

**MAXIMIZING YIELD OF SPRING MAIZE (*Zea mays* L.)
WITH THE MANIPULATION OF AGRONOMIC
PRACTICES**

Thesis Submitted for the Award of the Degree of

DOCTOR OF PHILOSOPHY

in

Agronomy

By

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DECLARATION

I hereby declare that the present work in the thesis entitled “**Maximizing yield of spring maize (*Zea mays* L.) with the manipulation of agronomic practices**” is the outcome of research work carried out by me under the supervision of Dr. Ujagar Singh Walia, working as a Professor, in the Department of Agronomy, School of Agriculture, Lovely Professional University, Punjab, India. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigator. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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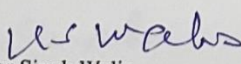
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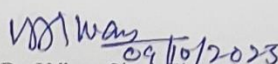
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Abstract

The field experiment entitled “**Maximizing yield of spring maize (*Zea mays* L.) with the manipulation of agronomic practices**” was carried out by conducting two independent experiments at the Agronomy Research Farm, Lovely Professional University, Phagwara during spring season of 2023 and 2024. Both experiments were conducted in Split Plot Design with four replications. In the first experiment, there were three main plots : ridge sowing, flat sowing with single row and flat sowing with paired row and five sub plot treatments *i.e.* pendimethalin + atrazine pre-emergence followed by (*fb*) straw mulching, pendimethalin pre-emergence with intercropping cowpea *fb* earthing up & straw mulching, intercropping *Sesbania fb* earthing up and straw mulching, two hand weedings (4 and 6 weeks after sowing) and unweeded (control). The results indicated that among the planting patterns, weed count (m^{-2}) and weed dry weight (q ha^{-1}) was significantly lower in ridge sowing as compared to other planting patterns during 2023 and 2024. Among the weed control treatments, the weed count and weed dry weight was significantly lower in both intercropping treatments during both years. The growth parameters like plant height (cm), plant dry weight (g plant^{-1}), number of leaves per plant etc. were significantly higher under ridge sowing and flat sown with single row as compared to paired row planting method. The intercropping of cowpea or *Sesbania fb* earthing up and straw mulching significantly improved the plant height (cm), plant dry weight (g plant^{-1}), number of leaves per plant, stem girth (mm) and chlorophyll index as compared to other weed control treatments during 2023 and 2024. The yield attributes like cob girth (mm), number of rows per cob, number of grains per cob and 1000 grain weight (g) were significantly higher in ridge sowing and flat sown with single row as compared to paired row planting pattern during both years. These yield attributes were significantly higher in pendimethalin pre-emergence with intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching as compared to all other weed control treatments. On the basis of pooled data, the grain yield (q ha^{-1}) in ridge sowing (84.4 q ha^{-1}) and flat sown with single row of crop (83.1 q ha^{-1}) increased by 9.61 and 7.92%, respectively as compared to paired row planting (77.0 q ha^{-1}). Among weed control treatments, intercropping *Sesbania fb* earthing up & straw

mulching (91.6 q ha⁻¹), pendimethalin with cowpea *fb* earthing up & straw mulching (89.3 q ha⁻¹), pendimethalin + atrazine as pre-emergence *fb* straw mulching (83.3 q ha⁻¹) and two hand weedings (80.1 q ha⁻¹) increased the grain yield of maize crop by 44.48, 40.85, 31.39 and 26.34%, respectively as compared to unweeded (control) (63.4 q ha⁻¹) treatment. The protein content of grain in ridge sowing and flat sown with single row was significantly higher as compared to paired row planting. The protein content of grain in both intercropping treatments was significantly higher than other weed control treatments. Total nitrogen uptake by crop was also significantly higher in ridge sowing and flat sown with single row crop as compared to paired row planting. The intercropping treatments recorded significantly higher total nitrogen uptake by crop as compared to all other weed control treatments during both years. N uptake by weeds was significantly more in paired row planting as compared to other planting patterns. Among the weed control treatments, N uptake by weeds was significantly higher in unweeded (control) as compared to all other weed control treatments. These findings hold good for both years.

In the second experiment, main plots included organic manure treatments *i.e.* poultry manure (6.25 t ha⁻¹), FYM (15 t ha⁻¹), press mud (15 t ha⁻¹) and no organic manure. Sub-plots consist of four nitrogen levels *i.e.* 0% recommended dose of nitrogen (RDN), 75% RDN, 100% RDN and 125% RDN. The recommended dose of nitrogen to maize is 125 kg ha⁻¹. The plant height (cm), plant dry weight (g plant⁻¹) and number of nodes per plant in poultry manure and FYM were significantly higher as compared to press mud and no organic manure treatments. Among the nitrogen levels, the plant height (cm), stem girth (mm), internodal length (cm) and chlorophyll index was significantly higher in 100% RDN and 125% RDN as compared to other nitrogen levels. Use of poultry manure and FYM improved the plant dry weight and number of nodes per plant as compared to press mud and no organic manure treatment. Number of cobs per plant, number of grains per plant and cob girth (mm) were significantly higher in poultry manure and FYM as compared to other organic manure treatments. These yield attributes were significantly higher in 100% RDN and 125% RDN as compared to other nitrogen levels. Among the organic manures, the grain yield (q/ha) was increased by 16.22, 15.09 and 9.87% in poultry manure (82.4 q ha⁻¹), FYM (81.6

q ha⁻¹) and press mud (77.9 q ha⁻¹), respectively as compared to no organic manure (control) (70.9 q ha⁻¹) treatment on the basis of pooled data. Among the nitrogen levels, the grain yield was increased by 42.67, 40.39 and 26.55% with application of 125% RDN (87.6 q ha⁻¹), 100% RDN (86.2 q ha⁻¹) and 75% RDN (77.7 q ha⁻¹), respectively as compared to 0% RDN (control) (61.4 q ha⁻¹) treatment. Application of organic manures *i.e.* poultry manure, FYM and press mud significantly improved the protein content in grains as compared to no organic manure treatment. Similarly, application of 100% RDN and 125% RDN significantly increased the protein content in grains as compared to other nitrogen levels. The total N uptake by crop was significantly more in poultry manure and FYM as compared to press mud and no organic manure treatment. Among the nitrogen levels, the total N uptake by crop was significantly higher in 100% RDN and 125% RDN as compared to other nitrogen levels. These results hold good for both years.

