0.226	1.807	1.740	1.773
C ₉ F ₂	1.615	1.624	1.619	0.241	0.247	0.244	2.073	2.013	2.043
SEm±	0.032	0.035	0.024	0.002	0.003	0.002	0.033	0.034	0.023
CD (P=0.05)	0.090	0.100	0.066	0.007	0.008	0.005	0.093	0.095	0.066

Table 58a. Effect of row ratio and nutrient management on nutrient content in cowpea

Treatments	Nutrient content (%)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	2.098	2.266	2.182	0.229	0.230	0.230	0.878	1.144	1.011
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	2.309	2.356	2.333	0.229	0.239	0.234	0.973	1.162	1.068
C ₅ - M + R (1:1)	-	-	-	-	-	-	-	-	-
C ₆ - M + C (2:1)	2.151	2.488	2.319	0.237	0.239	0.238	0.958	1.141	1.049
C ₇ - M + R (2:1)	-	-	-	-	-	-	-	-	-
C ₈ - M + C (2:2)	2.374	2.601	2.487	0.245	0.249	0.247	1.073	1.164	1.119
C ₉ - M + R (2:2)	-	-	-	-	-	-	-	-	-
SEm±	0.017	0.022	0.014	0.002	0.001	0.001	0.006	0.007	0.004
CD (P=0.05)	0.049	0.062	0.039	0.004	0.003	0.003	0.016	0.019	0.012
2. Nutrient management									
F ₀ - Control	1.281	1.415	1.348	0.221	0.229	0.225	0.818	1.033	0.926
F ₁ - 50 % NPK	2.199	2.454	2.327	0.237	0.237	0.237	0.985	1.153	1.069
F ₂ - 100 % NPK	3.218	3.414	3.316	0.246	0.252	0.249	1.108	1.273	1.191
SEm±	0.010	0.013	0.008	0.001	0.001	0.001	0.003	0.004	0.003
CD (P=0.05)	0.028	0.036	0.022	0.003	0.002	0.002	0.009	0.011	0.007

Table 58b. Interaction effect of row ratio and nutrient management on nutrient content in cowpea

Interaction (C X F)	Nutrient content (%)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-
C ₂ F ₀	1.039	1.138	1.089	0.218	0.221	0.219	0.753	1.020	0.887
C ₂ F ₁	2.169	2.387	2.278	0.236	0.230	0.233	0.873	1.140	1.007
C ₂ F ₂	3.085	3.271	3.178	0.232	0.241	0.237	1.007	1.273	1.140
C ₃ F ₀	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-
C ₄ F ₀	1.349	1.481	1.415	0.213	0.228	0.221	0.787	1.067	0.927
C ₄ F ₁	2.283	2.309	2.296	0.234	0.237	0.235	1.007	1.133	1.070
C ₄ F ₂	3.295	3.279	3.287	0.241	0.251	0.246	1.127	1.287	1.207
C ₅ F ₀	-	-	-	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-	-	-	-
C ₆ F ₀	1.247	1.286	1.267	0.221	0.231	0.226	0.787	1.013	0.900
C ₆ F ₁	1.991	2.601	2.296	0.234	0.233	0.234	0.987	1.163	1.075
C ₆ F ₂	3.214	3.577	3.395	0.254	0.254	0.254	1.100	1.247	1.173
C ₇ F ₀	-	-	-	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-	-	-	-
C ₈ F ₀	1.490	1.757	1.623	0.232	0.235	0.233	0.947	1.033	0.990
C ₈ F ₁	2.353	2.521	2.437	0.245	0.250	0.248	1.073	1.173	1.123
C ₈ F ₂	3.278	3.527	3.402	0.258	0.261	0.260	1.200	1.287	1.243
C ₉ F ₀	-	-	-	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-	-	-	-
SEm±	0.030	0.038	0.024	0.003	0.002	0.002	0.010	0.011	0.008
CD (P=0.05)	0.084	0.107	0.067	0.008	0.006	0.005	0.028	0.032	0.021

Table 59a. Effect of row ratio and nutrient management on nutrient content in rice bean

Treatments	Nutrient content (%)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	2.092	2.251	2.171	0.240	0.240	0.240	1.013	1.058	1.036
C ₄ - M + C (1:1)	-	-	-	-	-	-	-	-	-
C ₅ - M + R (1:1)	2.237	2.372	2.304	0.245	0.246	0.246	1.062	1.118	1.090
C ₆ - M + C (2:1)	-	-	-	-	-	-	-	-	-
C ₇ - M + R (2:1)	2.132	2.249	2.190	0.242	0.245	0.243	1.076	1.060	1.068
C ₈ - M + C (2:2)	-	-	-	-	-	-	-	-	-
C ₉ - M + R (2:2)	2.154	2.305	2.229	0.246	0.247	0.247	1.056	1.098	1.077
SEm±	0.012	0.011	0.008	0.001	0.001	0.001	0.006	0.005	0.004
CD (P=0.05)	0.035	0.032	0.023	0.004	0.004	0.003	0.018	0.014	0.011
2. Nutrient management									
F ₀ - Control	1.897	1.878	1.888	0.239	0.240	0.239	0.852	0.880	0.866
F ₁ - 50 % NPK	2.149	2.339	2.244	0.244	0.244	0.244	1.073	1.103	1.088
F ₂ - 100 % NPK	2.414	2.665	2.540	0.248	0.250	0.249	1.230	1.267	1.248
SEm±	0.007	0.006	0.005	0.001	0.001	0.001	0.004	0.003	0.002
CD (P=0.05)	0.020	0.018	0.013	0.002	0.002	0.002	0.010	0.008	0.006

Table 59b. Interaction effect of row ratio and nutrient management on nutrient content in rice bean

Interaction (C X F)	Nutrient content (%)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-
C ₃ F ₀	1.836	1.882	1.859	0.237	0.237	0.237	0.800	0.867	0.833
C ₃ F ₁	2.069	2.307	2.188	0.239	0.239	0.239	1.100	1.020	1.060
C ₃ F ₂	2.369	2.564	2.467	0.243	0.244	0.244	1.140	1.287	1.213
C ₄ F ₀	-	-	-	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-	-	-	-
C ₅ F ₀	1.827	2.068	1.948	0.241	0.241	0.241	0.887	0.987	0.937
C ₅ F ₁	2.303	2.359	2.331	0.246	0.247	0.248	1.033	1.100	1.067
C ₅ F ₂	2.579	2.688	2.634	0.250	0.251	0.251	1.267	1.267	1.267
C ₆ F ₀	-	-	-	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-	-	-	-
C ₇ F ₀	1.857	1.560	1.709	0.233	0.236	0.234	0.920	0.840	0.880
C ₇ F ₁	2.113	2.445	2.279	0.243	0.243	0.243	1.033	1.100	1.067
C ₇ F ₂	2.424	2.741	2.583	0.249	0.256	0.253	1.273	1.240	1.257
C ₈ F ₀	-	-	-	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-	-	-	-
C ₉ F ₀	2.068	2.003	2.035	0.244	0.244	0.244	0.800	0.827	0.813
C ₉ F ₁	2.111	2.244	2.177	0.246	0.247	0.246	1.127	1.193	1.160
C ₉ F ₂	2.283	2.668	2.475	0.249	0.250	0.250	1.240	1.273	1.257
SEm±	0.021	0.019	0.014	0.002	0.002	0.002	0.011	0.008	0.007
CD (P=0.05)	0.061	0.055	0.040	0.007	0.007	0.005	0.031	0.024	0.019

4.5.3 Nutrient uptake

4.5.3.1 Nitrogen uptake

The data (Table 60a) revealed that both factors had a significant impact on nutrient uptake by fodder maize. Among the different row ratio, the crop grown under sole stand C_1 ($165.60 \text{ kg ha}^{-1}$) registered the highest nitrogen uptake by fodder maize as compared to other treatments. The lower and comparable nitrogen uptake by fodder maize was observed at C_5 ($104.53 \text{ kg ha}^{-1}$) and C_4 ($108.19 \text{ kg ha}^{-1}$) respectively. The nutrient management practices caused a significant variation on nitrogen uptake by fodder maize. The highest nitrogen uptake was observed at F_2 ($172.30 \text{ kg ha}^{-1}$) as compared to treatments F_1 ($123.17 \text{ kg ha}^{-1}$) and F_0 (78.90 kg ha^{-1}). The highest uptake of nitrogen by sole fodder maize was due to higher yield production of the crop. Similarly, the higher uptake of nitrogen by maize was also reported by Arif *et al.* (2024); Yadev *et al.* (2022) and Malunga *et al.* (2017). Likewise, Porte *et al.* (2019) also revealed the higher nitrogen uptake under the application of higher nitrogen ($160 \text{ kg ha}^{-1} \text{ N}$) then 80 kg ha^{-1} and 120 kg ha^{-1} .

It is evident from the result (Table 60b) that nitrogen uptake by fodder maize was significantly influenced by combinations of both different row ratio and nutrient management approaches. The higher nitrogen uptake was registered from the treatment receiving higher levels of nutrients application. Among the treatment combinations, the highest nitrogen uptake by fodder maize was registered at C_1F_2 ($233.80 \text{ kg ha}^{-1}$). The lowest nitrogen uptake by fodder maize was observed at C_5F_0 (67.49 kg ha^{-1}), C_8F_0 (69.51 kg ha^{-1}) followed by C_4F_0 (71.79 kg ha^{-1}), C_7F_0 (75.74 kg ha^{-1}) and C_9F_0 (76.67 kg ha^{-1}) respectively.

The nitrogen uptake by fodder cowpea was found significantly differed by the combination of both different row ratio and nutrient management practices (Table 61a). In regards to different row ratio, the higher nitrogen uptake by fodder cowpea was recorded at sole plot C_2 ($125.66 \text{ kg ha}^{-1}$) and the lowest nitrogen uptake was obtained at C_6 (67.38 kg ha^{-1}). With reference to nutrient management practices, the nitrogen uptake by fodder cowpea was significantly increase with the increase in application of

nutrients. The treatment F₂ (143.97 kg ha⁻¹) recorded the highest nitrogen uptake by fodder cowpea. Eventually, the lowest uptake was obtained at F₀ (43.26 kg ha⁻¹) and then at F₁ (88.70 kg ha⁻¹). This finding was in collateral with the findings reported by Arif *et al.* (2024) and Yadav *et al.* (2022).

Data (Table 61b) revealed that interaction of both different row ratio and nutrient management approaches lead to significantly increase in the uptake of nitrogen by fodder cowpea. The application of nutrient at different levels caused a variation in nitrogen uptake by the plant. Among the treatment combinations, the highest nitrogen uptake by fodder cowpea was registered at C₂F₂ (188.50 kg ha⁻¹) and then it was observed from C₈F₂ (144.20 kg ha⁻¹) and C₄F₂ (135.04 kg ha⁻¹). The lowest nitrogen uptake among the treatment combinations was observed from treatment C₆F₀ (30.61 kg ha⁻¹), C₄F₀ (41.07 kg ha⁻¹) and C₈F₀ (43.49 kg ha⁻¹) respectively.

The result (Table 62a) showed that nitrogen uptake by fodder rice bean was remarkably influenced by both factors. The nitrogen uptake by fodder rice bean significantly varied from each other. Among the different row ratio, the sole plot C₃ (121.978 kg ha⁻¹) marked the highest nitrogen uptake by the fodder rice bean, while the lowest nitrogen uptake was recorded at C₇ (52.619 kg ha⁻¹). Incase of nutrient management operation, the data revealed that nitrogen uptake by fodder rice bean significantly affected by application of nutrients at different levels. The highest nitrogen uptake by fodder rice bean was seen at F₂ (97.484 kg ha⁻¹) as compared other treatments. Likewise, the lowest nitrogen uptake by fodder rice bean was observed at F₀ (53.447) and then at F₁ (80.296). The higher nitrogen uptake by cowpea under sole crop was also reported by Arif *et al.* (2024).

The interaction result (Table 62b) showed that implementations of both intercropping of fodder rice bean with fodder maize at different row ratio along with nutrient management improved the nitrogen uptake by fodder rice bean. The treatment combinations revealed that application of nutrient at 100 % RDF marked the highest nitrogen uptake than those treatments receiving 50 % RDF and 0 % RDF (control). Among all the treatment combinations, the highest nitrogen uptake was recorded at C₃F₂ (149.333 kg ha⁻¹) and C₃F₁ (125.273 kg ha⁻¹). The lowest nitrogen uptake was

observed at C₇F₀ (30.032 kg ha⁻¹), C₅F₀ (42.850 kg ha⁻¹) and C₉F₀ (49.581 kg ha⁻¹) respectively.

4.5.3.2 Phosphorus uptake

The phosphorus uptake by fodder maize was found to be significant (Table 60a). The phosphorus uptake by fodder maize ranged from 16.11 kg ha to 24.88 kg ha⁻¹. The highest phosphorus uptake by treatment under different row ratio was observed at C₁ (24.88 kg ha⁻¹) and the lowest phosphorus uptake was seen at C₅ (16.11 kg ha⁻¹) followed by C₄ (16.32 kg ha⁻¹). With regard to nutrient management practices, the phosphorus uptake was differed remarkably with increase in nutrient applications (Table 60a). The highest phosphorus uptake was recorded at F₂ (24.26 kg ha⁻¹), while the lowest phosphorus uptake was marked at F₀ (13.72 kg ha⁻¹). The highest phosphorus uptake by fodder maize under sole crop was also reported by Arif (2024): Dahmardeh *et al.* (2010): Kumar and Faruqui (2009).

The interaction of both different row ratio and nutrient management worked out significantly on phosphorus uptake by fodder maize (Table 60b). Among the treatment combinations, the highest phosphorus uptake by fodder maize was observed at C₁F₂ (32.76 kg ha⁻¹) followed by C₆F₂ (26.17 kg ha⁻¹) and C₇F₂ (25.23 kg ha⁻¹). Similarly, the lowest phosphorus uptake was recorded at treatment C₅F₀ (11.20 kg ha⁻¹) followed by C₄F₀ (11.44 kg ha⁻¹) and C₉F₀ (11.89 kg ha⁻¹) as compared to other treatments.

The result (Table 61a) showed that phosphorus uptake by fodder cowpea was significantly improved by both factors. Regarding the different row ratio, the highest phosphorus uptake was registered at sole plot C₂ (13.00 kg ha⁻¹). The lowest phosphorus uptake by fodder cowpea was obtained from C₆ (6.67 kg ha⁻¹) and C₄ (8.10 kg ha⁻¹). In response to nutrient management approaches, the highest phosphorus uptake was seen at F₂ (10.82 kg ha⁻¹) as compared to F₁ (9.18 kg ha⁻¹) and F₀ (7.88 kg ha⁻¹) respectively. This finding was in collateral with the findings reported by Arif *et al.* (2024) and Yadav *et al.* (2022).

The interaction result (Table 61b) revealed that interaction of both factors was remarkable. The highest phosphorus uptake by the fodder cowpea was registered at treatment C₂F₂ (14.03 kg ha⁻¹) and it was followed by C₂F₁ (13. kg ha⁻¹). Among all the treatment combinations, the lowest phosphorus uptake by fodder cowpea was recorded at C₆F₀ (5.48 kg ha⁻¹) and then at C₄F₀ (6.41 kg ha⁻¹) respectively.