Keywords: earthing up, green manuring, nitrogen levels, organic manures, planting patterns, spring maize, straw mulching

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“Finally, whatever you are prepared for, automatically it comes to you.” This is the rule of nature, therefore, start preparing what you want, once you are ready, it has to come and day-by-day your target becomes true. But for this great achievement you have to say thanks to those who comes in your way to help, to inspire, to show the good and bad at each step and that’s why I feel it is indeed my great privilege and immense pleasure in availing this golden opportunity to express my wholehearted sense of gratitude and indescribable indebtedness to all those who made this research possible.

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TABLE OF CONTENT

S. No.	Page No.
INTRODUCTION	1-6
REVIEW OF LITERATURE	7-24
MATERIALS AND METHODS	25-53
RESULTS AND DISCUSSION	54-204
SUMMARY AND CONCLUSION	205-216
REFERENCES	217-232
LIST OF PUBLICATIONS	233
LIST OF CONFERENCES	234

LIST OF TABLES

Table no.	Title	Page no.
3.1	Weather parameters during 2023 and 2024	25
3.2	Physio-chemical properties of experimental field before sowing	26
3.9.1	ANOVA Table for experiment 1	45
3.9.2	ANOVA Table for experiment 2	45
	Experiment 1	
4.1.1a	Effect of planting patterns and weed control treatments on weed count (m^{-2}) at 45 and 75 DAS	57
4.1.1b	Effect of planting patterns and weed control treatments on weed count (m^{-2}) at 105 DAS and at harvest	58
4.1.2a	Weed dry weight accumulation (q ha^{-1}) at 45 and 75 DAS as influenced by planting patterns and weed control treatments	63
4.1.2b	Weed dry weight accumulation (q ha^{-1}) at 105 DAS and at harvest as influenced by planting patterns and weed control treatments	64
4.1.3	Interactive effect of planting patterns and weed control treatments on weed dry weight (q ha^{-1}) at harvest during 2023 and 2024	65
4.1.4	Effect of planting patterns and weed control treatments on weed control efficiency (%) at harvest	68
4.2.1	Effect of planting patterns and weed control treatments on plant height (cm) at 45, 75, 105 DAS and at harvest	73
4.2.2	Effect of planting patterns and weed control treatments on plant dry weight (g plant^{-1}) at 45, 75 and 105 DAS	78
4.2.3	Number of leaves per plant at 45, 75, 105 DAS and at harvest as influenced by planting patterns and weed control treatments	83
4.2.4	Number of nodes per plant at 45, 75 DAS and at harvest as influenced by planting patterns and weed control treatments	88
4.2.5	Effect of planting patterns and weed control treatments on stem	92

	girth (mm) at 75, 105 DAS and at harvest	
4.2.6	Effect of planting patterns and weed control treatments on internodal length (cm) at 75, 105 DAS and at harvest	95
4.2.7	Chlorophyll index at 45, 75 and 105 DAS as influenced by planting patterns and weed control treatments	99
4.3.1	Effect of planting patterns and weed control treatments on number of cobs per plant, cob length (cm) and cob girth (mm)	102
4.3.2	Effect of planting patterns and weed control treatments on number of rows per cob, number of grains per cob and 1000 grain weight (g)	107
4.3.3	Grain yield (q ha^{-1}) and stover yield (q ha^{-1}) as influenced by planting patterns and weed control treatments	113
4.3.4	Interactive effect of planting patterns and weed control treatments on grain yield (q ha^{-1}) and stover yield (q ha^{-1}) during 2023	114
4.3.5	Biological yield (q ha^{-1}) and harvest index (%) as influenced by planting patterns and weed control treatments	118
4.4.1	Effect of planting patterns and weed control treatments on economics of spring maize (average of two years)	120
4.5.1	Effect of planting pattern and weed control treatments on N content in grains (%), N content in stover (%) and protein content (%)	124
4.5.2	Effect of planting patterns and weed control treatments on N uptake by grains (kg ha^{-1}), N uptake by stover (kg ha^{-1}) and total N uptake by crop (kg ha^{-1})	128
4.5.3	Effect of planting pattern and weed control treatments on N content in weeds (%) and N uptake by weeds (kg ha^{-1})	132
4.6.1	Effect of planting patterns and weed control treatments on soil pH, EC and OC after harvest	134
4.6.2	Effect of planting patterns and weed control treatments on available N, available P and available K (kg ha^{-1}) of soil after	136

	harvest	
	Experiment 2	
4.1.1	Weed count (m^{-2}) at 75, 105 DAS and at harvest as influenced by organic manures and nitrogen levels	139
4.1.2	Effect of organic manures and nitrogen levels on weed dry weight (q ha^{-1}) at 75, 105 DAS and at harvest	143
4.2.1	Plant height (cm) at 45, 75, 105 DAS and at harvest as influenced by organic manures and nitrogen levels	148
4.2.2	Effect of organic manures and nitrogen levels on plant dry weight (g plant^{-1}) at 45, 75 and 105 DAS	153
4.2.3	Effect of organic manures and nitrogen levels on number of leaves per plant at 45, 75, 105 DAS and at harvest	157
4.2.4	Effect of organic manures and nitrogen levels on the number of nodes per plant at 45, 75 DAS and at harvest	161
4.2.5	Effect of organic manures and nitrogen levels on stem girth (mm) at 75, 105 DAS and at harvest	164
4.2.6	Internodal length (cm) at 75, 105 DAS and at harvest as influenced by organic manures and nitrogen levels	167
4.2.7	Effect of organic manures and nitrogen levels on chlorophyll index at 45, 75 and 105 DAS	170
4.3.1	Effect of organic manures and nitrogen levels on number of cobs per plant, cob length (cm) and cob girth (mm)	174
4.3.2	Interactive effect of organic manures and nitrogen levels on cob girth (mm) during 2024	175
4.3.3	Number of rows per cob, number of grains per cob and 1000 grain weight (g) as influenced by organic manures and nitrogen levels	180
4.3.4	Interactive effect of organic manures and nitrogen levels on number of grains per cob during 2024	181
4.3.5	Grain yield and stover yield (q ha^{-1}) as influenced by organic manures and nitrogen levels	186

4.3.6	Interactive effect of organic manures and nitrogen levels on grain yield (q ha^{-1}) during 2023, 2024 and pooled	187
4.3.7	Interactive effect of organic manures and nitrogen levels on stover yield (q ha^{-1}) during 2023	188
4.3.8	Effect of organic manures and nitrogen levels on biological yield (q ha^{-1}) and harvest index (%)	192
4.4.1	Effect of organic manures and nitrogen levels on economics of spring maize (average of two years)	193
4.5.1	Effect of organic manures and nitrogen levels on N content in grains (%), protein content in grains (%) and N content in stover (%)	197
4.5.2	Effect of organic manures and nitrogen levels on N uptake by grains (kg ha^{-1}), N uptake by stover (kg ha^{-1}) and total N uptake by crop (kg ha^{-1})	200
4.6.1	Effect of organic manures and nitrogen levels on soil pH, EC and OC (%) after harvest	202
4.6.2	Effect of organic manures and nitrogen levels on available N, P and K (kg ha^{-1}) of soil after harvest	204

LIST OF FIGURES

Figure no.	Title	Page no.
	Experiment 1	
4.1.1	Effect of planting patterns and weed control treatments on weed count (m^{-2}) for 2023 and 2024	59
4.1.2	Effect of planting patterns and weed control treatments on weed dry weight (q ha^{-1}) for 2023 and 2024	66
4.2.1	Effect of planting patterns and weed control treatments on plant height (cm) during 2023 and 2024	74
4.2.2	Effect of planting patterns and weed control treatments on plant dry weight (g plant^{-1}) during 2023 and 2024	79
4.2.3	Effect of planting patterns and weed control treatments on number of leaves per plant during 2023 and 2024	84
4.3.1	Effect of planting patterns and weed control treatment on cob length (cm) and cob girth (mm) during 2023 and 2024	103
4.3.2	Effect of planting patterns and weed control treatments on number of grains per cob and 1000 seed weight (g) during 2023 and 2024	108
4.3.3	Effect of planting Patterns and weed control treatments on grain yield (q ha^{-1}) and stover yield (q ha^{-1}) of maize during 2023 and 2024	115
4.5.1	Effect of planting patterns and weed control treatments on N uptake by grains, N uptake by stover & N uptake by crop during 2023 & 2024	129
	Experiment 2	
4.1.1	Effect of organic manures and nitrogen levels on weed count (m^{-2}) during 2023 and 2024	140
4.1.2	Effect of organic manures and nitrogen levels on weed dry weight (q ha^{-1}) during 2023 and 2024	144
4.2.1	Effect of organic manures and nitrogen levels on plant height	149

	(cm) during 2023 and 2024	
4.2.2	Effect of organic manures and nitrogen levels on plant dry weight (g plant^{-1}) during 2023 and 2024	154
4.2.3	Effect of organic manures and nitrogen levels on number of leaves per plant during 2023 and 2024	158
4.3.1	Effect of organic manures and nitrogen levels on cob length (cm) and cob girth (mm) during 2023 and 2024	176
4.3.2	Effect of organic manures and nitrogen levels on number of grains per cob and 1000 seed weight (g) during 2023 and 2024	182
4.3.3	Effect of organic manures and nitrogen levels on grain yield (q ha^{-1}) and stover yield (q ha^{-1}) during 2023 and 2024	189

LIST OF ABBREVIATION

Abbreviation	Full name
a.i.	Active ingredient
ANOVA	Analysis of variance
@	At the rate of
&	And
⁰ C	Degree Celsius
C.D.	Critical difference
cm	Centimetre
DAS	Days after sowing
dS	Deci siemens
EC	Electrical conductivity
<i>fb</i>	Followed by
FYM	Farmyard manure
g	Gram
ha	Hectare
<i>i.e.</i>	that is
K	Potassium
kg	Kilograms
mg	Milligram
mm	Millimetre
m ²	Meter square
N	Nitrogen
NS	Non-significant
OC	Organic carbon
%	Percent
P	Phosphorus
pH	Potential of hydrogen
q	Quintal
RDN	Recommended dose of nitrogen

SE(m)	Standard error of means
SPAD	Soil Plant Analysis Development
SSP	Single super phosphate
t	Ton
WAS	Weeks after sowing
WCE	Weed control efficiency

CHAPTER 1

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crop cultivated throughout the world as it is highly versatile and having wider adaptability. Maize is referred to as the queen of cereals due to its superior genetic yield potential. It can be grown on wider range of climates, ecologies and seasons. It is cultivated across 170 countries which are having diverse soil types, varying climate and different management practices. The total world production of maize was 1229.63 million metric tonnes from 205.27 million hectare of land with productivity of 5.99 t ha⁻¹ during 2023-24 (Anonymous, 2024a). Among all the major maize growing countries, USA is the top producing nation with contribution of 35% towards productivity; China is the second largest producer with 20% of the maize production. The average global productivity of maize was 5.99 t ha⁻¹ but the productivity in USA was almost double *i.e.* 11.13 t ha⁻¹. India ranks 7th in maize production where it is grown on 11.24 million hectare with production of 37.66 million metric tonnes (Anonymous, 2024a). The average productivity in India was 3.35 t ha⁻¹ and the major states cultivating maize are Punjab, Uttar Pradesh, Andhra Pradesh, Haryana, Gujarat, and Rajasthan. However, Andhra Pradesh has highest productivity of maize (7.13 t ha⁻¹) (Anonymous, 2023). In Punjab, maize was grown on 99.3 thousand hectares of land with 4.10 lakh tonnes of production. Productivity of maize under Punjab conditions was 43.93 q ha⁻¹ (Anonymous, 2024b).

Maize has been used for human as well as animal consumption. Maize can be grown for grain and fodder purposes. It serves as source of basic raw material for number of industrial products for food (25%), cattle feed (12%), chicken feed (49%), starch (12%), brewing (1%) and seed (1%) (Barla *et al.*, 2016). It is also used in industries for corn starch, wax, syrup, corn flakes, tanning material etc. (Wiqar *et al.*, 2021). In India, maize is cultivated throughout the year. Maize kernel provides carbs (71.88 g), protein (8.84 g), fat (4.57 g), fibre (2.15 g), ash (2.33 g), moisture (10.23 g), minerals (1.5 g), phosphorus (348 mg), potassium (286 mg), magnesium (139 mg), sulphur (114 mg) and traces of sodium, riboflavin, amino acids, calcium, iron, thiamine, vitamin K and copper per 100 g of edible portion (Saritha *et al.*, 2020). In northern India, *kharif* season is main growing season of this crop but can also be

grown during spring. However, in south India, maize can be grown during any season *i.e.* *rabi*, spring and *kharif*. Spring season maize is generally cultivated in the fields vacated by potato, sugarcane, fodders etc. The yield levels of this season are very high as there is less attack of insect pests and diseases and availability of abundance of sun light which reduces the cost involved on the plant protection measures and hence increasing the margin of net profit for the farmers. However, the water requirements of this season crop are very high and sometimes its maturity coincides with monsoon rains which can be avoided by timely sowing of spring season maize *i.e.* in the first fortnight of February. Requirement of nutrients and water by maize crop are more during *rabi* season which saves it from cold or chilling injury. The yield of *rabi* maize is generally more as compared to *kharif* maize (Urmila *et al.*, 2020) as higher plant population is preferred in winter maize than *kharif* maize. Due to better temperature conditions, the crop remains green even after maturity with higher nutritive value. Similarly, the grain yield of spring sown maize is also higher than *kharif* maize due to which it is getting popularity in north-western States of India like Punjab, Haryana, etc. Now, maize has also been utilized in the form of sweet corn and popcorn which have very good market potential at national as well as international level. Spring maize can be cultivated from the end of February to mid-June in Punjab.