The phosphorus uptake by fodder rice bean was significantly improved by both different row ratio and nutrient management (Table 62a). Among the different row ratio, the highest phosphorus uptake was seen in the treatment C₃ (12.609 kg ha⁻¹). Likewise, the lowest phosphorus uptake was recorded at C₇ (5.693 kg ha⁻¹). In case of nutrient management, the data (Table 62a) showed that the phosphorus uptake differed with application of nutrients. Among the treatments, the highest phosphorus uptake by fodder rice bean was observed at F₂ (9.450 kg ha⁻¹) in comparison with F₁ (8.634 kg ha⁻¹) and F₀ (6.699 kg ha⁻¹) respectively. Comparably, the highest uptake of phosphorus from sole crop was also reported by Arif *et al.* (2024) and Yadav *et al.* (2022).

The interaction result (Table 62b) disclosed that both factors *i.e.*, different row ratio and nutrient management operation caused a remarkable impact on phosphorus uptake by fodder rice bean. Among the factor interactions, the highest uptake of fodder rice bean was recorded at C₃F₂ (13.807 kg ha⁻¹) and C₃F₁ (12.856). Subsequently, the lowest phosphorus uptake was registered from treatment C₇F₀ (4.135 kg ha⁻¹), C₅F₀ (5.551 kg ha⁻¹) and C₉ (5.947 kg ha⁻¹) respectively.

4.5.3.3 Potassium uptake

The potassium uptake by fodder maize was varied remarkably by both factors (Table 60a). Among the different row ratio, the highest potassium uptake was registered at C₁ (183.44 kg ha⁻¹). The lowest uptake of potassium was seen at C₅ (120.15 kg ha⁻¹) and then C₄ (126.61 kg ha⁻¹) and C₈ (129.39 kg ha⁻¹). When it comes to nutrient management, the potassium uptake was increase with increase in nutrients application. The highest potassium uptake by fodder maize was obtained at F₂ (198.81 kg ha⁻¹) in compared with F₁ (140.93 kg ha⁻¹) and F₀ (88.03 kg ha⁻¹). Arif *et al.* (2024) and Yadav *et al.* (2022) also reported the highest uptake of potassium at sole crop

The result (Table 60b) of both factors interaction showed that potassium uptake significantly differed from each other. The highest uptake of potassium was observed from the treatments receiving higher levels of nutrient. Among all the treatment combinations, the highest potassium uptake by fodder maize was recorded at C₁F₂ (247.94 kg ha⁻¹) and then at C₆F₂ (226.61 kg ha⁻¹), C₇F₂ (203.86 kg ha⁻¹). The lowest uptake of potassium was registered at C₅F₀ (70.90 kg ha⁻¹), C₉F₀ (74.85 kg ha⁻¹) and C₈F₀ (78.81 kg ha⁻¹) respectively.

Result (Table 61a) showed that potassium uptake by fodder cowpea was significantly influenced by both factors. Among the different row ratio, the highest uptake of potassium was recorded at C₂ (57.52 kg ha⁻¹), while the lowest potassium uptake by fodder cowpea was observed at C₆ (29.67 kg ha⁻¹) and C₄ (37.42 kg ha⁻¹). With regard to nutrient management, the highest potassium uptake by fodder cowpea was registered at F₂ (51.88 kg ha⁻¹) and the lowest potassium uptake was recorded at F₀ (32.60 kg ha⁻¹). In the same way, Arif *et al.* (2024) and Yadav *et al.* (2022) also recorded the highest uptake of potassium at sole crop.

The interaction results (Table 61b) confirmed that both factors caused a significant variation in potassium uptake by the crop. From the data, it was found that the highest potassium uptake of fodder cowpea was recorded at C₂F₂ (67.67 kg ha⁻¹) followed by C₉F₂ (52.76 kg ha⁻¹) and C₄F₂ (49.76 kg ha⁻¹). Likewise, the lowest potassium uptake was recorded at C₆F₀ (22.05 kg ha⁻¹) and C₄F₀ (27.19 kg ha⁻¹) respectively.

Potassium uptake by fodder rice bean were affected by both factors (Table 62a). Regarding the different row ratio, the highest potassium uptake was recorded at C₃ (54.961 kg ha⁻¹) as compared to other treatments. The lowest potassium uptake by fodder rice bean was seen at C₇ (25.387 kg ha⁻¹). With response to nutrient management practices, the potassium uptake by fodder rice bean was significantly improved by application of nutrients. The highest potassium uptake was observed from F₂ (47.299 kg ha⁻¹) in compared with F₁ (38.632 kg ha⁻¹) and F₀ (24.016 kg ha⁻¹) respectively.

The interaction result (Table 62b) revealed that growing of fodder rice bean under different row ratio along with nutrient management caused a remarkable impact on potassium uptake by fodder rice bean. Among all the treatment combinations, the highest potassium uptake was observed from treatments C₃F₂ (68.801 kg ha⁻¹) and C₃F₁ (56.965 kg ha⁻¹). The lowest potassium uptake was recorded at C₇F₀ (15.457 kg ha⁻¹) followed by C₉F₀ (19.833 kg ha⁻¹) and C₅F₀ (21.655 kg ha⁻¹) respectively.

Table 60a. Effect of row ratio and nutrient management on nutrient uptake by maize

Treatments	Nutrient uptake (kg ha ⁻¹)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	155.18	176.02	165.60	24.28	25.47	24.88	169.88	197.00	183.44
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	102.42	113.97	108.19	15.53	17.10	16.32	118.55	134.67	126.61
C ₅ - M + R (1:1)	101.36	107.71	104.53	15.56	16.66	16.11	117.45	122.85	120.15
C ₆ - M + C (2:1)	130.30	139.42	134.86	20.19	21.90	21.05	146.47	161.36	153.92
C ₇ - M + R (2:1)	129.47	145.12	137.29	20.24	21.80	21.02	144.35	163.46	153.90
C ₈ - M + C (2:2)	106.66	116.80	111.73	16.18	17.65	16.91	125.85	132.93	129.39
C ₉ - M + R (2:2)	106.41	116.22	111.32	16.33	17.57	16.95	128.06	133.40	130.73
SEm±	1.70	2.02	1.32	0.14	0.20	0.12	1.63	1.69	1.17
CD (P=0.05)	4.82	5.74	3.70	0.40	0.58	0.35	4.61	4.80	3.29
2. Nutrient management									
F ₀ - Control	74.82	82.97	78.90	13.18	14.25	13.72	88.13	87.93	88.03
F ₁ - 50 % NPK	114.03	132.31	123.17	18.06	20.18	19.12	135.39	146.46	140.93
F ₂ - 100 % NPK	167.63	176.98	172.30	23.74	24.78	24.26	183.87	213.76	198.81
SEm±	0.98	1.17	0.76	0.08	0.12	0.07	0.94	0.98	0.68
CD (P=0.05)	2.78	3.31	2.14	0.23	0.33	0.20	2.66	2.77	1.90

Table 60b. Interaction effect of row ratio and nutrient management on nutrient uptake by maize

Interaction (C X F)	Nutrient uptake (kg ha ⁻¹)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	102.79	114.61	108.70	16.57	17.21	16.89	115.98	126.29	121.14
C ₁ F ₁	140.78	167.82	154.30	23.96	25.96	24.96	172.50	189.99	181.25
C ₁ F ₂	221.97	245.62	233.80	32.32	33.24	32.78	221.14	274.74	247.94
C ₂ F ₀	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-
C ₃ F ₀	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-
C ₄ F ₀	67.22	76.72	71.97	10.62	12.26	11.44	77.93	84.57	81.25
C ₄ F ₁	102.81	120.80	111.81	14.99	16.82	15.91	118.61	139.28	128.94
C ₄ F ₂	137.23	144.39	140.81	20.98	22.23	21.61	159.10	180.16	169.63
C ₅ F ₀	63.24	71.74	67.49	10.91	11.49	11.20	72.52	69.29	70.90
C ₅ F ₁	104.88	115.35	110.12	15.49	17.43	16.46	119.16	122.99	121.07
C ₅ F ₂	135.94	136.03	135.99	20.30	21.06	20.68	160.68	176.27	168.47
C ₆ F ₀	76.43	87.96	82.20	15.00	17.01	16.00	100.52	77.04	88.78
C ₆ F ₁	115.41	132.32	123.86	20.04	21.90	20.97	142.17	150.55	146.36
C ₆ F ₂	199.07	197.98	198.52	25.53	26.81	26.17	196.73	256.49	226.61
C ₇ F ₀	73.73	77.76	75.74	15.74	16.47	16.11	96.50	104.49	100.50
C ₇ F ₁	128.70	149.43	139.06	20.57	22.88	21.72	150.00	164.68	157.34
C ₇ F ₂	185.97	208.18	197.08	24.42	26.05	25.23	186.53	221.20	203.86
C ₈ F ₀	68.45	70.57	69.51	11.81	13.20	12.51	82.48	75.13	78.81
C ₈ F ₁	104.14	122.02	113.08	15.78	18.32	17.05	119.40	120.65	120.02
C ₈ F ₂	147.40	157.81	152.61	20.94	21.42	21.18	175.66	203.01	189.34
C ₉ F ₀	71.90	81.43	76.67	11.64	12.13	11.89	71.01	78.69	74.85
C ₉ F ₁	101.52	118.40	109.96	15.63	17.93	16.78	125.91	137.08	131.49
C ₉ F ₂	145.82	148.83	147.32	21.73	22.63	22.18	187.25	184.43	185.84
SEm±	2.94	3.50	2.29	0.24	0.35	0.21	2.82	2.93	2.03
CD (P=0.05)	8.35	9.94	6.41	0.69	1.00	0.60	7.99	8.31	5.70

Table 61a. Effect of row ratio and nutrient management on nutrient uptake by cowpea

Treatments	Nutrient uptake (kg ha ⁻¹)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	119.16	132.16	125.66	12.75	13.24	13.00	49.16	65.88	57.52
C ₃ - Sole Rice bean (R)	-	-	-	-	-	-	-	-	-
C ₄ - M + C (1:1)	79.99	87.94	83.97	7.62	8.59	8.10	32.75	42.09	37.42
C ₅ - M + R (1:1)	-	-	-	-	-	-	-	-	-
C ₆ - M + C (2:1)	62.50	72.26	67.38	6.50	6.85	6.67	26.67	32.68	29.67
C ₇ - M + R (2:1)	-	-	-	-	-	-	-	-	-
C ₈ - M + C (2:2)	81.36	100.44	90.90	8.99	9.79	9.39	39.54	46.04	42.79
C ₉ - M + R (2:2)	-	-	-	-	-	-	-	-	-
SEm±	0.94	1.28	0.80	0.07	0.11	0.07	0.29	0.57	0.32
CD (P=0.05)	2.68	3.63	2.23	0.21	0.32	0.19	0.82	1.61	0.89
2. Nutrient management									
F ₀ - Control	39.02	47.51	43.26	7.27	8.48	7.88	26.73	38.47	32.60
F ₁ - 50 % NPK	81.52	95.89	88.70	9.13	9.23	9.18	37.28	44.87	41.07
F ₂ - 100 % NPK	136.74	151.21	143.97	10.49	11.14	10.82	47.08	56.68	51.88
SEm±	0.55	0.74	0.46	0.04	0.06	0.04	0.17	0.33	0.18
CD (P=0.05)	1.55	2.10	1.29	0.12	0.18	0.11	0.47	0.93	0.51

Table 61b. Interaction effect of row ratio and nutrient management on nutrient uptake by cowpea

Interaction (C X F)	Nutrient uptake (kg ha ⁻¹)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-
C ₂ F ₀	53.80	61.97	57.88	11.28	11.94	11.61	38.98	55.21	47.10
C ₂ F ₁	122.70	138.53	130.61	13.37	13.33	13.35	49.43	66.15	57.79
C ₂ F ₂	180.99	196.00	188.50	13.61	14.45	14.03	59.07	76.27	67.67
C ₃ F ₀	-	-	-	-	-	-	-	-	-
C ₃ F ₁	-	-	-	-	-	-	-	-	-
C ₃ F ₂	-	-	-	-	-	-	-	-	-
C ₄ F ₀	35.81	46.33	41.07	5.66	7.16	6.41	20.89	33.50	27.19
C ₄ F ₁	76.44	75.13	75.78	7.83	7.72	7.77	33.70	36.93	35.31
C ₄ F ₂	127.74	142.35	135.04	9.36	10.89	10.13	43.67	55.85	49.76
C ₅ F ₀	-	-	-	-	-	-	-	-	-
C ₅ F ₁	-	-	-	-	-	-	-	-	-
C ₅ F ₂	-	-	-	-	-	-	-	-	-
C ₆ F ₀	26.45	34.76	30.61	4.70	6.26	5.48	16.68	27.41	22.05
C ₆ F ₁	53.95	72.84	63.39	6.34	6.54	6.44	26.67	32.60	29.63
C ₆ F ₂	107.11	109.19	108.15	8.47	7.74	8.10	36.64	38.04	37.34
C ₇ F ₀	-	-	-	-	-	-	-	-	-
C ₇ F ₁	-	-	-	-	-	-	-	-	-
C ₇ F ₂	-	-	-	-	-	-	-	-	-
C ₈ F ₀	40.01	46.97	43.49	7.44	8.57	8.00	30.36	37.74	34.05
C ₈ F ₁	72.98	97.05	85.01	8.98	9.34	9.16	39.31	43.81	41.56
C ₈ F ₂	131.10	157.29	144.20	10.54	11.47	11.00	48.95	56.57	52.76
C ₉ F ₀	-	-	-	-	-	-	-	-	-
C ₉ F ₁	-	-	-	-	-	-	-	-	-
C ₉ F ₂	-	-	-	-	-	-	-	-	-
SEm±	1.64	2.22	1.38	0.13	0.19	0.12	0.50	0.98	0.55
CD (P=0.05)	4.64	6.29	3.86	0.37	0.55	0.33	1.42	2.79	1.54

Table 62a. Effect of row ratio and nutrient management on nutrient uptake by rice bean

Treatments	Nutrient uptake (kg ha ⁻¹)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
1. Cropping system									
C ₁ - Sole Maize (M)	-	-	-	-	-	-	-	-	-
C ₂ - Sole Cowpea (C)	-	-	-	-	-	-	-	-	-
C ₃ - Sole Rice bean (R)	118.840	125.115	121.978	12.651	12.567	12.609	53.856	56.066	54.961
C ₄ - M + C (1:1)	-	-	-	-	-	-	-	-	-
C ₅ - M + R (1:1)	55.648	71.092	63.370	6.462	7.647	7.055	28.379	35.146	31.763
C ₆ - M + C (2:1)	-	-	-	-	-	-	-	-	-
C ₇ - M + R (2:1)	45.307	59.931	52.619	5.090	6.295	5.693	22.883	27.891	25.387
C ₈ - M + C (2:2)	-	-	-	-	-	-	-	-	-
C ₉ - M + R (2:2)	64.168	76.505	70.336	7.309	8.068	7.689	32.137	36.829	34.483
SEm±	0.875	0.917	0.634	0.103	0.109	0.075	0.376	0.444	0.291
CD (P=0.05)	2.484	2.603	1.778	0.292	0.311	0.211	1.066	1.261	0.816
2. Nutrient management									
F ₀ - Control	52.154	54.741	53.447	6.609	6.789	6.699	23.102	24.930	24.016
F ₁ - 50 % NPK	73.826	86.767	80.296	8.222	9.047	8.634	36.654	40.609	38.632
F ₂ - 100 % NPK	86.993	107.975	97.484	8.803	10.097	9.450	43.186	51.411	47.299
SEm±	0.505	0.529	0.366	0.059	0.063	0.043	0.217	0.257	0.168
CD (P=0.05)	1.434	1.503	1.026	0.169	0.179	0.122	0.615	0.728	0.471