Low maize productivity in India relative to rest of the world can be attributed to a number of causes, the most notable of which is poor weed management, which poses a severe danger to crop yield. Weeds compete with maize plants for space, nutrient, light and moisture and hence crop growth will be poor and ultimately there is reduction in the grain yield. The harvesting operations also become difficult and quality of grain is also hampered. Weeds can cause yield loss ranging from 28-93% depending on soil, climate, management practices and weed control methods etc. The economic loss in maize crop due to weeds can be around 25.3% which is a very serious problem (Gharde *et al.*, 2018). A lot of pre- and post-harvest yield losses occur in maize due to various reasons. The yield loss ranged from 27-60% in maize crop due to weed infestation in eastern states (Moinuddin, 2018). The crop loss due to insect pest and diseases in maize was 5% (Dhaliwal *et al.*, 2010). The average yield loss in maize due to post harvest handling was 4.1% (Nanda *et al.*, 2012). So, the

overall yield losses in maize crop were 18.65% which were lower than losses in wheat (22.65%) and rice (32.5%) (Kumar *et al.*, 2022). So, there is a need to control weeds effectively to get economical yield.

The weeds can be controlled through hand weeding, hoeing, chemical, integrated and biological method. However, the efficiency of these methods are different and only a single method is not enough to control the losses due to weeds. Hand weeding is one of the traditional method of weed control, it not only reduces weed competition but also loosen up the soil for better crop growth which is highly required during the initial stages of the crop growth. The use of hand weeding along with herbicide application helped the maize crop to grow normally and produce higher yield than crop in which unrestricted weed growth was allowed (Ullah *et al.*, 2008). The pre-emergence application of herbicides have been utilized to a great extent as in spring maize, the initial crop growth is quite slow due to low temperature conditions. So, maintaining weed free conditions, application of pre-emergence herbicides like pendimethalin and atrazine are highly beneficial. Solely dependence on herbicides can be harmful as they negatively impact the soil flora and fauna and may also show residual effects on the succeeding crops. Adoption of integrated approach is best advised under these conditions which not only reduces the dependence on herbicides but also benefits the crop in terms of better yield. The integration of various methods must be done to minimum the losses due to weeds.

The use of green manuring crops as cover crops also helps to reduce the weed germination and their growth as they cover the ground quickly and do not give any chance to weeds to dominate the crop plants. Green manuring crops like Dhaincha (*Sesbania aculeata*), sunhemp (*Crotalaria juncea*), cowpea (*Vigna unguiculata*) etc. can be utilized along with the weed control, they fix the atmospheric nitrogen which helps enhances the nitrogen use efficiency. The losses due to weeds can be reduced by integrating hand weeding, with the selective use of herbicides. The application of the straw mulch is highly beneficial in spring maize as its irrigation water requirements are more than *kharif* maize, so mulching reduces the evaporation losses and will control weeds by maintaining a cover on the soil. During the initial stages of spring maize, the temperature remains low but straw mulching also improves the soil

temperature, thus enhancing crop growth and development. Another benefit of straw mulching is that after certain period, it gets decomposed in the soil and improves soil properties. Another important agronomic practice is earthing up which provides support to plant and also soil becomes loose due to earthing up and this practice improves aeration. The weeds get uprooted by this practice and results in reduction of crop-weed competition. Proper use of integrated approach for weed management in spring maize in early stages almost eliminates the use of post emergence herbicides which is a significant achievement in terms of a step towards sustainability.

The fertility of the soil is getting degraded with the widespread use of synthetic fertilizers which leads to deficiency of micronutrients and secondary macronutrients also. The less use of organic manures leads to reduction in soil organic carbon and problem becomes more severe due to continuous cultivation of cereals which are exhaustive crops. Degrading soil fertility due to modern intensive agriculture can be sustained with the Integrated Nutrient Management approach. Integrated Nutrient Management can be defined as use of organic, inorganic and biofertilizers in a combination which improves the soil fertility and crop productivity. The adverse impacts of use of only inorganic fertilizers can be reduced with Integrated Nutrient Management. According to Laudicina *et al.* (2011), the use of organic materials like fertilizers, insecticides and biofertilizers should be encouraged in the era of crop intensification. Organic manures like farmyard manure (FYM), vermicompost, poultry manure, press mud, gobar gas slurry etc. has multiple benefits as they supply balanced nutrients including micronutrients also. Along with NPK, organic manures also contain the micronutrients which enhance the soil properties and ultimately crop yield. The addition of organic matter increases the microbial activity in soil which in turn enhances the nutrient availability and toxic substances gets decomposed into no harmful compounds. Organic manures also increase the soil's ability to retain water.

The nutrient release by organic manures is slow as compared to chemical fertilizers and organic manures also contain trace elements (Shaji *et al.*, 2021). The slow release of nutrients helps the crop to get nutrition for the longer period. The leaching losses of nutrients in organic manures are very less than chemical fertilizers.

The growth and yield of maize was significantly improved by combination of organic and inorganic fertilizers which also enhanced the soil fertility (Jjagwe *et al.*, 2020). The use of these organic byproducts not only enhances the yield of the crop but also maintains the soil health which has been on a declining trend from a long time. As an exhaustive crop, maize responds very well to organic manures like FYM and poultry manure as these manures apart from supplying nutrients, also improve soil physical properties.

The deficiency of nitrogen has been found in Indian soils which vary from state to state. For growth and development of plants, nitrogen is very essential as it makes 1- 4% of dry matter. Presence of nitrogen in plant tissues is highly influenced by the nitrogen status of soil and fertilizers applied. The productivity of maize is increased with the amount of available nitrogen which increases the yield of the crop. Under monsoon conditions, excessive application of nitrogen should be avoided as it leads to nitrate leaching and harmful emissions of gases (Bibi *et al.*, 2016) which results in lower nitrogen use efficiency. Excessive leaching of nitrates contaminates the drinking water which has caused cancer in the Malwa belt of Punjab. In Indian soils, the nitrogen use efficiency is between 30-35% in cereal crops and remaining part is lost (Kumar *et al.*, 2019). Nitrogen also regulates the other nutrients like phosphorus, potassium etc. Nitrogen increases the vegetative growth of plants, thus increasing the green plants yield of maize. Nitrogen is very essential component of amino acids to build the proteins, chlorophyll molecule, DNA and RNA and other plant components. Nitrogen also plays important role in photosynthesis, plant growth, physiological and biological process in plant metabolism.