Table 62b. Interaction effect of row ratio and nutrient management on nutrient uptake by rice bean

Interaction (C X F)	Nutrient uptake (kg ha ⁻¹)								
	N			P			K		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
C ₁ F ₀	-	-	-	-	-	-	-	-	-
C ₁ F ₁	-	-	-	-	-	-	-	-	-
C ₁ F ₂	-	-	-	-	-	-	-	-	-
C ₂ F ₀	-	-	-	-	-	-	-	-	-
C ₂ F ₁	-	-	-	-	-	-	-	-	-
C ₂ F ₂	-	-	-	-	-	-	-	-	-
C ₃ F ₀	88.955	93.699	91.327	11.562	10.766	11.164	38.942	39.295	39.118
C ₃ F ₁	122.974	127.572	125.273	12.771	12.940	12.856	58.755	55.174	56.965
C ₃ F ₂	144.591	154.075	149.333	13.619	13.995	13.807	63.871	73.730	68.801
C ₄ F ₀	-	-	-	-	-	-	-	-	-
C ₄ F ₁	-	-	-	-	-	-	-	-	-
C ₄ F ₂	-	-	-	-	-	-	-	-	-
C ₅ F ₀	40.017	45.683	42.850	5.261	5.841	5.551	19.356	23.954	21.655
C ₅ F ₁	56.831	76.767	66.799	6.723	8.215	7.469	28.326	36.621	32.474
C ₅ F ₂	70.096	90.826	80.461	7.403	8.885	8.144	37.455	44.864	41.160
C ₆ F ₀	-	-	-	-	-	-	-	-	-
C ₆ F ₁	-	-	-	-	-	-	-	-	-
C ₆ F ₂	-	-	-	-	-	-	-	-	-
C ₇ F ₀	31.198	28.866	30.032	3.899	4.371	4.135	15.383	15.531	15.457
C ₇ F ₁	49.042	64.936	56.989	5.647	6.472	6.060	24.017	29.252	26.634
C ₇ F ₂	55.683	85.991	70.837	5.723	8.042	6.883	29.250	38.891	34.071
C ₈ F ₀	-	-	-	-	-	-	-	-	-
C ₈ F ₁	-	-	-	-	-	-	-	-	-
C ₈ F ₂	-	-	-	-	-	-	-	-	-
C ₉ F ₀	48.446	50.716	49.581	5.715	6.179	5.947	18.725	20.941	19.833
C ₉ F ₁	66.455	77.792	72.124	7.745	8.559	8.152	35.519	41.390	38.454
C ₉ F ₂	77.601	101.007	89.304	8.467	9.467	8.967	42.168	48.157	45.163
SEm±	1.516	1.588	1.098	0.178	0.190	0.130	0.651	0.770	0.504
CD (P=0.05)	4.302	4.508	3.079	0.506	0.538	0.365	1.846	2.184	1.413

4.6. Economics analysis

4.6.1 Cost of cultivation (₹ ha⁻¹)

The cost of cultivation differed among the treatment combinations (Table 63). The highest cost of cultivation was observed from treatment C₁F₂ in both 2022 (₹ 31551.82/- ha⁻¹) and 2023 (₹ 32340.82/- ha⁻¹), which was followed by treatments C₆F₂ (₹ 31487.82/- ha⁻¹, ₹ 32276.82/- ha⁻¹), C₄F₂ and C₈F₂ (₹ 31451.82/- ha⁻¹, 32240.82/- ha⁻¹) respectively. However, the least cost of cultivation among the treatment combinations was recorded at C₃F₀ in both years of investigations *i.e.*, 2022 (₹ 27162.00/- ha⁻¹) and 2023 (₹ 27951.00/- ha⁻¹) and the second lowest cost of cultivation was obtained from both C₅F₀ and C₉F₀ in first year (₹ 27662.00/- ha⁻¹) and second year of investigations (₹ 28451.00/- ha⁻¹).

4.6.2. Gross returns (₹ ha⁻¹)

The data presented in Table 63, showed the significant variation in gross return. The highest value of gross return was recorded from treatment C₆F₂ (₹ 140216.50/- ha⁻¹) which was followed by C₉F₂ (₹ 138250.00/- ha⁻¹) and C₈F₂ (₹ 137650.00/- ha⁻¹) respectively in 2022. During second year (2023) of investigation, the highest gross return was registered from C₉F₂ (₹ 148814.00/- ha⁻¹) and followed by C₈F₂ (₹ 146892.50/- ha⁻¹) and (₹ 143916.50/- ha⁻¹). Among all the treatment combinations, the lowest value of gross return was obtained from C₃F₀ (₹ 65582.50 /- ha⁻¹, ₹ 68332.50/- ha⁻¹) and C₂F₀ (₹ 76667.50 /- ha⁻¹, ₹ 81645.00/- ha⁻¹) followed by C₅F₀ (₹ 80817.50/- ha⁻¹, ₹ 84707.50/- ha⁻¹) in both 2022 and 2023. This finding was in similar with the findings report by Bhagat *et al.* (2017). They evaluated the economics return of maize grown with cowpea under sole, 1:1 and 2:1 row ratio. Under this research, the highest gross return was observed at 2:1 when compared to 1:1 and sole crop.

4.6.3 Net return (₹ ha⁻¹)

The results (Table 64) showed that growing of fodder maize with fodder cowpea and fodder rice bean at different row ratio long with nutrient management

practices produced the higher net return. Among all the treatment combinations, the highest net return in both 2022 and 2023 was observed from the treatments C₆F₂ (₹108728.68/- ha⁻¹, ₹111639.68/- ha⁻¹), C₉F₂ (₹ 107198.18/- ha⁻¹, ₹ 116973.18/- ha⁻¹), C₇F₂ (₹ 107078.48/- ha⁻¹, ₹ 113737.98/- ha⁻¹) and C₈F₂ (₹ 106198.18/- ha⁻¹, ₹ 114651.68/- ha⁻¹) respectively. Likewise, the lowest net return was recorded at C₃F₀ (₹ 38420.50/- ha⁻¹, ₹ 40381.50/- ha⁻¹) and C₂F₀ (₹ 48705.50/- ha⁻¹, ₹ 52894.00/- ha⁻¹) in both 2022 and 2023. All intercropping system contributed great extent of net income return over monocropping system. Combinations of nutrient management practices along with intercropping of maize with cowpea managed to increase the net return of the intercropping system (Amanullah *et al.*, 2020). Similarly, Bhagat *et al.* (2017) also reported the highest net income return at 2:1 row ratio in comparison with 1:1 row ratio and monocrop.

4.6.4 Benefit:Cost ratio

The combinations of different row ratio along with nutrient management practices recorded the higher benefit cost ratio of the fodder crops (Table 64). The highest B:C ratio of the treatment combinations was recorded from treatments C₉F₂ (3.45, 3.67), C₇F₂ (3.43, 3.55), C₆F₂ (3.45, 3.46) and then at C₈F₂ (3.43, 3.55) in both years of investigation. Among all the treatment combinations, the crops grown under sole stand recorded comparatively lower benefit cost ratio. The lowest B:C ratio was observed at treatment C₃F₀ (1.41, 1.44) followed by C₂F₀ (1.74, 1.84) respectively. In this research, it was found that increase B:C ratio under intercropping system was due to obtaining of yield from intercrop in all the intercropping systems. The highest B:C ratio of the intercropping system was observed at 2:1 row ratio (Bhagat, 2017). Similarly, application of nutrients at intercropping of maize with cowpea also improved the B:C ratio of the intercropping system (Amanullah *et al.*, 2020). Sharma (2008) also reported the highest B:C ratio of the intercropping system at 2:2 row ratio followed by 1:1 and 2:1 as compared to sole crop.

Table 63. Cost of cultivation (₹ ha⁻¹) and Gross return (₹ ha⁻¹) of maize intercrop with legume grown under different row ratio and nutrient management

Treatments	Cost of cultivation (₹ ha ⁻¹)		Gross return (₹ ha ⁻¹)	
	2022	2023	2022	2023
C ₁ F ₀	28162.00	28921.00	83266.00	85400.00
C ₁ F ₁	29856.91	30645.91	102534.00	110000.00
C ₁ F ₂	31551.82	32340.82	117800.00	119600.00
C ₂ F ₀	27962.00	28751.00	76667.50	81645.00
C ₂ F ₁	29656.91	30445.91	84167.50	87770.00
C ₂ F ₂	31351.82	32140.82	91500.00	94082.50
C ₃ F ₀	27162.00	27951.00	65582.50	68332.50
C ₃ F ₁	28856.91	29645.91	89167.50	92917.50
C ₃ F ₂	30551.82	31340.82	94500.00	102770.00
C ₄ F ₀	28062.00	28851.00	88066.50	91791.00
C ₄ F ₁	29756.91	30545.91	110832.50	115528.50
C ₄ F ₂	31451.82	32240.82	127816.50	142648.50
C ₅ F ₀	27662.00	28451.00	80817.50	84707.50
C ₅ F ₁	29356.91	30145.91	114000.00	123167.50
C ₅ F ₂	31051.82	31840.82	134298.50	141104.00
C ₆ F ₀	28098.00	28887.00	94084.00	98450.00
C ₆ F ₁	29792.91	30581.91	115766.50	125245.00
C ₆ F ₂	31487.82	32276.82	140216.50	143916.50
C ₇ F ₀	27831.70	28620.70	91983.50	97761.00
C ₇ F ₁	29526.61	30315.61	119051.50	131901.50
C ₇ F ₂	31221.52	32010.52	138300.00	145748.50
C ₈ F ₀	28062.00	28851.00	98451.50	99505.00
C ₈ F ₁	29756.91	30545.91	115666.00	125671.50
C ₈ F ₂	31451.82	32240.82	137650.00	146892.50
C ₉ F ₀	27662.00	28451.00	84198.50	89633.50
C ₉ F ₁	29356.91	30145.91	113648.50	126626.50
C ₉ F ₂	31051.82	31840.82	138250.00	148814.00

Table 64. Net return (₹ ha⁻¹) and B:C ratio of maize intercrop with legume grown under different row ratio and nutrient management

Treatments	Net return (₹ ha ⁻¹)		B:C ratio	
	2022	2023	2022	2023
C ₁ F ₀	55104.00	56479.00	1.96	1.95
C ₁ F ₁	72677.09	79354.09	2.43	2.59
C ₁ F ₂	86248.18	87259.18	2.73	2.70
C ₂ F ₀	48705.50	52894.00	1.74	1.84
C ₂ F ₁	54510.59	57324.09	1.84	1.88
C ₂ F ₂	60148.18	61941.68	1.92	1.93
C ₃ F ₀	38420.50	40381.50	1.41	1.44
C ₃ F ₁	60310.59	63271.59	2.09	2.13
C ₃ F ₂	63948.18	71429.18	2.09	2.28
C ₄ F ₀	60004.50	62940.00	2.14	2.18
C ₄ F ₁	81075.59	84982.59	2.72	2.78
C ₄ F ₂	96364.68	110407.68	3.06	3.42
C ₅ F ₀	53155.50	56256.50	1.92	1.98
C ₅ F ₁	84643.09	93021.59	2.88	3.09
C ₅ F ₂	103246.68	109263.18	3.32	3.43
C ₆ F ₀	65986.00	69563.00	2.35	2.41
C ₆ F ₁	85973.59	94663.09	2.89	3.10
C ₆ F ₂	108728.68	111639.68	3.45	3.46
C ₇ F ₀	64151.80	69140.30	2.30	2.42
C ₇ F ₁	89524.89	101585.89	3.03	3.35
C ₇ F ₂	107078.48	113737.98	3.43	3.55
C ₈ F ₀	70389.50	70654.00	2.51	2.45
C ₈ F ₁	85909.09	95125.59	2.89	3.11
C ₈ F ₂	106198.18	114651.68	3.38	3.56
C ₉ F ₀	56536.50	61182.50	2.04	2.15
C ₉ F ₁	84291.59	96480.59	2.87	3.20
C ₉ F ₂	107198.18	116973.18	3.45	3.67

CHAPTER - V
SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

The field investigation entitled “**Effect of row ratio and nutrient management on performance of maize (*Zea mays* L.) based legume intercropping system**” was conducted during *kharif* season for two consecutive years 2022-2023 and 2023-2024, at the experimental farm of Department of Agronomy, School of Agricultural Sciences, Medziphema, Nagaland University, Campus: Medziphema, Nagaland. The experiment was laid out in randomized block design with nine level in intercropping system and three levels in nutrient management. The intercropping system consists of C₁- sole fodder maize, C₂- sole fodder cowpea, C₃- sole fodder rice bean, C₄- fodder maize + fodder cowpea (1:1), C₅- fodder maize + fodder rice bean (1:1), C₆- fodder maize + fodder cowpea (2:1), C₇- fodder maize + fodder rice bean (2:1), C₈- fodder maize + fodder cowpea (2:2) and C₉- fodder maize + fodder rice bean (2:2), while three levels of nutrient management *i.e.*, F₀- 0 % RDF, F₁- 50 % RDF and F₂- 100 % RDF. The prominent findings of the present studied are summarized in this chapter through following heads and sub head given below:

5.1 Fodder maize

5.1.1 Growth parameters

- Among the intercropping system, sole maize (C₁) significantly maintained the highest plant height and number of leaves plant⁻¹ of fodder maize at 20 DAS, 40 DAS, 60 DAS and 80 DAS of the observations. The treatment C₄ recorded the highest leaf area of fodder maize at 20 DAS, 40 DAS, 60 DAS and 80 DAS (222.74 cm², 436.23 cm², 630.84 cm² and 699.44 cm²). The largest stem girth of the plant was observed in C₁ and C₉ at 20 DAS (2.96 cm, 2.92 cm), 40 DAS (4.82 cm, 4.78 cm), 60 DAS (6.17 cm, 6.13 cm) and 80 DAS (7.04 cm, 7.02 cm). At 20 DAS, the highest leaf:stem ratio was recorded at C₉ (3.391). However, C₅ recorded the highest leaf:stem ratio comparatively at 40 DAS (0.336), 60 DAS (0.453), 80 DAS (0.333). The highest fresh weight and dry weight of fodder maize was recorded at C₄ and C₅ in all the stages of the observation (*i.e.*, 20 DAS, 40 DAS, 60 DAS and 80 DAS).

- The vegetative growth parameters like plant height, leaf area, number of leaves, leaf:stem ratio, stem girth, fresh weight and dry weight of fodder maize was significantly increase with increase in nutrient application levels. The fodder maize fertilized with 100 % RDF (F_2 - 60-30-30 kg ha⁻¹) significantly produced the highest vegetative growth in all the stages of observations as compared to F_1 (50 % RDF) and F_0 (control).
- Among all the treatment combinations, C_1F_2 recorded the highest plant height and number of leaves plant⁻¹ of fodder maize at 20, 40, 60 and 80 DAS, while C_4F_2 significantly managed to recorded the highest leaf area in all the stages of observation. Incase of leaf:stem ratio, the highest leaf:stem ratio was recorded from treatment C_5F_2 and followed by C_4F_2 and C_9F_2 .
- The highest fresh weight of the plant was recorded in C_4F_2 (36.46 g plant⁻¹) and followed by C_5F_2 (30.17 g plant⁻¹), C_8F_2 (28.92 g plant⁻¹). At 20 DAS, C_4F_2 (4.63 g plant⁻¹) recorded the highest dry weight of plant followed by C_5F_2 (4.25 g plant⁻¹) and thereon C_4F_2 maintained the highest dry weight of the plant at 40 DAS (40.66 g plant⁻¹), 60 DAS (126.16 g plant⁻¹) and 80 DAS (273.60 g plant⁻¹). The treatment C_1F_1 recorded the largest stem girth at 20 DAS (3.38 cm), 40 DAS (5.53 cm) and 80 DAS (7.40 cm). However, at 60 DAS, the largest stem girth was recorded at C_6F_2 (6.95 cm).

5.1.2 Yield

- The green fodder yield of fodder maize was significantly higher during second year (2023) as compared to first year of investigation (2022). The fodder maize planted under sole stand registered the highest green fodder yield (51.550 t ha⁻¹) and the second higher green fodder yield of fodder maize (43.710 t ha⁻¹, 44.272 t ha⁻¹) was observed at 2:1 row ratio. Incase of nutrient management, the highest green fodder yield of fodder maize (46.831 t ha⁻¹) was registered at F_2 (100 % RDF). Among all the treatment interactions, C_1F_2 (59.350 t ha⁻¹), C_1F_1 (53.133 t ha⁻¹), C_6F_2 (51.617 t ha⁻¹) and C_7F_2 (51.117 t ha⁻¹) recorded the highest and comparable green fodder yield of fodder maize.

- In respect to different row ratio, the highest dry fodder yield of fodder maize was registered at sole maize C₁ (11.412 t ha⁻¹) and the second highest and comparable dry fodder yield was found at C₇ (9.291 t ha⁻¹) and C₆ (9.142 t ha⁻¹). Application of 100 % RDF registered the highest dry fodder yield of fodder maize (10.247 t ha⁻¹). The interaction results revealed the highest dry fodder yield of fodder maize at C₁F₂ (13.718 t ha⁻¹).
- Under intercropping system, the highest total green fodder yield and dry fodder yield of fodder maize + fodder cowpea and fodder maize + fodder rice bean was recorded from C₆ (56.588 t ha⁻¹, 11.928 t ha⁻¹) and C₇ (59.131 t ha⁻¹, 11.615 t ha⁻¹), which was followed by treatments C₈ and C₉. The application of nutrient at 100 % RDF (F₂) recorded the highest total green fodder yield and dry fodder yield. Among all the interactions, the highest total green fodder yield and dry fodder yield was recorded at C₆F₂ and C₇F₂.

5.1.3 Quality analysis

- The highest crude protein content in fodder maize was registered in C₇ (9.63 %) followed by C₆ (9.35 %). The application of nutrient at 100 % RDF (F₂) registered significantly the crude protein of fodder maize. Among the treatment interactions, the higher and comparable crude protein content in fodder maize was recorded from C₆F₂ (11.78 %), C₇F₂ (11.11 %) and C₁F₂ (11.03 %), while the highest crude protein yield of fodder maize was obtained at C₁ (9.89 q ha⁻¹). Likewise, among the nutrient management, application of nutrient @ 100 % RDF (F₂) recorded the highest crude protein yield of fodder maize (10.51 q ha⁻¹). Among all the treatment combinations, the highest crude protein yield of fodder maize (14.40 q ha⁻¹) was registered from C₁F₂.
- The highest crude fibre content of fodder maize was recorded at sole crop C₁ (24.09 %), while the highest ash content of fodder maize was entered at sole maize C₅ (8.77 %). Likewise, in nutrient management, the treatment F₂ (100 % RDF) recorded the highest crude fibre content of (27.18 %) and the highest ash content (10.23 %) in fodder maize.

5.1.4 Intercropping studies

- Among the different row ratio, treatment C₄ and C₅ recorded the higher and comparable crop growth rate, leaf area index of fodder maize at 20-40 DAS and 40-60 DAS, while the highest land equivalent ratio of the system was recorded from 2:2 followed by 2:1 row ratio. The land used efficiency of the fodder maize was 23.28 %. Subject to nutrient management practices, the treatment F₂ recorded the highest crop growth rate, leaf area index and land equivalent of the system in all the stages of the observations. Among all the interactions, the highest crop growth rate of fodder maize was seen at C₄F₂ (20.02 g m⁻² day⁻¹), while C₁F₂ (1.004) recorded the highest leaf area index. The higher land equivalent ratio of the system was registered at C₈F₂ (1.338).
- The highest net assimilation ratio of fodder maize was obtained at C₁ (0.00233 g cm² day) and for nutrient management, the treatment F₂ maintained the highest net assimilation in both 20-40 DAS (0.00214 g cm² day) and 40-60 DAS (0.00351 g cm² day). Among all the treatment combinations, the higher and comparable net assimilation rate of fodder maize at 20-40 DAS was registered at C₁F₂ (0.00264 g cm² day) while C₁F₂ (0.00388 g cm² day) recorded the highest at 40-60 DAS.
- The highest relative growth rate of fodder maize at 20-40 DAS and 40-60 DAS was recorded at C₁ (0.04932 g g⁻¹ day⁻¹) and C₆ (0.02801 g g⁻¹ day⁻¹). Among the interactions, the highest relative growth rate of fodder maize was found in treatment C₁F₂ (0.05154 g g⁻¹ day⁻¹) followed by C₇F₂ (0.05085 g g⁻¹ day⁻¹), C₁F₁ (0.05059 g g⁻¹ day⁻¹) and C₅F₂ (0.05033 g g⁻¹ day⁻¹).
- The highest relative crowding co-efficient of the system was observed at C₆ (3.467) and C₈ (3.108). In case for nutrient management, the treatment F₂ recorded the highest relative crowding co-efficient of the system. In interactions, C₆F₂ (4.821) followed by C₈F₂ (4.165) recorded the highest relative crowding co-efficient of the fodder maize.
- The highest aggressivity and competition ratio of the fodder maize was recorded at C₄ followed by C₅. With regard to nutrient management, the highest aggressivity and competition ratio of fodder maize was registered from F₀ (control), while

treatments C₄F₀ (0.482) and C₄F₁ (0.447) registered the highest aggressivity and competition ratio of the fodder maize.

- With regard to maize fodder equivalent yield, all intercropping system significantly registered the highest maize fodder equivalent yield than sole maize. The highest maize fodder equivalent yield was recorded from treatment C₈ (603.19 q ha⁻¹) and followed by C₉ (584.31 q ha⁻¹). Among the nutrient management, the highest maize fodder equivalent yield of fodder maize was recorded from treatment F₂ (69157 q ha⁻¹) and the lowest maize fodder equivalent yield (446.44 q ha⁻¹) was obtained from F₀ (control).

5.1.5 Chemicals analysis

5.1.5.1 Soil pH and soil organic carbon (%)

- The soil pH and soil organic carbon present in the soil after harvest was not significantly affected by both factors.

5.1.5.2 Available N, P and K after harvest

- Significantly, the highest available nitrogen and phosphorus in soil was registered in sole rice bean C₃ (276.54 kg ha⁻¹, 23.69 kg ha⁻¹) and sole cowpea C₂ (276.54 kg ha⁻¹, 23.49 kg ha⁻¹). With subject to nutrient management, the highest available nitrogen and phosphorus present in the soil was observed from F₂ (273.77 kg ha⁻¹, 24.15 kg ha⁻¹). Among all the treatment combinations, the highest available nitrogen and phosphorus present in the soil was observed from treatment C₃F₂ (296.83 kg ha⁻¹) followed by C₂F₂ (292.84 kg ha⁻¹).
- The highest available potassium present in the soil was recorded at C₂ (172.67 kg ha⁻¹) and C₃ (169.37 kg ha⁻¹). Similarly, in nutrient management, F₂ (156.45 kg ha⁻¹) registered the highest available potassium in the soil. In interactions, treatment C₃F₂ (191.61 kg ha⁻¹) followed by C₂F₂ (186.01 kg ha⁻¹) recorded the highest available potassium.

5.1.6 Plant analysis

5.1.6.1 N, P and K content (%)

- The highest nitrogen, phosphorus and potassium content in fodder maize was observed at C₉ followed by C₈. In case of nutrient management, the highest nutrient content was observed from F₂. Among the treatment combinations, the highest nitrogen content in fodder maize was recorded from treatment C₇F₂ (1.783 %) followed by C₆F₂ (1.778 %), C₈F₂ (1.708 %) and C₁F₂ (1.703 %).
- Among all the treatment interactions, the highest nitrogen content was obtained at C₆F₂ and C₇F₂. While C₉F₂ and C₄F₂ registered the highest phosphorus content in fodder maize, while the highest potassium content was recorded at C₉F₂ and C₈F₂.

5.1.6.2 Nutrient uptake (kg ha⁻¹)

- Significantly, the crop grown under sole stand C₁ registered the highest nitrogen, phosphorus and potassium uptake. While the lowest nutrient uptake by fodder maize was observed from treatments C₅ and C₄.
- In case of nutrient management, the highest nitrogen, phosphorus and potassium uptake was observed at F₂. However, among the factor interactions, the highest nutrient uptake by fodder maize was observed at C₁F₂ followed by C₆F₂ and C₇F₂.

5.1.7 Economics analysis

- The highest value of gross return was observed from treatment C₉F₂ (₹ 138250.00/- ha⁻¹, ₹ 148814.00/- ha⁻¹) which was followed by treatments C₇F₂ (138300.00/- ha⁻¹, 145748.50/- ha⁻¹), C₆F₂ (140216.50/- ha⁻¹, 143916.50/- ha⁻¹) and C₈F₂ (₹ 137650.00/- ha⁻¹, ₹ 146892.50/- ha⁻¹) in both years of investigations.
- Among all the treatment combinations, the highest net return in both years of investigations was observed from C₉F₂ (₹ 108498.18/- ha⁻¹, ₹ 116973.18/- ha⁻¹), C₇F₂ (₹ 108348.18/- ha⁻¹, ₹ 113707.68/- ha⁻¹), C₆F₂ (109848.28/- ha⁻¹, 111459.28/- ha⁻¹) and C₈F₂ (₹ 107273.18/- ha⁻¹, ₹ 114426.68/- ha⁻¹) respectively.

- Among all the treatment combinations, the highest B:C ratio of the investigation was recorded from treatments C₉F₂ (3.45, 3.67), C₇F₂ (3.43, 3.55), C₆F₂ (3.45, 3.46) and then at C₈F₂ (3.38, 3.56) both 2022 and 2023.

5.2 Fodder cowpea

5.2.1 Growth parameters

- Significantly, the higher vegetative growth like plant height, leaf width, leaf:stem ratio, number of leaves plant⁻¹ and primary branches plant⁻¹ was recorded at sole crop (C₂) in most stages of the observation. However, the longer leaf length was registered from C₆ and C₄. With subject to nutrient management, the higher vegetative growth of fodder cowpea was observed under application of nutrient @ 100 % RDF.
- The highest fresh weight of fodder cowpea at 20 DAS was obtained at C₄. However, from 40 DAS onward, the treatment C₂ statistically recorded the highest fresh weight of fodder cowpea at 40 DAS, 60 DAS and 80 DAS. Significantly, the treatments C₄ and C₂ recorded the highest dry weight of fodder cowpea at 20 DAS. From the next observation onwards, C₂ produced the highest dry weight of fodder cowpea at 40 DAS, 60 DAS and 80 DAS. Regarding the nutrient management practices, the treatment F₂ (100 % RDF) recorded the highest fresh weight and dry weight of fodder cowpea at 20 DAS (3.74 g plant⁻¹), 40 DAS (33.38 g plant⁻¹), 60 DAS (100.35 g plant⁻¹) and 80 DAS (137.33 g plant⁻¹).
- The interaction of intercropping system with nutrient management approaches had a significant impact on vegetative growth of fodder cowpea. Among the treatment interactions, the higher vegetative growth was recorded from the treatments which nutrient application at 100 % RDF.

5.2.2 Yield

- With reference to different row ratio, fodder cowpea planted under sole stand registered the highest green fodder and dry fodder yield of fodder cowpea, then it was observed from 2:2 row ratio as compared to planted under different row ratio *i.e.*, 1:1 and 2:1. Likewise, the treatment F₂ recorded the highest green fodder and

dry fodder yield of fodder cowpea than treatments F_1 and F_0 . However, among the treatment combinations, the higher green fodder yield and dry fodder yield of fodder cowpea was registered at C_2F_2 followed by C_2F_1 .

5.2.3 Qualitative analysis

- The highest crude protein content of fodder cowpea was recorded at sole cowpea C_2 (18.05 %). Among the nutrient management, application of nutrients at 100 % RDF (F_2) registered significantly the highest crude protein of fodder cowpea (19.69 %) as compared to treatments F_1 and F_0 respectively.
- Among the treatment interactions, the highest crude protein content of fodder cowpea was observed at C_2F_2 (19.90 %), which was statistically on par with C_4F_2 (19.82 %), C_8F_2 (19.52 %) and C_6F_2 (19.52 %).
- With respect to different row ratio, the highest crude protein yield of fodder cowpea (8.7 q ha⁻¹) was recorded at sole plot *i.e.*, C_1 and it was followed by C_8 (4.65 q ha⁻¹). The application nutrients @ 100 % RDF (F_2) recorded the highest crude protein yield of fodder cowpea (6.45 q ha⁻¹) in comparison to treatments F_1 and F_0 .
- Among all the treatment combinations, the highest crude protein yield of fodder cowpea (10.10 q ha⁻¹) was registered at C_2F_2 respectively.
- The highest crude fibre content in fodder cowpea was obtained at sole plot C_2 (22.72 %). In case of nutrient management, the highest crude fibre content in fodder cowpea (25.56 %) was registered from treatment receiving nutrient @ 100 % RDF (F_2).
- Among all the treatment combinations, the fodder maize (28.00 %), fodder cowpea (26.54 %) and fodder rice bean (27.14 %) planted under sole stand with application of nutrient at 100 % RDF (F_2) recorded the highest crude fibre content as compared to other treatments.
- Sole grown fodder cowpea (19.60 %) recorded the highest ash content when compared to other treatments. The application of nutrient at 100 % RDF @ 60-30-30 NPK kg ha⁻¹ recorded the highest ash content of fodder cowpea (23.66 %).

- Fodder cowpea recorded the highest ash content when it was grown with fodder maize under different row ratio *i.e.*, 1:1, 2:1 and 2:2 along with application of NPK at 100 % RDF (60-30-30 kg ha⁻¹).