The maize crop can be cultivated under different planting patterns like bed planting, ridge or furrow planting, flat with single row and paired row planting etc. Bed planting and ridge planting are gaining popularity as these methods save crop from lodging and also crop plants receives better soil physical conditions. The different methods of planting pattern have effect on growth and development of maize crop. The availability of space and light interception is highly influenced under different planting patterns. Under paired row planting, two rows are planted at closer spacing which might face intraspecific competition that might not be suitable for sole

maize. However, in paired row technology, intercropping is very successful and loss in the maize yield may be compensated by the yield of intercrops. In the ridge and furrow planting, there will be optimized canopy structure and improved light interception, thus increasing the maize yield (Liu *et al.*, 2018). The sowing of maize on ridge also reduces the weed germination as during the formation of ridges, weed seeds get buried under the soil particularly in the ridge portion. The yield of the maize crop improved with the ridge furrow planting along with mulching which suppressed the weeds and allowed the crop to growth with minimum competition (Jia *et al.*, 2018). The response of maize crop to different plant density and row configurations is different. The single row flat sowing followed by earthing up is also gaining popularity as after earthing up the growth and yield of maize is significantly improved.

So, in order to find out the perfect combination of weed control methods with different planting patterns and suitable organic manures to be used in maize along with chemical fertilizer, this investigation was conducted with the following objectives:

1. To determine the influence of planting patterns and weed control methods on growth and yield of spring maize.
2. To find out the effect of organic manures and different nitrogen levels on growth and development of spring maize.
3. To find out the interactive effect of planting patterns with weed control treatments as well as of different organic manures with N levels, if any.
4. To work out the uptake of N by crop and weeds as well as effect on crop quality by different treatments.

CHAPTER 2

REVIEW OF LITERATURE

The relevant literature pertaining to research project entitled, “**Maximizing yield of spring maize (*Zea mays* L.) with the manipulation of agronomic practices**” have been reviewed under the following sub heads:

2.1 Losses due to weeds.

2.2 Role of planting pattern on growth and yield of maize.

2.3 Effect of organic manures on growth of weeds and crop.

2.4 Role of green manures, mulches and earthing up in maize productivity.

2.5 Effect of nitrogen levels on growth and yield of maize.

2.6 Effect of organic manures, planting patterns and nitrogen levels on quality parameters of maize.

2.1 Losses due to weeds

Devkota *et al.* (2024) reported that the weeds caused 52% reduction in the yield of maize crop that leads to a significant loss in yield and ultimately net profit. The grain yield under weed free treatment was 6.14 t ha⁻¹ and under weedy check, the grain yield was just 2.96 t ha⁻¹.

Lavanya *et al.* (2024) carried out an experiment on maize and reported that during two years of study, the losses in grain yield due to weeds ranged from 32.81 to 48.81%. The reduction in the maize yield was due to the competition by weeds with crop for light, space and nutrients.

Lukangila *et al.* (2024) conducted a study on maize crop at University of Lubumbashi, Democratic Republic of the Congo and they reported that significantly higher grain yield was recorded in herbicide spray of Imazethapyr (7.66 t ha⁻¹) which was at par with hand hoeing (7.62 t ha⁻¹). The reduction in grain yield was 84.20 and 84.12 % under control (no weeding) as compared to spray of imazethapyr and hand hoeing, respectively.

Sahoo *et al.* (2024a) conducted an experiment on weed dynamics in rice-maize rotation at Dr. Rajendra Prasad Central Agricultural University, Pusa from 2019

to 2021 and they reported that application of vermicompost mulch and live mulch improved the growth and yield of maize. The weed free treatment produced 93.7 % more grain yield than unweeded (control) plot which was found to be at par with vermicompost mulch and live mulch (*Sesbania spp.* and *Pisum sativum*).

Sahoo *et al.* (2024b) investigated weed dynamics in maize during 2019 and 2020 at Institute of Agriculture, Sriniketan, West Bengal and they reported that application of tembotrione + atrazine (1500 g ha⁻¹) produced significantly higher grain yield (44.41 and 47.18 q ha⁻¹) as compared to control (weedy check) which produced grain yield of 25.39 and 28.00 q ha⁻¹, during 2019 and 2020, respectively. The reduction in yield under control (weedy check) was 42.82 and 40.65 % as compared to spraying of tembotrione + atrazine (1500 g ha⁻¹) during both year, respectively.

A study was conducted at G. B. Pant University of Agriculture and Technology, Uttarakhand by Shukla *et al.* (2024) on maize and they reported that the highest grain yield (7.2 t ha⁻¹) was recorded in weed free treatment, it was followed by 6.94 t ha⁻¹ in atrazine @ 1 kg ha⁻¹ fb hand weeding treatment. The grain yield was lowest (3.46 t ha⁻¹) in weedy treatment (control).

Alptekin *et al.* (2023) conducted an experiment on weed management in maize crop during 2019 and 2020 and they reported that the grain yield (8.12 and 7.71 t ha⁻¹) was lowest in the weedy check (control) and highest grain yield (12.88 and 12.37 t ha⁻¹) was recorded in weed free treatment during both the years.

Sharma *et al.* (2022) reported that around 37% of the worldwide losses in maize production are due to weeds only which can be minimized with integrated approach for weed management.

Landau *et al.* (2021) reported that the maize crop with poor weed control, had an average yield loss of 50% compared with the treatments having higher weed control efficiencies.

Nedeljkovic *et al.* (2021) experimented on the impacts of weeds on the yield of maize crop during 2016 and 2017 and they reported that the loss of corn yield was 91% in weedy plots *i.e.* without any herbicide application.

Gharde *et al.* (2018) conducted a study to estimate yield losses due to weeds using data of 1581 experiments conducted on Farm Research demonstrations from 2003 to 2014 and they reported that the potential yield loss and actual yield loss in maize crop were 43.4 % and 25.3 %, respectively.

Imoloame *et al.* (2017) observed that weed growth influences maize yield when maize crop was kept weed free up to 9 weeks after sowing, the yield loss was only 5-10%. However, in unweeded crop, the highest yield loss of 84-85% was recorded followed by unrestricted weed growth up to 12 weeks after sowing with nearly 80% yield loss.