5.2.4 Intercropping studies

- The highest crop growth rate of fodder cowpea was recorded from C₂ at 20-40 DAS and 40-60 DAS. With regard to nutrient management, the highest crop growth rate of fodder cowpea at 20-40 DAS and 40-60 DAS was recorded from treatment F₂ (100 % RDF). Among the interactions, the highest relative growth rate at 20-40 DAS and 40-60 DAS was recorded at C₂F₂.
- The higher and comparable leaf area index of fodder cowpea at 20 DAS and 40 DAS was recorded at C₂.
- The highest net assimilation rate of fodder cowpea was recorded at C₂ in both 20-40 DAS (0.01932 g cm² day) and 40-60 DAS (0.01849 g cm² day). With regard to nutrient management, the highest net assimilation ratio of fodder cowpea was registered at F₂ in both 20-40 DAS and 40-60 DAS. Among all the treatment combinations, C₂F₂ (0.02054 g cm² day) recorded the highest net assimilation rate at 40-60 DAS and 40-60 DAS.
- The highest relative growth rate of fodder cowpea was observed from treatments C₂ and C₆ at 20-40 DAS, while C₈ and C₆ recorded the higher relative growth rate at 40-60 DAS. Incase of treatment interactions, the highest growth rate of fodder cowpea at 20-40 DAS and 40-60 DAS was observed from C₆F₂ and C₈F₂.
- The highest relative crowding co-efficient for fodder cowpea was recorded at C₈ (1.427). Incase nutrient management, the treatment F₂ (100 % RDF) recorded the highest relative crowding coefficient of fodder cowpea. With subject to interactions, the highest relative crowding coefficient was observed at C₈F₂ and C₆F₂.
- Under different row ratio, the lowest aggressivity of fodder cowpea was observed at C₄, incase of nutrient management, treatment F₀ recorded the highest aggressivity, while C₄F₀ recorded the highest aggressivity, among the treatment interactions.
- The highest competition ratio of fodder cowpea under different row ratio was observed at C₆. Among the nutrient management operations, the treatment F₂

recorded the highest competition ratio of fodder cowpea as compared to F₁ and F₀. In interactions, C₆F₂ recorded the highest competition ratio of fodder cowpea.

5.2.5 Plant analysis

5.2.5.1 Nutrient content (%)

- The highest nitrogen, phosphorus and potassium content in fodder cowpea was observed at sole cowpea (C₂). In case of nutrient management approaches, the treatment F₂ recorded the highest nutrient content (N, P and K). Likewise, among the treatment interactions, the highest nitrogen and phosphorus content in fodder cowpea was recorded at C₈F₂. However, the highest potassium content was observed from C₆F₂ (1.243 %) and followed by C₄F₂ (1.207 %).

5.2.5.2 Nutrient uptake (kg ha⁻¹)

- The highest nitrogen, phosphorus and potassium uptake by fodder cowpea was recorded at sole plot C₂. Similarly, with subject to nutrient management, treatment F₂ (100 % RDF) recorded the highest nitrogen, phosphorus and potassium uptake by fodder cowpea. Under interactions, the highest nitrogen, phosphorus and potassium uptake by fodder cowpea was registered at C₂F₂ followed by treatments C₈F₂ and C₄F₂.

5.3. Rice bean

5.3.1 Growth parameters

- The sole crop treatment C₃ significantly recorded the highest plant height, leaf stem ratio, stem girth, primary branches, fresh weight and dry weight of fodder rice bean at 20 DAS, 40 DAS, 60 DAS and 80 DAS. The higher number of leaves plant⁻¹ at 20 DAS was recorded from treatment C₇ and followed by C₃ sole rice bean. The longest leaf length and leaf width at 20 DAS was recorded at sole rice bean (C₃). However, the leaf length from 40 DAS to 80 DAS onward, it was registered from C₅ and C₉ respectively. The longest width at 40 DAS was observed at C₉, while C₇ recorded the longest leaf width at 60 DAS and 80 DAS.

- With regard to nutrient management practices, the highest vegetative growth of fodder rice bean was registered at F₂ (100 % RDF). The interactions results revealed that application of nutrient at 100 % RDF significantly registered the higher growth of fodder rice bean as compared to F₁ (50 % RDF) and F₀ (0 % RDF).
- Among all the treatment combinations, C₃F₂ recorded the highest plant height at 20 DAS, 40 DAS, 60 DAS and 80 DAS. The highest leaf length of fodder rice bean at 20 DAS, 40 DAS, 60 DAS and 80 DAS was recorded from C₃F₂ and C₅F₂. The longest leaf width was recorded at C₃F₂ at 20 DAS, 40 DAS, and for 60 DAS, it was registered from C₉F₂, while C₅F₂ and C₇F₂ recorded the highest leaf width at 80 DAS. Among all the interactions, the highest leaf stem ratio, stem girth and number of leaves plant⁻¹ at 20 DAS, 40 DAS, 60 DAS and 80 DAS was recorded at C₃F₂, while the highest number of leaves plant⁻¹ at 20 DAS was counted in C₇F₂. The treatments C₅F₂ and C₃F₂ recorded the highest primary branches at 20 DAS, 40 DAS and 60 DAS. The highest fresh weight and dry weight of fodder rice bean was recorded at C₃F₂.

5.3.2 Yield

- The fodder rice bean planted under sole stand followed 2:2 significantly registered the highest green fodder and dry fodder yield of fodder rice bean as compared to 2:1 and 1:1 row ratio. In case nutrient management, the treatment F₂ recorded the highest green fodder and dry fodder yield of fodder rice bean compared to F₁ and F₀. Among the treatment combinations, the highest green and dry fodder yield of fodder rice bean was recorded at C₃F₂ and C₃F₁ respectively.

5.3.3 Qualitative analysis

- The highest crude protein content of fodder rice bean was recorded at sole rice bean C₃ (18.62 %) while the remaining treatments registered similar trend of crude protein content.
- The application of nutrient at 100 % RDF (F₂) registered significantly the highest crude protein of fodder rice bean (18.63 %) as compared to treatments F₁ and F₀ respectively.

- Among the treatment interactions, the highest crude protein content in fodder rice bean was found in C₃F₂ (20.37 %) followed by C₃F₁ (18.90 %).
- With respect to different row ratio, the highest crude protein yield of fodder rice bean (6.83 q ha⁻¹) was recorded at sole plot C₃ respectively and followed by C₉ (3.02 q ha⁻¹).
- The crude protein content in fodder rice bean was found to be the highest in C₃F₂ (20.37 %) followed by C₃F₁ (18.90 %). The applications of nutrient @ 100 % RDF (F₂) registered the highest crude protein yield of the fodder rice bean (4.57 q ha⁻¹) in compared to treatments F₁ and F₀.
- Among all the treatment combinations, the highest crude protein yield of fodder rice bean (7.74 q ha⁻¹) was registered from C₁F₂ followed by C₂F₂ and C₃F₂ respectively.
- The highest crude fibre content in fodder rice bean was recorded at sole plot C₃ (23.00 %). Incase of nutrient management, the highest crude fibre content of fodder rice bean (26.07 %) was registered from treatment receiving 100 % RDF (F₂). Among all the treatment combinations, the fodder rice bean (27.14 %) planted under sole stand with application of 100 % RDF nutrient (F₂) recorded the highest crude fibre content in compared to other treatments.
- The treatment sole plot C₃ recorded the highest ash content (13.83 %) when compared with other treatments. The application of nutrients at 100 % @ 60:30:30 NPK kg ha⁻¹ recorded the highest ash content of fodder rice bean (17.10 %).
- Likewise, the higher and similar trend of ash content in fodder rice bean was observed when it was grown with fodder maize at different row ratio along with 100 % RDF (60-30-30 NPK kg ha⁻¹).

5.3.4 Intercropping studies

- Incase different row ratio, the treatment C₃ significantly maintained the highest crop growth rate of fodder rice bean at 20-40 DAS and 40-60 DAS. With regards to nutrient management, the highest crop growth rate of fodder rice bean was registered at 20-40 DAS and 40-60 DAS was recorded at F₂. Correspondingly, in interactions, treatment C₃F₂ recorded the highest crop growth rate at 20-40 DAS and 40-60 DAS.

- The highest leaf area index observed in C₃ at 20 DAS (0.2751) and 40 DAS (1.9269).
- The higher net assimilation rate of fodder rice bean at 20-40 DAS was registered at sole plot C₇, while C₃ registered the highest net assimilation rate at 40-60 DAS. Subject to nutrient management, the highest net assimilation rate of fodder rice bean was recorded at F₂ in both the stages of observation *i.e.*, 20-40 DAS and 40-60 DAS. The highest net assimilation rate of fodder rice bean was seen in treatment C₃F₂ at 20-40 DAS and 40-60 DAS.
- The highest relative growth rate was obtained in treatment C₇ at 20-40 DAS and C₉ at 40-60 DAS. In case of nutrient management, treatment F₂ in both 20-40 DAS and 40-60 DAS registered the highest relative growth rate of fodder rice bean. Among the treatment combinations, the highest relative growth rate at 20-40 DAS and 40-60 DAS was observed at C₇F₂ and C₉F₂.
- The highest relative crowding co-efficient for fodder rice bean was recorded at C₉ (1.285). In case of nutrient management, F₂ (100 % RDF) recorded the highest relative crowding co-efficient of fodder rice bean. With regards to interactions, the highest relative crowding co-efficient of fodder rice bean was registered at C₉F₂.
- The lowest aggressivity of fodder rice bean was observed under C₅. In case of nutrient management, treatment F₀ recorded the highest aggressivity, while the treatment C₁F₀ recorded the highest aggressivity among the treatment interactions.
- Among the different row ratio, the highest competition ratio was recorded at treatment C₇ and in case of nutrient management, the highest competition ratio was observed at F₂.

5.3.5 Plant analysis

5.3.5.1 Nutrient content (%)

- The highest nitrogen and potassium content in fodder rice bean was recorded under sole stand C₅ followed by C₉, while treatment C₉ recorded the highest of phosphorus content of fodder rice bean. Regarding the nutrient management practices, the treatment F₂ registered the highest nitrogen, phosphorus and potassium content.

- Among the treatment interactions, the highest nitrogen and potassium content in fodder rice bean was observed at C₅F₂, while phosphorus content in fodder rice bean was obtained at C₇F₂.

5.3.5.2 Nutrient uptake (kg ha⁻¹)

- The sole plot C₃ marked the highest nitrogen, phosphorus and potassium uptake by the fodder rice bean. Among the nutrient management, the highest uptake of nitrogen, phosphorus and potassium by the fodder rice bean was seen at F₂ as compared F₁ and F₀ treatments. Regarding the interactions, the highest uptake of nitrogen, phosphorus and potassium by fodder rice bean was recorded from C₃F₂ and C₃F₁.

Conclusions

The study revealed that the performance of fodder maize-based legume intercropping system was significantly influenced by the combinations of row ratio and nutrient management. In accordance with the research objectives, the conclusions of the study are presented below:

1. The study revealed that a suitable row ratio significantly influences the productivity and compatibility of fodder maize and legume intercropping system. Among all the treatment combinations, the 2:1 row ratio followed by 2:2 row ratio proved to be the most suitable row ratio for fodder maize-based legume intercropping.
2. Application of an optimum NPK dose significantly improved the growth, nutrient uptake and the fodder quality of the maize based legume intercropping system. Among the different levels of nutrient management, an application of NPK @ 100 % RDF *i.e.*, 60-30-30 kg ha⁻¹ registered the best fodder quality of the crop.
3. Economics analysis showed that intercropping system with the 100 % RDF dose and suitable row ratio offered the higher net returns and benefit-cost ratio compared to all other treatments. Thus, integrating appropriate row ratio proportion with balanced fertilization is both agronomically and economically viable for sustainable fodder production.

APPENDICES

APPENDICES

Appendix 1: Operation-wise fixed cost incurred for the cultivation of fodder maize during both years of the experimentations

A. Fixed cost		2022-2023			2022-2023		
Sl. No	Name of the operations	Time or Quanty required	Rate (₹ Unit ⁻¹)	Cost (₹ ha ⁻¹)	Time or Quanty required	Rate (₹ Unit ⁻¹)	Cost (₹ ha ⁻¹)
1	Cultivator	3 hrs	1300	3900	3 hrs	1300	3900
2	Rotavator	2 hrs	1300	2600	2 hrs	1300	2600
3	Layout	4 men day	400/men/day	1600	4 men day	400/men/day	1600
4	Seed sowing and Fertilizers application	6 men day	400/men/day	2400	6 men day	400/men/day	2400
5	Hand weeding	6 men day	400/men/day	2400	7 men day	400/men/day	2800
6	Thinning & earthing up	7 men day	400/men/day	2800	7 men day	400/men/day	2800
7	Insecticides	1/2 L Neem oil	550/L	550	1 L Neem oil	550/ L	550
		300 g Immamectin	450/100 g	1350	300 g Immamectin	450/100 g	1350
		100 g Minchu	230/100 g	230	100 g Minchu	230/100 g	230
		1.5 L Chloropyriphose	550/500 ml	1650	1.5 L Chloropyriphose	550/500 ml	1650
		4 men day	400/men/day	1600	4 men day	400/men/day	1600
8	Fungicide	200 g Saaf	241/100 g	241	100 g Saaf	241/100 g	241
9	Harvesting	6 men day	400/men/day	2400	6 men day	400/men/day	2400
10	Miscellaneous			1000			1600
Total Fixed cost (₹ ha ⁻¹)				24721			25721

Appendix II. Cost of variable inputs used for the cultivation of fodder maize during both years of the experimentations

Cost of variable inputs ha ⁻¹					Cost (₹ ha ⁻¹)	Total cost (₹ ha ⁻¹)
Sl. No.	Inputs		Inputs/Quantity	Rate (₹ Unit ⁻¹)		
A. Seeds						
1	C ₁	- Maize	40	80 kg ⁻¹	3200	3200
2	C ₂	- Cowpea	30	100 kg ⁻¹	3000	3000
3	C ₃	- Rice bean	20	110 kg ⁻¹	2200	2200
4	C ₄	- Maize	20	80 kg ⁻¹	1600	3100
		- Cowpea	15	100 kg ⁻¹	1500	
5	C ₅	- Maize	20	80 kg ⁻¹	1600	2700
		- Rice bean	10	110 kg ⁻¹	1100	
6	C ₆	- Maize	26.7	80 kg ⁻¹	2136	3136
		- Cowpea	10	100 kg ⁻¹	1000	
7	C ₇	- Maize	26.7	80 kg ⁻¹	2136	2869.7
		- Rice bean	6.67	110 kg ⁻¹	733.7	
8	C ₈	- Maize	20	80 kg ⁻¹	1600	3100
		- Cowpea	15	100 kg ⁻¹	1500	
9	C ₉	- Maize	20	80 kg ⁻¹	1600	2700
		- Rice bean	10	110 kg ⁻¹	1100	

Appendix III. Cost of variable inputs used for the cultivation of fodder maize during both years of the experimentations

b. Fertilizers				Cost (₹ ha ⁻¹)			Total Cost (₹ ha ⁻¹)
Treatments	Nitrogen (Urea @ ₹ 6.4 kg ⁻¹)	Phosphorus (SSP @ ₹ 8.4 kg ⁻¹)	Potassium (MoP @ ₹ 19.6 kg ⁻¹)	Urea	SSP	MOP	
C ₁ F ₀	0	0	0	0	0	0	0
C ₁ F ₁	65.22	93.75	25	417.408	787.5	490	1694.908
C ₁ F ₂	130.44	187.5	50	834.816	1575	980	3389.816
C ₂ F ₀	0	0	0	0	0	0	0
C ₂ F ₁	65.22	93.75	25	417.408	787.5	490	1694.908
C ₂ F ₂	130.44	187.5	50	834.816	1575	980	3389.816
C ₃ F ₀	0	0	0	0	0	0	0
C ₃ F ₁	65.22	93.75	25	417.408	787.5	490	1694.908
C ₃ F ₂	130.44	187.5	50	834.816	1575	980	3389.816
C ₄ F ₀	0	0	0	0	0	0	0
C ₄ F ₁	65.22	93.75	25	417.408	787.5	490	1694.908
C ₄ F ₂	130.44	187.5	50	834.816	1575	980	3389.816
C ₅ F ₀	0	0	0	0	0	0	0
C ₅ F ₁	65.22	93.75	25	417.408	787.5	490	1694.908
C ₅ F ₂	130.44	187.5	50	834.816	1575	980	3389.816
C ₆ F ₀	0	0	0	0	0	0	0
C ₆ F ₁	65.22	93.75	25	417.408	787.5	490	1694.908
C ₆ F ₂	130.44	187.5	50	834.816	1575	980	3389.816
C ₇ F ₀	0	0	0	0	0	0	0
C ₇ F ₁	65.22	93.75	25	417.408	787.5	490	1694.908
C ₇ F ₂	130.44	187.5	50	834.816	1575	980	3389.816
C ₈ F ₀	0	0	0	0	0	0	0
C ₈ F ₁	65.22	93.75	25	417.408	787.5	490	1694.908
C ₈ F ₂	130.44	187.5	50	834.816	1575	980	3389.816
C ₉ F ₀	0	0	0	0	0	0	0
C ₉ F ₁	65.22	93.75	25	417.408	787.5	490	1694.908
C ₉ F ₂	130.44	187.5	50	834.816	1575	980	3389.816

Appendix IV. Calculation of return from the cultivation

Fodder maize GFY (q ha ⁻¹)			Fodder legume GFY (q ha ⁻¹)			Fodder maize income (₹ ha ⁻¹)			Fodder legume income (₹ ha ⁻¹)			Total income (₹ ha ⁻¹)		
2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
416.33	427.00	421.67	-	-	-	83266.00	85400.00	84334.00	-	-	-	83266.00	85400.00	84334.00
512.67	550.00	531.33	-	-	-	102534.00	110000.00	106266.00	-	-	-	102534.00	110000.00	106266.00
589.00	598.00	593.50	-	-	-	117800.00	119600.00	118700.00	-	-	-	117800.00	119600.00	118700.00
-	-	-	306.67	326.58	316.63	-	-	-	76667.50	81645.00	79157.50	-	-	-
-	-	-	336.67	351.08	343.88	-	-	-	84167.50	87770.00	85970.00	-	-	-
-	-	-	366.00	376.33	371.17	-	-	-	91500.00	94082.50	92792.50	-	-	-
-	-	-	262.33	273.33	267.83	-	-	-	65582.50	68332.50	66957.50	-	-	-
-	-	-	356.67	371.67	364.17	-	-	-	89167.50	92917.50	91042.50	-	-	-
-	-	-	378.00	411.08	394.54	-	-	-	94500.00	102770.00	98635.00	-	-	-
273.67	288.33	281.00	133.33	136.50	134.92	54734.00	57666.00	56200.00	33332.50	34125.00	33730.00	88066.50	91791.00	89930.00
350.00	377.33	363.67	163.33	160.25	161.79	70000.00	75466.00	72734.00	40832.50	40062.50	40447.50	110832.50	115528.50	113181.50
403.67	415.33	409.50	188.33	238.33	213.33	80734.00	83066.00	81900.00	47082.50	59582.50	53332.50	127816.50	142648.50	135232.50
252.00	260.00	256.00	121.67	130.83	126.25	50400.00	52000.00	51200.00	30417.50	32707.50	31562.50	80817.50	84707.50	82762.50
345.00	375.00	360.00	180.00	192.67	186.33	69000.00	75000.00	72000.00	45000.00	48167.50	46582.50	114000.00	123167.50	118582.50
412.33	416.67	414.50	207.33	231.08	219.21	82466.00	83334.00	82900.00	51832.50	57770.00	54802.50	134298.50	141104.00	137702.50
346.67	361.00	353.83	99.00	105.00	102.00	69334.00	72200.00	70766.00	24750.00	26250.00	25500.00	94084.00	98450.00	96266.00
424.67	458.00	441.33	123.33	134.58	128.96	84934.00	91600.00	88266.00	30832.50	33645.00	32240.00	115766.50	125245.00	120506.00
510.67	521.67	516.17	152.33	158.33	155.33	102134.00	104334.00	103234.00	38082.50	39582.50	38832.50	140216.50	143916.50	142066.50
355.33	369.33	362.33	83.67	95.58	89.63	71066.00	73866.00	72466.00	20917.50	23895.00	22407.50	91983.50	97761.00	94873.50
435.67	473.67	454.67	127.67	148.67	138.17	87134.00	94734.00	90934.00	31917.50	37167.50	34542.50	119051.50	131901.50	125476.50
504.00	518.33	511.17	150.00	168.33	159.17	100800.00	103666.00	102234.00	37500.00	42082.50	39792.50	138300.00	145748.50	142026.50
277.67	282.00	279.83	171.67	172.42	172.04	55534.00	56400.00	55966.00	42917.50	43105.00	43010.00	98451.50	99505.00	98976.00
338.33	383.67	361.00	192.00	195.75	193.88	67666.00	76734.00	72200.00	48000.00	48937.50	48470.00	115666.00	125671.50	120670.00
407.00	423.00	415.00	225.00	249.17	237.08	81400.00	84600.00	83000.00	56250.00	62292.50	59270.00	137650.00	146892.50	142270.00
254.33	272.33	263.33	133.33	140.67	137.00	50866.00	54466.00	52666.00	33332.50	35167.50	34250.00	84198.50	89633.50	86916.00
330.33	371.67	351.00	190.33	209.17	199.75	66066.00	74334.00	70200.00	47582.50	52292.50	49937.50	113648.50	126626.50	120137.50
415.00	421.67	418.33	221.00	257.92	239.46	83000.00	84334.00	83666.00	55250.00	64480.00	59865.00	138250.00	148814.00	143531.00

Cost of green fodder legume = ₹ 250 q⁻¹, Cost of green fodder maize = ₹ 200 q⁻¹

REFERENCES

REFERENCES

- Adeleke, M. A. and Haruna, I. M. 2012. Residual nitrogen contribution from grain legume to the growth and development of succeeding maize crop. *International Scholarly Research Network*. **12**:1-6.
- Ali, A., Adnan, M., Safdar, M. E., Asif, M., Mahmood, A. and Nadeem, M. 2020. Role of potassium in enhancing growth, yield and quality of maize (*Zea mays* L.). *International Journal of Biosciences*. **16**(6):210-219.
- Ali, S., Sahiba, M., Malik, A., Fayyaz-ul-Hassan and Ansar, M. 2012. Growth of rainfed fodder maize under different levels of nitrogen. *Pakistan Journal of Agricultural Research*. **25**(3):196-205.
- Allen, J. R. and Obura, R. K. 1983. Yield of corn, cowpea and soybean under different intercropping systems. *Agronomy Journal*. **75**:1005-1009.
- Amanullah, Bashir, S. F., Qahar, A., Shah, S., Ahmad, B. and Iqbal, A. 2015. Interactive effects of nitrogen and sulfur on growth, dry matter partitioning and yield of maize. *Pure Application of Biology*. **4**(2):164-170.
- Amanullah, M. M. and Nivethita, S. 2020. Forage intercropping and fertilizer levels on productivity and economics of maize-based food cum fodder system. *International Journal of Current Microbiology and Applied Sciences*. **9**(50):2904-2911.
- Amos, R. N., Jens, B. A. and Symon, M. 2012. On farm evaluation of yield and economic benefits of short-term maize legume intercropping systems under conservation Agriculture in Malawi. *Field Crop Research*. **132**:149-157.
- Anonymous. 2019. 20th Livestock Census. All India Report, DAHD&F. Ministry of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India. www.dahd.nic.in.
- Anonymous. 2021. Maize Outlook Report - January to May. *Agricultural Market Intelligence Centre*, ANGRAU, Lam.
- Anonymous. 2024. ANGRAU - Crop Outlook Reports of Andhra Pradesh Maize-June to May, 2023-24. Centre for Agriculture and Rural Development Policy Research.
- AOAC. 2005. Official Methods of Analysis. (18th Edn.), *Association of Official Analytical Chemists*. Arlington, Virginia, USA, p. 19-28.

- Arif, M., Kumar, A. and Pourouchottame, R. 2024. Intercropping of maize and cowpea for enhancing productivity, profitability and land use efficiency. *Bangladesh Journals of Botany*. **53**(2):235-242. <https://doi.org/10.3329/bjb.v53i2.74035>.
- Arshad, M. 2017. Effect of intercropping, elevation and nitrogen dose on performance of maize-mungbean cropping systems. *Biological Life and Environmental Sciences*. **54**(4):353-364.
- Arya, R. L. and Niranjana, K. P. 1995. Productivity of sorghum (*Sorghum bicolor*) as affected by legumes intercropping under different fertility systems. *Indian Journal of Agricultural Sciences*. **65**(3):175-177.
- Asangla, H. A. and Gohain, T. 2016. Effect of fodder yield and quality attributes of maize (*Zea mays* L.) + cowpea (*Vigna unguiculata* L.) intercropping and different nitrogen levels. *International Journal of Agricultural Science and Research*. **6**(2):349-356.
- Asangla, H. K. 2015. Fodder production potential of maize (*Zea mays* L.) + cowpea (*Vigna unguiculata*) intercropping under different nitrogen levels. Ph.D. thesis, School of Agricultural Sciences, Nagaland University.
- Askegaard, M. and Eriksen, J. 2008. Residual effect and leaching of N and P in cropping systems with clover and ryegrass catch crops on a coarse sand. *Agriculture Ecosystems and Environment*. **123**(1-2):99-108.
- Ayub, M., Ahmad, R., Nadeem, M. A., Ahmad, B. and Khan, R. M. A. 2003a. Effect of different levels of nitrogen and seed rates on growth, yield and quality of maize fodder. *Pakistan Journal of Agricultural Sciences*. **40**(3-4):140-143.
- Ayub, M., Nadeem, M. A., Ahmad, R. and Javaid, F. 2003. Response of maize fodder to different nitrogen levels and harvesting times. *Pakistan Journal of Life and Social Sciences*. **1**(1):45-47.
- Ayub, M., Nadeem, M. A., Sharar, M. S. and Mahmood, N. 2002. Response of maize (*Zea mays* L.) fodder to different levels of nitrogen and phosphorus. *Asian Journal of Plant Sciences*. **1**(4):352-354.
- Azim, A., Khan, A. G., Nadeem, M. A. and Muhammad, D. 2000. Influence of maize and cowpea intercropping on fodder production and characteristics of silage. *Asian Australian Journal of Animal Science*. **13**(6):781-784.
- Bahuguna, A. and Pal, M. S. 2020. Effect of establishment method and nutrient management on growth and yield of baby corn (*Zea mays* L.) in Tarai region of Uttarakhand. *Pantnagar Journal of Research*. **18**(2):125-129.
- Bahuguna, A. and Pal, M. S. 2021. Effect of crop establishment methods and nutrient management options on productivity and economics of baby corn (*Zea mays* L.). *Pantnagar Journal of Research*. **19**(1):16-20.

- Baishya, L. K., Jamir, T., Walling, N. and Rajkhowa, D. J. 2021. Evaluation of Maize (*Zea mays* L.) + Legume Intercropping System for Productivity, Profitability, Energy Budgeting and Soil Health in Hill Terraces of Eastern Himalayan Region. *Legume Research*. **44**(11):1343-1347.
- Barker, D. J. and Culman, S. W. 2020. Fertilization and nutrient management. *Forages: The Sciences of Grassland Agricultural*. **2**:473-496.
- Beremjungla. 2015. Nutrient management in maize (*Zea mays* L.) based intercropping systems under the rainfed condition of Nagaland. Ph.D. thesis, School of Agricultural Sciences, Nagaland University.
- Bhagat, S., Gupta, M., Banotra, M., Sharma, A., Kumar, S. and Sharma, A. 2017. Production potential and economics of fodder maize (*Zea mays*) varieties sown under varying intercropping systems with cowpea (*Vigna unguiculata*). *International Journal of Current Microbiology and Applied Sciences*. **6**(12):4082-4087.
- Bhaumik, S., Rajeev, Kumar, S., Fayaz, S., Choudhary, M., Narender, K. and Sharma, S. 2023. Impact of nutrients on the development and yield of fodder maize (*Zea mays* L.): A Review. *Agricultural Reviews*. 1-7. Doi.10.18805/ag.R-2631.
- Bray, R. H. and Kurtz, L. T. 1945. Determination of total, organic and available forms of phosphorus in soils. *Soil Science*. **59**(1):39-46.
- Chaudhary, R., Gupta, S. J., Kohli, A., Choudhary, S. R. and Singh, M. K. 2020. Studies on green fodder quality, quality and economics of cereal forage sown alone and intercrop with cowpea. *International Journal of Current Microbiology and Applied Sciences*. **9**(11):1893-1902.
- Dahmardeh, M., Ghanbari, A., Syahsar, B. A. and Ramrodi, M. 2010. The role of intercropping maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L.) on yield and soil chemical properties. *African Journal of Agricultural Research*. **5**(8):631-636.
- Dahmardeh, M., Ghanbari, A., Syasar, B. and Ramroudi, M. 2009. Effect of intercropping maize with cowpea on green forage yields and quality evaluation. *Asian Journal of Plant Sciences*. **8**(3):235-239.
- Deb, R. 1993. Reap more biomass through diversity in forestry. *Intensive Agriculture*. **XXXI**(5-8):23-26.
- Deb, R., Shankararnaryan, A. K. and Pathak R. S. 1989. The fodder trees of India and their importance. *Indian Forester*. **106**:306-311.
- Deore, S. M., Patel, M. R., Patel, P. M., Patel, H. K. and Patel, U. J. 2013. Production potential of forage maize (*Zea mays* L.) - cowpea (*Vigna unguiculata* L.)

- intercropping system as influenced by row ratios. *Advance Research Journal of Crop Improvement*. **4**(2):110-112.
- Dhamodharam, P., Sankaran, V. M., Suresh, S. and Rajakumar, D. 2021. Effects of humic acid and macronutrients on fodder maize and fodder cowpea intercropping. *The Pharma Innovation Journal*. **10**(11):384-388.
- Dhamodharan, P., Kiruthika, K. and Gunalarasi, G. 2023. Response of macronutrient and humic acid on physiological attributes of fodder cereal-pulse intercropping system. *International Journal of Veterinary Sciences and Animal Husbandry*. **8**(6):24-28.
- Dhonde, A. S., Thorat, N. H., Thorat, S. D. and Pilane, M. S. 2016. Effect of intercropping of maize (*Zea mays* L.) + cowpea (*Vigna unguiculata*) on production of green fodder. *Ecological Environmental & Conservation*. **22**(1):309-312.
- Dudge, K. S., Kudtarkar, U. S., Chavan, V. G., Bodake, P. S. and Awaghade, A. M. 2022. Intercropping indices of fodder maize (*Zea mays*) and fodder cowpea (*Vigna unguiculata*) under various row proportions. *The Pharma Innovation Journal*. **11**(12):908-911.
- Eskandari, H. 2012. Yield and quality of forage produced in intercropping of maize (*Zea mays*) with cowpea (*Vigna sinensis*) and mungbean (*Vigna radiata*) as double cropped. *Journal of Basic Application Sciences Research*. **2**(1):93-97.
- Eskandari, H. and Ghan-bari, A. 2009. Intercropping of maize (*Zea mays*) and cowpea (*Vigna sinensis*) as whole-crop forage: Effect of different planting pattern on total dry matter production and maize forage quality. *Notulae Botanicae Horticulture Agrobotanici Cluj-Napoca*. **37**(2):152-155.
- Eskandari, H., Ghanbari-Bonjar, A., Galavi, M. and Salari, M. 2009. Forage quality of cow pea (*Vigna sinensis*) intercropped with corn (*Zea mays*) as affected by nutrient uptake and light interception. *Notulae Botanical Horticulture Agrobotanici Cluj-Napoca*. **37**(1):171-174.
- Fusuo, Z. and Li, L. 2003. Using competitive and facultative interaction in intercropping systems enhances crop productivity and nutrients use efficiency. *Plant and Soil*. **248**:305-312.
- Gaikwad, D. D., Pankhaniya, R. M., Singh, B., Patel, K. G. and Viridia, H. M. 2022. Studies on growth and productivity of maize-cowpea intercropping system under different spatial arrangements and nutrient levels. *The Pharma Innovation Journal*. **11**(2):2506-2512.
- Ganvit, V. C., Surve, V. H., Sharma, S. and Ganvit, J. B. 2018. Forage production potential of oat (*Medicago sativa* L.) - lucerne (*Avena sativa*) intercropping under sole and intercropping systems. *Journal of Pharmacognosy and Phytochemistry*. **7**(5):705-707.