Soltani *et al.* (2016) investigated the impact of weeds on yield losses in corn at University of Guelph, Canada during 2007-2013 and reported that the weeds reduced the corn yield. The yield of maize was highest under the treatment which provided 95% weed control as compared to unweeded (control).

Amare *et al.* (2015) reported from west Shewa Orimia, Ethiopia that the maize yield was only 23.12 q ha⁻¹ under weedy check treatment whereas the yield was highest (69.89 q ha⁻¹) under hand weeding treatment. The relative yield loss under weedy check treatment was 63.65 % which was highest among the other treatments including herbicide applications.

Suresha *et al.* (2015) conducted an experiment at CSK HP Krishi Vishvavidyalaya, Himachal Pradesh and they reported that weeds caused 15.7% to 35.6% yield loss in maize-based cropping system. They also reported that weeds cause nutrient loss.

Mukhtar *et al.* (2007) carried out an investigation on maize crop in Northern State, Sudan and found that 58-62% and 67-79% reduction in maize yield was recorded in winter and summer crop, respectively under the unrestricted weed growth

periods. They also reported that plant height was reduced by 65% under weedy conditions.

2.2 Role of planting pattern on growth and yield of maize

A two-year study was conducted at Chandra Shekhar Azad University of Agriculture and technology, Uttar Pradesh by Bhayankar *et al.* (2024) on sowing methods in maize and they reported that the growth and yield under ridge sowing was better than conventional sowing. The grain yield under ridge sowing (65.42 and 67.03 q ha⁻¹) was significantly higher as compared to conventional flat sowing (64.30 and 65.85 q ha⁻¹) during 2022 and 2023, respectively.

Langhari *et al.* (2024) carried an experiment at Research Farm of Sindh Agriculture University, Pakistan on sowing methods in maize and they reported that plant height (173.39 cm) and grain yield (35.11 q ha⁻¹) in ridge sowing were significantly higher in comparison to drilling and broadcasting of maize.

Meng *et al.* (2024) reported that ridge sowing in maize significantly improved the dry biomass accumulation and grain yield of maize as compared to flat sowing. The increase in grain yield was 12.33% in ridge sowing as compared to flat sowing.

Yousuf *et al.* (2023) conducted a study on various sowing methods in maize crop and reported that minimum tillage and ridge sowing method produced significantly higher grain and stover yield of maize as compared to conventional flat sowing method.

Ali *et al.* (2022) conducted a study at University of Engineering and Technology, Pakistan on various planting methods in maize crop and found out that sowing of maize on ridges produce significantly better crop growth, yield attributes and grain yield than normal flat sowing method.

Ma *et al.* (2022) while working at the experimental station of Ping'an seed company, China reported that ridge sown maize improved the yield by 5 – 11% as compared to flat sowing as better soil physical conditions and growth characteristics were available in the ridge sowing of the crop.

Deng *et al.* (2019) reported that the sowing on ridges improved the grain yield of maize. During 2013 and 2014, the grain yield was significantly higher under ridge sowing (128.63 and 111.75 q ha⁻¹) as compared to grain yield under flat sowing (111.98 and 99.53 q ha⁻¹), respectively.

Dong *et al.* (2017) conducted a two-year study on maize and observed that there was increase of 15% in the yield of crop by ridge sowing in maize as compared to other methods. The increase of 11% in harvest index was also observed in this study.

Raihan *et al.* (2017) conducted a study on different planting methods at Afghanistan National Agricultural Sciences and Technology University, Kandahar and reported that sowing of maize crop on ridges, produced significantly higher number of grains per cob, 1000-grain weight and grain yield as compared to line sowing and broadcasting methods of planting maize.

Gul *et al.* (2015) conducted a study to check effects of sowing methods on growth and yield of maize at Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir and found that the plant height, dry matter accumulation, cob length, 100- seed weight was significantly higher under the ridge sowing of maize during both years of study. Seed and stover yield was also higher under ridge sowing than flat sowing of maize crop.

Khan *et al.* (2012) investigated the impact of ridge sowing on the growth and yield of maize hybrids and reported that the growth and grain yield of maize was higher under the ridge planting than flat planting and bed planting. However, plant population and harvest index remained non-significant under different planting methods of maize crop.

Zamir *et al.* (2012) investigated the effects of different sowing methods and mulches on spring maize and observed that the grain yield was higher (6.21 t ha⁻¹) under ridge planting followed by ridge sowing on double side and bed sowing. However, the lowest yield was obtained under furrow sowing which was recorded as 3.83 t ha⁻¹. Under flat sowing, the maize yield was 4.43 t ha⁻¹.

Bakht *et al.* (2011) conducted the experiment at KPK Agricultural University, Pakistan and they observed that the growth, yield attributes and grain yield of maize under the ridge and raised bed sowing were significantly better than flat sowing either in lines or broadcasting methods.

Valadabadi *et al.* (2010) reported that the physiological growth parameters of maize were increased under different planting pattern. Highest TDW (1810 gm/m²), LAI (4.4), RGR (0.075 g/g/day), CGR (34.1 g/g/m²/day) were achieved under two row planting which were lower in the single row planting.

Abdullah *et al.* (2008) conducted a study on impact of planting methods and weed control methods on maize at NWFP Agricultural University, Pakistan and they reported that interactive effect of planting methods and weed control methods was significant. Ridge sowing + Stomp 30EC recorded significantly higher yield as compared to other sowing methods and weed control treatments.

Quanqi *et al.* (2008) reported that under the bed planting, the grain yield of maize was 2.5% higher than furrow planting whereas lowest was in flat planting. The number of grains was higher in bed and furrow planting as compared with flat planting. However, 1000 grain weight and the number of rows per ear do not differ significantly under various planting patterns.

Bakht *et al.* (2007) found that the 1000 grain weight and number of grains per cob of maize differed significantly by different planting methods. The number of grains cob⁻¹ (439.8), grain yield (3494 kg ha⁻¹) and stalk yield (7093.75 kg ha⁻¹) were highest under the ridge planting as compared to flat planting method.

Memom *et al.* (2007) reported that the maize emergence was higher under the ridge planting. The plant height was 156.2 cm under ridge planting as compared to broadcasting and seed drill sowing. The grain yield was 4.88 t ha⁻¹ and 5.83 t ha⁻¹ under broadcasting and seed drill sowing. However, the highest grain yield (6.35 t ha⁻¹) was recorded under ridge planting of maize crop. The cost of cultivation was higher under ridge planting but the returns were also higher in ridge planting with better B:C ratio.

2.3 Effect of organic manures on growth of weeds and crop

Abrol *et al.* (2024) conducted a study at Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu on integrated nutrient management and they reported that the mean grain yield was significantly higher in FYM as compared to no organic manure. Moreover, application of 40 kg N ha⁻¹ along with 10 t ha⁻¹ of FYM produced highest yield as compared to 20 and 30 kg N ha⁻¹ along with FYM @ 10 t ha⁻¹ during all the years of experimentation.

Essilfie *et al.* (2024) reported that application of chicken manure improved the grain yield of maize. The highest grain yield (43.75 q ha⁻¹) was obtained with half dose by chicken manure and half dose by chemical fertilizers which was followed by 38.15 q ha⁻¹ of grain yield under 3 t ha⁻¹ of chicken manure. The lowest grain yield (26.43 q ha⁻¹) was observed in control *i.e.* no fertilized crop. Interactive effect of chicken manure and chemical fertilizers was significant. The combined application of chicken manure (3 t ha⁻¹) + 50% NPK produced significantly higher grain yield than alone chicken manure or 100% NPK application. This showed that positive interaction of chicken manure and inorganic fertilizers.

Mbabah *et al.* (2024) conducted an experiment at Akwa Ibom State University, Nigeria and they reported that the application of poultry manure in maize produced highest plant height (214.27 cm), stem girth (24.35 mm) and cob length (17.38 cm) and significantly higher grain weight as compared to pig droppings, goat dropping and control (no organic manure).

Rasool *et al.* (2023) conducted a pot experiment on maize at University of Sargodha, Pakistan with different levels of poultry manures and four different varieties and they reported that increasing the level of poultry manure up to 75 g per pot significantly improved the plant height, dry weight per plant and grain yield of maize in all the varieties as compared to control *i.e.* without poultry manure.

Asfaw (2022) observed the impact of animal manures on maize growth while working at Woillu Woreda, Ethiopia and found out that the application of organic manures produced significantly higher grain yield of maize as compared to no

organic manure treatments. The highest grain yield (5.7 t ha^{-1}) was recorded in poultry manure treatment.

Dwivedi *et al.* (2022) conducted an experiment at SHUATS, Uttar Pradesh and they observed that integrating the organic manures with chemical fertilizers improved the plant height, crop dry weight, number of cobs per plant and grain yield of maize as compared to chemical fertilizer application alone.

Singh *et al.* (2022) while working at LPU, Phagwara, Punjab found that with the application of FYM and vermicompost along with the chemical fertilizers significantly enhanced the plant height, number of leaves and grain yield of maize as compared to other treatment combination which does not included the organic manures.

Mulyati *et al.* (2021) reported that the application of organic manure along with chemical fertilizers improved the plant growth rate, number of leaves, fresh weight of shoots and grain weight of maize crop. Moreover, the soil properties like CEC, total soil nitrogen, available soil phosphorus and exchangeable potassium percentage also improved with the use of organic manures.

Berdjour *et al.* (2020) conducted a study at SARI, Ghana and they reported that interactive effect of poultry manure and nutrient levels was significant. The application of poultry manure (2 t ha^{-1}) + NPK ($120:60:60 \text{ kg ha}^{-1}$) produced significantly higher grain yield as compared to all other poultry manure and NPK combinations.

Kandil *et al.* (2020) investigated the influence of organic manures on maize crop and observed that the application of compost @ 10 t ha^{-1} significantly improved the plant height, grain yield and stover yield as compared to no organic manure application.

Sigaye *et al.* (2020) reported that the use of organic manure along with inorganic nutrients improved growth & yield of maize crop. The highest grain yield (74.94 q/ha) & biomass yield (187.18 q/ha) was produced by replacing 50% of nitrogen

and phosphorus with vermicompost. Use of organic manures also improved the soil properties.

Adeyemo *et al.* (2019) conducted a study in southwestern Nigeria & they observed that the dry cob weight and grain yield of maize was improved with use of poultry manure @ 10 t/ha. Cob weight was lowest under the control *i.e.* without application of poultry manure. However, the highest fresh shoot biomass was under 6 t ha⁻¹ of poultry manure whereas the dry shoot biomass was highest in the maize crop under poultry manure @ 8 t/ha.

Mahmood *et al.* (2017) found that leaf area index, grain yield and harvest index improved with use of FYM, sheep manure and poultry manure along with inorganic manures. The grain yield and straw yield was higher with inorganic + poultry manure followed by inorganic + sheep manure and inorganic + FYM.

Arif *et al.* (2015) while working at Agriculture Research Station, Khyber Pakhtunkhwa, Pakistan found that application of FYM and sheep manure increased weed density, weed fresh and dry weight. The FYM treated plots had weed density of 39 m⁻², weed fresh biomass of 261.59 g/m² and dry biomass 102.33 g/m² which was higher than plots applied with sheep manure. However, the maize yield was also increased and recorded as 24.00 and 24.38 q ha⁻¹ under FYM and sheep manure treated plots, respectively in comparison to unfertilized plots.

Okoroafor *et al.* (2013) studied the effects of poultry manure and pig manure on maize at Federal College of Agriculture, Nigeria and they reported that use of poultry manure improved soils' chemical and physical properties which produced significantly higher plant height, stem girth and grain yield of maize in comparison to pig dung and no organic manure treatments.

Efthimiadou *et al.* (2012) investigated in southern Greece on maize and found that the use of organic manure increases count & weed dry weight and increase was proportional to application of the organic manures. But the dry weight and yield of maize increased with the application of organic manures along and with the chemical fertilizers.

Farhad *et al.* (2009) experimented on the spring maize and observed that the application of poultry manure improved the plant height, grain yield and biological yield of maize crop. The grain yield was highest (5.11 t ha⁻¹) with the application of poultry manure at the rate of 12 t ha⁻¹ whereas the lowest yields (1.79 t ha⁻¹) was recorded under the control treatment without poultry manure application.

Boateng *et al.* (2006) studied the effects of different levels of poultry manure on maize crop and found that the application of the poultry manure at 6 t ha⁻¹ produced 2.6 t ha⁻¹ of grain yield which was higher than lower levels of poultry manures *i.e.* 2 and 4 t ha⁻¹ and chemical fertilizer use. However, the difference in grain yield with 8 and 6 t ha⁻¹ application of poultry manure were found to be non-significant.

Adeniyi *et al.* (2005) investigated the effect of poultry manure on growth and yield of maize and reported that the application of poultry manure at the rate of 3 t ha⁻¹ along with chemical fertilizers produced highest dry matter yield and grain yield of maize crop. The poultry manure application alone, also improved the plant height, leaf area and grain yield of maize crop.