- Gardner, F. P. and Kisakye, J. 1990. Productivity of bean-maize intercrops as influenced by bean type and planting date and maize density. *Proceedings Soil and Crop Science Society of Florida*. **49**:139-146.
- Geiler, K. E. 2001. Nitrogen fixation in tropical cropping system (2nd ed.). CABI publishing, Wallingford, UK. <http://dx.doi.org/10.1079/9780851994178.000>.
- Ghanbari-Bonjar, A. 2000. Intercropped wheat (*Triricum aestivum*) and bean (*Vicia faba*) as a low-input forage. Ph.D. thesis. Wye College, University of London.
- Ginwal, D. S., Kumar, R., Ram, H., Dutta, S., Arjun, M. and Hindoriya, P. S. 2019b. Fodder productivity and profitability of different maize and legume intercropping systems. *Indian Journal of Agricultural Sciences*. **89**(9):1451-1455.
- Ginwal, D. S., Kumar, R., Ram, H., Meena, R. K. and Kumar, U. 2019a. Quality characteristics and nutrient yields of maize and legume forages under changing intercropping row ratios. *Indian Journal of Animal Sciences*. **89**(3):281-286.
- Gomez, K. A. and Gomez, A. A. 1984. Statistical procedures for agricultural research. John Wiley and sons.
- Gupta, M., Bhagat, S., Kumar, S., Kour, S. and Gupta, V. 2019. Production potential and quality of fodder maize (*Zea mays*) varieties under varying intercropping systems with cowpea (*Vigna unguiculata*). *Range Management and Agroforestry*. **40**(2):243-249.
- Halikatti, S. I. and Banarasilal, B. 2011. Production potentiality of maize as influenced by planting geometry, mulching and grain legume intercropping. *Karnataka Journal of Agricultural Sciences*. **11**(4).
- Hamdollah, E. and Ghanbari, A. 2009. Intercropping of maize (*Zea mays*) and cowpea (*Vigna sinensis*) as whole-crop forage: Effect of different planting pattern on total dry matter production and maize forage quality. *Notulae Botanicae Horticulture Agrobotanici Cluj-Napoca*. **37**(2):152-155.
- Hembran, J. and Kundu, C. K. 2016. Effect of integrated nutrient management on growth, yield and quality of forage cropping system. *Journal of Agricultural Science and Research*. **3**(1):17-22.
- Hnamte, C. L., Lalrammawia and Gopichand, B. 2016. Effect of NPK fertilizers on growth and yield of maize under different jhum cycles in Mizoram. *Science Vision*. **16**(2):59-67.
- Hongchun, X., Shen, H., Zhang, L., Zhang, Y., Guo, X., Wang, P. and Zuo, Y. 2013. Comparative proteomic analysis for assessment of the ecological significance of maize and peanut intercropping. *Journal of Proteomics*. **78**:447-460.

- Iderawumi, A. R. M. 2014. Effect of cowpea on growth and yield parameter in a maize-cowpea intercrop. *Journal of Management and Science*. **3**(1):37-42.
- Ijaz, M., Mahmood, A. and Ullah, H. 2014. Response of maize hybrid (*Zea mays* L.) to different levels of potassium. *Agricultural Research Communication Centre*. **1**(1):30-38.
- Iqbal, A. and Amanullah, M. 2015. Impact of potassium rates and their application time on dry matter partitioning biomass and harvest index of maize (*Zea mays*) with and without cattle dung application. *Emirates Journal of Food Agriculture*. **25**(5):447-453.
- Iqbal, A., Akbar, N., Khan, H. Z., Abbas, R. N. and Ahmad, J. 2012. Productivity of summer legume forages intercropped with maize as affected by mixed cropping in different sowing techniques. *The Journal of Animal & Plant Sciences*. **22**(3):758-763.
- Iqbal, A., Ayub, M., Zaman, H. and Ahmad, R. 2006. Impact of nutrient management and legume association on agro-qualitative traits of maize forage. *Pakistan Journal of Botany*. **38**(4):1079-1084.
- Iqbal, A., Iqbal, M. A., Raza, A., Akbar, N., Abbas, R. N. and Khan, H. Z. 2014. Integrated nitrogen management studies in forage maize. *American-Eurasian Journal of Agricultural and Environmental Sciences*. **14**(8):744-747.
- Islam, H., Ahmad, A. B. M. and Jubayer, F. 2014. Biomass yield and chemical composition of maize (*Zea mays*) fodder using compost as fertilizer. *International Journal of Chemical and Biochemical Sciences*. **1**:2349-2724.
- Jackson, M. L. 1973. Soil chemical analysis, pentice hall of India Pvt. Ltd., New Delhi, India, 498, 151-154.
- Jakhar, S. P., Patel, B. S., Patel, B. J., Bhatt, R. K. and Bhatt, V. K. 2009. Effect of row spacing and seed ratio on green forage yield and economics of lucerne and chicory under different mixed/intercropping systems. *Forage Research*. **35**(3):157-160.
- Jan, R., Saxena, A., Jan, R., Khanday, M. and Jan, R. 2016. Intercropping indices and yield attributes of maize and black cowpea under various planting pattern. *The Bioscan*. **11**(2):1-5.
- Jassal, R. K., Kang, J. S., Singh, H. and Singh, T. 2017. Growth, phenology and seed yield of fodder maize in relation to different planting methods and nitrogen levels. *International Journal of Current Microbiology and Applied Sciences*. **6**(4):1723-1735.
- Jat, P. C., Rathore, S. S. and Sharma, R. K. 2014. Effect of integrated nitrogen management and intercropping systems on yield attributes and yield of maize. *Indian Journal of Hill Farming*. **27**(1):91-99.

- Javanmard, A., Nasiri, Y. and Shekari, F. 2014. Competition and dry matter yield in intercrops of barley and legume for forage. *Albanian Journal of Agricultural Science*. **13**(I):22-32.
- Jena, N., Vani, K. P., Rao, V. P. and Sankar, A. S. 2015. Effect of nitrogen and phosphorus fertilizers on growth and yield of quality protein maize (QPM). *International Journal of Sciences and Research*. **12**(4):197-198.
- Kalia, R., Saroch, K. and Kumar, N. 2001. Production potential of oat (*Avena sativa*) based forage intercropping systems under sub-humid mid hill conditions of Himachal Pradesh. *Forage Research*. **27**(2):79-82.
- Kanakeri, V. V. 1991. Studies on intercropping of legumes in kharif maize and their residual effect on succeeding wheat. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.
- Kanduri, A. B., Patil, P. V. and Mogale, P. S. 2016. Green fodder yield and nutrient composition of African tall maize fodder (*Zea mays*) with various nitrogen-phosphorus levels. *International Journal of Advanced in Engineering, Management and Science*. **2**(5):279-281.
- Karki, U. 1985. Impact of crossbred cows on the economy of small farmers and their performance. *Nepalese Journal of Animals Sciences*. **9**(9).
- Khan, A., Munsif, F., Akhtar, K., Afridi, M. Z., Zahoor, Ahmad, Z., Fahad, S., Ullah, R., Khan, F. A. and Din, M. 2014. Response of fodder Maize to various levels of nitrogen and phosphorus. *American Journal of Plant Sciences*. **5**:2323-2329.
- Krishna, C. R., Babu, A. S., Raju, S., Vijay, K. and Nayak, A. S. 2022a. Evaluation of fodder production and nutritional composition of fresh and ensiled African tall maize (*Zea mays* L.) grown under various types and levels of fertilization. *International Journal of Economic Plants*. **9**(4):276-280.
- Kumar, A., Kumar, R., Kumar, S., Singh, R., Kumar, J. and Pal, L. 2018. Effect of various levels of nitrogen on growth, yield and quality pf fodder maize. *Journal of Pharmacognosy and Phytochemistry*. **7**(5):898-900.
- Kumar, A. M. R., Fathima, P. S., Yogananda, S. B., Sowmyalatha, B. S. and Bhagyalakshmi, T. 2024. Fodder maize (*Zea mays*) growth, yield and quality as influenced by foliar application of nano urea and urea under varying levels of nitrogen. *International Journal of Research in Agronomy*. **7**(3):490-494.
- Kumar, D., Singh, M., Kumar, S., Meena, R. K., Yadav, R. M., Makarana, G., Kushwaha, M., Dutta, S., Kumar, R. and Rajesh. 2022. Productivity and quality enhancement in fodder maize (*Zea mays*) cultivars through nutrient management strategies. *Indian Journal of Agricultural Sciences*. **92**(1):126-30.
- Kumar, M. R., Fathima, P. S., Yogananda, S. B., Sowmyalatha, B. S. and Bhagyalakshmi, T. 2024. Fodder maize (*Zea mays* L.) growth, yield and quality

- as influenced by foliar application of nano urea and urea under varying levels of nitrogen. *International Journal of Research in Agronomy*. **7**(3):490-494.
- Kumar, R. S. and Narmadha, R. 2021. Maize with green legume fodder intercropping system. *Agriculture Development and Economic Transformation in Global Scenario*. 157-163.
- Kumar, R., Devendra, S. and Lal, J. B. 2017. Nitrogen management in maize-based legume intercropping system. *Asian Journal of BioScience*. **12**(2):51-78.
- Kumar, R., Kumar, S., Singh, M., Meena, B. S., Tomar, S. K., Datt, C., Ram, H. and Rathore, D. K. 2016. Performance of quality protein maize under different planting windows. *Indian Journal of Animals Nutrition*. **33**:154-159.
- Kumar, R., Rathore, D. K., Singh, M., Kumar, P. and Khippal, A. 2016. Effect of phosphorus and zinc nutrition on growth and yield of fodder cowpea. *Legume Research*. **39**:262-267.
- Kumar, R., Singh, M., Tomar, S. K., Meena, B. S. and Rathore, D. K. 2016. Productivity and nutritive parameters of fodder maize under varying plant density and fertility levels for improved animal productivity. *Indian journal of Animal Research*. **50**(2):199-202.
- Kumar, S. and Faruqui, S. A. 2009. Production potential and economic viability of food-forage based cropping system under irrigated condition. *Indian Journal of Agronomy*. **54**(1):36-41.
- Kumar, S. and Faruqui, S. A. 2010. Forage production technologies for different agro-ecological regions. Tech. Pub. No. 01/2010, AICRP on Forage Crops, IGFRI, Jhanshi. pp44.
- Kumar, S., Rawat, C. R. and Melkania, N. P. 2005. Forage production potential and economics of maize (*Zea mays*) and cowpea (*Vigna unguiculata*) intercropping under rainfed conditions. *Indian Journal of Agronomy*. **50**(3):184-186.
- Kumari, A., Kumar, P., Ahmad, E., Singh, M., Kumar, R., Yadav, R. K., Datt, C. and Chinchmalatpure, A. 2014. Fodder yield and quality of oats fodder (*Avena sativa*) as influenced by salinity of irrigation water and applied nitrogen levels. *Indian Journal of Animal Nutrition*. **31**(3):266-271.
- Kussie, B., Tadele, Y. and Asresie, A. 2024. Effect of maize (*Zea mays* L.) and cowpea (*Vigna anguiculata* L.) intercropping on agronomic performance, yield and nutritional values of maize and cowpea under supplementary irrigation. *Heliyon*. **10**:1-9.
- Law-ogbomo, I. E. and Law-ogbomo, J. E. 2009. The performance of *Zea mays* as influenced by NPK fertilizer application. *Notulae Scientia Biologicae*. **1**(1):59-62.

- Li, L., Sun, J., Zhang, F., Li, X., Yang, S. and Rengel, Z. 2001. Wheat-maize or wheat-soybean strip intercropping yield advantage and interspecific interaction on nutrients. *Field Crop Research*. **71**:123-137.
- Li, S. X., Zhao-Hui, W. and Stewart, B. A. 2011. Differences of some leguminous and non-leguminous crops in utilization of soil phosphorus and responses to phosphate fertilizers. *Advances Agronomy*. **110**:125-249.
- Liu, J. H., Zeng, Z. H., Jiao, L. X., Hu, Y. G., Wang, Y. and Li, H. 2006. Intercropping of different silage maize cultivars and alfalfa. *Acta Scientiarum Agronomy*. **32**:125-130.
- Malunga, I., Lelei, J. J. and Makumba, W. 2017. Effect of mineral nitrogen and legume intercrops on maize (*Zea mays* L.) nitrogen uptake, nutrient use efficiency and yields in Chitedze and Zomba, Malawi. *Sustainable Agriculture Research*. **7**(1):64.
- Manoj, K. N., Shekara, B. G. and Shoba, D. 2020. Production potential and forage quality of cereal-legume intercropping systems in cauvery command area of Karnataka. *International Journal of Current Microbiology and Applied Sciences*. **9**(5):2319-7706.
- Mauriya, A. K., Hashim, M., Verma, R. B., Kumar, P., Kumari, M., Sahu, R., Verma, R. K. and Maurya, V. K. 2025. Evaluation of Rabi Maize-based Intercropping System for Augmenting the Productivity and Profitability of Rabi Maize under Irrigated Conditions of Bihar. *Indian Journal of Agricultural Research*. **59**(7):1131-1135.
- McGilchrist, C. A. 1965. Analysis of competition experiments. *Biometrics*. 975-985.
- Meena, A., Solanki, R. M., Malam, K. V. and Palanjiya, R. R. 2019. Effect of spacing and nitrogen levels on quality parameters and nitrogen uptake of fodder maize (*Zea mays* L.). *International Journal of Chemical Studies*. **7**(5):2355-2357.
- Miedema, P. 1982. The effects of low temperature on *Zea mays*. *Advances Agronomy*. **35**:93-128.
- Mishra, K. 2019. Evaluation of maize cowpea intercropping as fodder through front line demonstration. *Journal of Medicinal Plants Studies*. **7**(3):82-85.
- Nadeem, M. A., Iqbal, Z., Ayub, M., Mubeen, K. and Ibrahim, M. 2009. Effect of nitrogen application on forage yield and quality of maize sown alone and in mixture with legumes. *Pakistan Journal of Life Social Sciences*. **7**(2):161-167.
- Naik, M. S. P., Sumathi, V. and Kadiri, L. 2017. Response of optimum nitrogen rate in maize with legume intercropping system. *SAARC Journal of Agriculture*. **15**(1):139-148.

- Nisar, S., Rashid, Z., Touseef, A., Kumar, R., Nissa, S. U., Faheem, J., Angrez, A., Sabina, N., Shabeena, M., Tanveer, A., Amal, S., Rakshanda, A., Raies, B. and Dar, Z. A. 2024. Productivity of fodder maize (*Zea mays* L.) SFM-1 under varied sowing dates and nitrogen levels. *International Journal of Bio-resource and Stress Management*. **15**(1):01-12.
- Ogutu, M. O., Muasya, R. and Ouma, G. 2012. Effects of nitrogen fertilizer applications in a bean–maize based intercropping systems and locations on seed quality of common bean in Western Kenya. *International Research of Journal Agriculture Sciences*. **2**(11):481-492.
- Pal, V. and Kamboj, K. 2021. Effect of different levels of nitrogen on growth and fodder quality of maize (*Zea mays* L.). *International Journal of Chemical Studies*. **9**(1):198-199.
- Pandey, D., Bhatnagar, A., Singh, G. and Samarth. 2019. Growth response of intercropped maize (*Zea mays* L.) and urdbean (*Vigna mungo* L.) under different planting patterns and nutrient management practices. *Pantnagar Journal of Research*. **17**(2):99-106.
- Pandey, P. and Bhambri, M. C. 2017. Growth response of maize to different crop arrangements and nutrient managements under maize (*Zea mays* L.) and soybean (*Glycine max* L.) intercropping system. *Plant Archives*. **17**(2):967-972.
- Pandita, A. K., Shah, M. H. and Bali, A. S. 2000. Effect of row ratio in cereal-legume intercropping systems on productivity and competition functions under Kashmir conditions. *Indian Journal of Agronomy*. **45**:48-53.
- Pant, H. K., Mislevy, P. and Rechcigl, J. E. 2004. Effects of phosphorus and potassium on forage nutritive value and quality. *Environmental implications. Agronomy Journal*. **96**:1299-1305.
- Panwar, D., Chouhan, D., Singh, D., Singh, R. P. and Nepalia, V. 2020. Performance of fodder maize (*Zea mays* L.) under varying plant densities and fertility levels. *International Journal of Current Microbiology and Applied Sciences*. **11**:255-260.
- Parihar, C. M., Jat, S. L., Singh, A. K., Kumar, R. S., Hooda, K. S. and Singh, D. K. 2011. Maize production technologies in India. DMR Technical Bulletin 2011/Directorate of Maize Research, Pusa Campus, New Delhi-110012.Pp30.
- Patel, B. B., Patel, P. T. and Bhatt, V. K. 2008. Yield and quality of forage sorghum as influenced by intercropping of cowpea and nitrogen under rainfed conditions. *Forage Research*. **34**:170-173.
- Patel, J. R. and Rajagopal, S. 2001. Production potential of forage maize (*Zea mays*) with legumes under intercropping system. *Indian Journal of Agronomy*. **46**(2):211-215.

- Patel, J. R. and Rajagopal, S. 2002. Performance of sorghum and cowpea forage in intercropping. *Forage Research*. **28**(3):181-182.
- Patil, Y. G., Mevada, K. D., Vaghela, G. M. and Bedis, M. R. 2022. Economics, equivalent yield and land equivalent ratio for maize with chickpea intercropping system under middle Gujarat condition. *The Pharma Innovation Journal*. **11**(10):1887-1890.
- Piper, C. S. 1966. Soil and plant analysis. Academic Press. pp 47-77.
- Porte, C., Jha, S. K. and Dwivedi, S. K. 2019. Nitrogen use efficiency in African tall fodder maize (*Zea mays* L.) as affected by nitrogen levels and planting geometry. *International Journal of Chemical Studies*. **7**(2):1163-1167.
- Pragya, P. and Bhambri, M. C. 2017. Growth response of maize to different crop arrangements and nutrient managements under maize (*Zea mays* L.) and soybean (*Glycine max* L.) intercropping system. *Plant Archives*. **17**(2):967-972.
- Prajapati, B., Tiwari, S. and Kewalanand. 2018. Effect of fodder based intercropping systems on quality of fodder. *Forage Research*. **43**(4):308-313.
- Prasanna, B. M. 2014. Maize research for development scenario: challenges and opportunities for Asia. In: Prasanna, B. M. *et al.* (eds) 12th Asian maize conference and expert consultation on maize for food, feed and nutritional security, book of extended summaries, 30 October - 01 November, Bangkok, Thailand. pp 2-11.
- Prasanthi, K. and Venkateswaralu, B. 2014. Fodder quality in fodder maize-legume intercropping systems. *Journal of Tropical Agriculture*. **52**(1):86-89.
- Pual, N. C., Pual, U., Pual, S. C. and Pual, S. K. 2019. Effects of plant spacing and nitrogen level on the green fodder yield of maize (*Zea mays* L.). *Archives of Agricultural and Environmental Science*. **4**(3):307-312.
- Radford, P. J. 1967. Growth Analysis Formulae - Their Use and Abuse 1. *Crop Science*. **7**(3):171-175.
- Ram, K. and Meena, R. S. 2014. Evaluation of pearl millet and mungbean intercropping systems in arid region of Rajasthan (India). *Bangladesh Journal Botanical*. **43**(3):367-370.
- Ram, S. N. 2015. Response of guinea grass (*Panicum maximum* JACQ.)- legumes intercropping to weed control. *Forage Research*. **41**(1):15-18.
- Rashid, M. and Iqbal, M. 2012. Effects of phosphorus fertilization on the yield and quality of maize (*Zea mays*) fodder on clay loam soil. *The Journal of Animal and Plant Sciences*. **22**(1):199-203.

- Reddy, D. M., Devi, S. K. B. and Sultan, M. A. 2004. Fodder based intercropping for higher biomass and quality fodder production. *Forage Research*. **29**(4):217-218.
- Richard, L. A. 1954. Diagnosis and improvement of saline alkaline soils. Agricultural Handbook No. 60, US Department of Agriculture.
- Rihab, M., Zubair, E. I., Fadlalla, B., Hussien, A., Hussien, M. and Abdelkreim, M. 2015. Effect of different nitrogen fertilization levels on yield of maize (*Zea mays* L.) as winter forage. *International Journal of Scientific and Technology Research*. **10**(4):197-201.
- Rosegrant, M. R, Ringler, C., Sulser, T. B, Ewing, M., Palazzo, A. and Zhu, T. 2009. Agriculture and food security under global change: prospects for 2025/2050. IFPRI, Washington, DC.
- Ross, S. M., King, J. R., Donovan, J. T. and Spaner, D. 2004. Intercropping berseem clover with barley and oat cultivars for forage. *Agronomy Journal*. **96**:1719-1729.
- Rundan, V., Singh, M., Praveen, B. R., Yadav, M. B. N. and Chethanbabu, R. T. 2023. Proximate composition assessment of fodder maize with rice bean intercropping under different nutrient management practices. *Annals of Plant and Soil Research*. **25**(4):641-648.
- Rusinamhodzi, L., Corbeels, M., Justice, N. and Ken, E. G. 2012. Maize-grain legume intercropping is an attractive option for ecological intensification that reduces climatic risk for smallholder farmers in central Mozambique. *Field Crop Research*. **136**:12-22.
- Sairam, M., Maitra, S., Sain, S., Gaikwad, D. J. and Sagar, L. 2024. Dry matter accumulation and physiological growth parameters of maize as influenced by different nutrient management practices. *Agricultural Science Digest*. **44**(2):219-225.
- Shams, A. S. and Lamloom, M. M. 2020. Intercropping cowpea with some yellow maize hybrids under different nitrogen fertilizer rates. *Acta Scientific Agriculture*. **4**(12):23-34.
- Sharma, K. C. 2008. Fodder productivity and economics of multi-cut pearl millet intercropped with clusterbean. *Indian Journal of Agronomy*. **53**(1):51-56.
- Sharma, R. P., Singh, A. K. and Raman, K. R. 2009. Fodder productivity and economics of pearl millet (*Pennisetum typhoides*) with legumes intercropping under various row proportions. *Indian Journal of Agronomy*. **54**(3):301-305.
- Sharma, R. P., Singh, A. K., Poddar, B. K. and Raman, K. R. 2008. Forage production potential and economics of maize (*Zea mays*) with legumes intercropping under various row Proportions. *Indian Journal of Agronomy*. **53**(2):121-124.

- Shiferaw, B., Prasanna, B. M., Hellin, J. and Banziger, M. 2011. Crops that feed the world. Past successes and future challenges to the role played by maize in global food security. *Food Sector*. **3**:307-327.
- Singh, B., Kumar, R., Dhukia, R. S. and Singh, B. P. 2005. Effect of intercropping on the yield of summer fodders. *Forage Research*. **31**(1):59-61.
- Singh, M., Rundani, V. and Onte, S. 2020. Rice bean: High valued fodder crop. *Indian Farming*. **70**(6):27-31.
- Skekinah, D. E. 2004. Performance of fodder maize (*Zea mays*) - based cropping system in a farming systems approach in western zone of Tamil Nadu. *Indian Journal of Agronomy*. **49**(1):22-25.
- Subbiah, B. V. and Asija, G. L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Current Science*. **25**:259-260
- Subrahmanya, D. J., Kumar, R., Pyati, P. S., Ram, H., Meena, R. K. and Tamta, A. .2019. Growth, yield and economics of fodder maize (*Zea mays*) as influenced by plant density and fertility levels. *Forage Research*. **45**(2):120-132.
- Surve, V. H., Arvadia, M. K. and Tandel, B. B. 2011. Effect of row ratio in cereal-legume fodder under intercropping systems on biomass production and economics. *Advance Research Journal of Crop Improvement*. **2**(2):197-199.
- Takele, E. E., Mekonnen, Z., Tsegaye, D. and Abebe, A. 2017. Effect of intercropping of legumes and rates of nitrogen fertilizer on yield and yield components of maize (*Zea mays* L.) at Arba Minch. *American Journal of Plant Sciences*. **8**:2159-2179.
- Tamta, A., Kumar, R., Ram, H., Meena, R. K., Kumar, U., Yadav, M. R., Subrahmanya, D. J. and Pandey, A. K. 2019. Nutritional portfolio of maize and cowpea fodder under various intercropping ratio and balanced nitrogen fertilization. *Indian Journal of Animal Sciences*. **89**(3):276-280.
- Telkar, S. G., Singh, A. K. and Kant, K. 2018. Determination of effective spatial arrangement for intercropping of maize + soybean using dry matter yield and competition interaction. *Journal of Pharmacognosy and Phytochemistry*. **7**(4):2239-2245.
- Thippeswamy and Alugandagi, S. C. 2001. Intercropping of legumes of sweet sorghum for higher green forage production. *Karnataka Journal of Agricultural Sciences*. **14**:905-909.
- Tripathi, S. N. 1989. Mixed cropping of forage species in relation to herbage yield and quality. *Indian Journal of Dryland Agricultural Research and Development*. **4**(2):68-72.

- Uher, D., Horvatić, I., Jareš, D. and Maćešić, D. 2019. influence of intercropping maize with cowpea on forage yield and quality. *Direct Research Journal of Agriculture and Food Science*. **7**(4):77-80.
- Usman, M., Nangere, M. G. and Musa, I. 2015. Effect of three levels of NPK fertilizer on growth parameters and yield of maize-soybean Intercrop. *International Journal of Scientific and Research Publications*. **5**(9):1-6.
- Valadabadi, S. A. and Farahani, H. A. 2010. Effects of planting density and pattern on physiological growth indices in maize (*Zea mays* L.) under nitrogenous fertilizer application. *Journal of Agricultural Extension and Rural Development*. **2**:40-47.
- Verma, S. S., Joshi, Y. P. and Saxena, S. C. 2005. Effect of row ratio of fodder sorghum (*Sorghum bicolor*) in pigeonpea (*Cajanus cajan*) intercropping system on productivity, competition function and economics under rainfed conditions of North India. *Indian Journal of Agronomy*. **50**(2):123-125.
- Vesterager, J. M., Nielsen, N. E. and Høgh-Jensen, H. 2008. Effects of cropping history and phosphorus source on yield and nitrogen fixation in sole and intercropped cowpea- maize systems. *Nutrients Cycling Agrosystems*. **80**:61-73.
- Walkley, A. and Black, I. A. 1934. An estimation of soil organic matter and proposed modification of the chromic acid titration method. *Soil Science*. **37**(1):29-38.
- Wasaya, A., Tahir, M., Manaf, A., Ahmed, M., Kaleem, S. and Ahmad, I. 2011. Improving maize productivity through tillage and nitrogen management. *African Journal of Biotechnology*. **10**(81):19025-19034.
- Watson, S. A. 2003. Description, development, structure, and composition of the corn kernel. In: P. J. White and L. A. Johnson (Eds.), Corn: chemistry and technology, 2nd ed. *American Association of Cereal Chemists, St. Paul*.
- Willey, R. 1979. Intercropping - its importance and research needs. Competition and yield advantages. *Fields Crop Abstract*. **32**:1-10.
- Willey, R. W. and Rao, M. R. 1980. A Competition ratio for quantifying competition between intercrops. *Experimental Agriculture*. **16**(2):117-125.
- Wit, D. C. T. 1960. On competition. Versl. Land Bouwk Onderzoek. **66**:1-82
- Yadahalli, V. R., Thirupathi, M., Patil, S. B., Immanuel, R. R. and Gnanasekar. 2022. Quality characters and yield of fodder maize as influenced by inorganics, organics and biological sources of nutrients. *The Pharma Innovation Journal*. **11**(11):2138-2144.
- Yadav, G., Rai, S., Adhikari, N., Yadav, S. P. S. and Bhattarai, S. 2022b. Efficacy of different doses of NPK on growth and yield of rice bean (*Vigna umbellata*) in

- Khadbari, Sankhuwasabha, Nepal. *Archives of Agriculture and Environmental Science*. **7**(4):488-494.
- Yadav, M. R., Singh, M., Kumar, R., Kumar, D., Meena, R. K., Ram, H. and Makarana, G. 2022a. Integrated nutrient management in maize - cowpea intercropping system is an attractive option to improve the fodder productivity and quality. *Communications in Soil Science and Plant Analysis*. Pp 1-15.
- Youssef, S. B., Kachout, S. S., Abidi, S., Saddem, B., Ismail, J. and Salem, H. B. 2019. Effect of different levels of nitrogen fertilization on forage yields and quality of hairy vetch (*Vicia villosa*, Roth) Triticale (*X Tritcosecale*, Witmack) mixtures. *The Open Agriculture Journal*. **13**:90-100.
- Zaman, Q. and Malik, M. A. 2000. Rice bean (*Vigna umbellata*) productivity under various maize-rice bean intercropping systems. *International Journal of Agriculture and Biology*. **2**(3):255-257.
- Zhang, J., Yin, B., Xie, Y., Li, J., Yang, Z. and Zhang, G. 2015. Legume-cereal intercropping improves forage yield, quality and degradability. *PLOS ONE*. **10**(12).
- Zuo, Y. M., Zhang, F. S., Li, X. L. and Cao, Y. P. 2000. Studies on the improvement in iron nutrition of peanut by intercropping with maize on a calcareous soil. *Plant Soil*. **220**:13-25.