2.4 Role of mulches for maize productivity

Begam *et al.* (2024) while working at ICAR- Agricultural Technology Application Institute, West Bengal reported that the intercropping cowpea with maize enhances the nutrition supply to crop which further boosts the yield of maize. The use of leguminous crop as intercrop is beneficial in improving the growth and productivity of maize.

A study carried out at Northwest A&F University, China by Liu *et al.* (2023) to evaluate the impact of straw mulching on maize crop and they found that using the straw mulching at 7.2 and 9.6 t ha⁻¹, significantly improved the nitrogen uptake and grain yield of maize during the two experimental years as compared to non-mulching treatments.

Khan *et al.* (2022) reported use of straw mulching improved the growth of maize. During 2018 and 2019, the significantly higher number of leaves (13.7 and 13.5) were recorded under the application of straw mulching as compared to non-mulching treatment (13.0 and 12.9), respectively.

Rahman *et al.* (2022) experimented in Ghana, West Africa and they reported that using cowpea as a live mulching in maize significantly improved that grain yield and stover yield during 2017 and 2018. Grain yield of 22.23 and 27.42 q ha⁻¹ was recorded under cowpea live mulch sown on the same day of maize crop during 2017 and 2018, respectively. Grain yield was significantly lower (16.05 and 20.92 q ha⁻¹) under no mulch treatment during both the years, respectively.

Rout *et al.* (2022) conducted an experiment at CUTM, Odisha and they reported that use of straw mulching @ 5 t/ha significantly enhanced the plant height and grain yield which was at par with application of straw mulching @ 2.5 t/ha. The significantly lower grain yield (5.23 t ha⁻¹) was produced under non-mulching treatment in comparison to straw mulching treatment.

Shashikanth *et al.* (2022) conducted an experiment at UAS, Gandhi Krishi Vigan Kendra, Bangalore and they reported that using the rice straw as mulching in maize crop recorded significantly more plant height, grain yield and biological yield in comparison to other organic mulches & non-mulching treatments.

A study was conducted at Changwu Agro-Ecological Station, China by Wang *et al.* (2022) on surface mulching in maize and observed that use of straw mulch significantly improved soil temperature and WUE that resulted in better growth characteristic and grain yield during three years of experimentation in comparison to non-mulching treatments.

Yang *et al.* (2021) observed that use of straw mulch in maize increased the above growth biomass as compared with no mulching treatment. The plant height was 231 and 241 cm under control and straw mulching treatments, respectively. Similarly, number of rows and panicle length was higher under straw mulching treatment. The grain yield of maize was 6.98 q ha⁻¹ higher in straw mulching treatment as compared to control plot *i.e.* no mulching treatment.

Noor *et al.* (2020) investigated the impacts of straw mulching on maize crop and found that use of straw mulching improved the yield by 18% and total dry biomass by 20% as compared to no-mulch treatment.

A study was conducted at Jiuzhuang, China by Zhang *et al.* (2020) on effects of straw mulching on maize crop. They reported that the cob length was 20.40 cm and 20.90 cm under no mulching and straw mulching treatment, respectively. The yield of maize was 130.95 kg ha⁻¹ more under the straw mulching as compared to no mulching treatment. The difference in harvesting index between straw mulching and no mulch treatment was 0.02%.

Javed *et al.* (2019) investigated the effects of mulching on maize yield and water use efficiency at ISES, Pakistan and they observed that the application of rice straw mulching improved the growth and productivity of maize crop. Plant height was 182.6 cm and 174.8 cm under rice straw mulching and control, respectively. Similarly, the stover and grain yield was 0.6 and 1.0 t/ha higher under rice straw mulching as compared with no mulching treatment.

Wu *et al.* (2017) studied effect of rice straw mulching on maize productivity and found that maize yield was increased by 16.5% and 29.6% with application of 5.0 and 10.0 t/ha of straw mulch as compared with no mulching, respectively.

Mupangwa *et al.* (2016) conducted a study on maize under various mulching materials for two years and reported that the use of organic mulches (maize residues and sun hemp residues) in the maize crop improved the soil water content and enhanced the grain and stover yield as compared to non-mulching treatments.

Tao *et al.* (2015) experimented on effects of straw mulching and tillage on maize crop and reported that the application of straw mulch increases yield of spring maize. The yield under mulching was 116.11 q ha⁻¹ which was 6.03 q ha⁻¹ higher than non-mulched treatment.

Qin *et al.* (2015) studied impact of straw mulching on maize and found that the application of straw mulching in maize increased the yield by 20% as compared to no mulch treatment. Under high temperature conditions, straw mulch treatment

produced almost similar yield as under plastic mulching in maize crop. Straw mulching also improved the nitrogen use efficiency of maize.

Shen *et al.* (2012) studied the effects of mulching on maize crop and reported that use of straw mulching in maize improved grain yield. In Chaoshil variety of maize, grain yield was 17.7% and 16.1% higher under application of straw mulch @ 6 and 12 t/ha, respectively over the control treatment.

According to a study conducted on spring maize by Zamir *et al.* (2012), the 1000 seed weight and grain yield was higher under wheat and rice straw mulch as compared to maize pith mulching. The grain yield of maize was 5.32 and 4.84 t/ha under wheat and rice straw mulching, respectively.

2.5 Effect of nitrogen levels on growth and yield of maize

Langhari *et al.* (2024) reported that the maize growth and yield improved with increasing level of nitrogen. The highest plant height (200 cm) & grain yield (40.70 q/ha) was recorded in treatment with N @ 150 kg/ha. The lowest grain yield (12.99 q/ha) was observed in control (0 kg/ha of N).

Rawal *et al.* (2024) experimented at National Agronomy Research Centre, Nepal on increasing the level of nitrogen in maize crop. The highest grain yield (101.37 q/ha) was produced under 210 kg/ha of N which was at par with 180 kg/ha of N with grain yield of 92.48 q/ha. Grain yield (51.67 q ha⁻¹) was significantly lower under the control (no fertilizer).

Regmi *et al.* (2024) experiment at Agriculture and Forestry University, Nepal and they found that plant height of maize improved with increased doses of nitrogen and highest grain yield (49.7 q/ha) was produced with N @ 150 kg/ha. Further, increasing dose of N to 200 kg/ha do not improve the yield and yield attributes.

Zou *et al.* (2024) while working at Red Soil Experimental Station, Qiyang, China reported that increasing nitrogen level improved the maize yield under low, medium and high soil fertility. The grain yield was highest with use of 112 and 150 kg/ha but reduced with 187 kg/ha of N in low fertility soil. Under the medium fertility soil, the grain yield improved significantly up to 187 kg/ha of N.

However, in high fertility soil the grain yield was significantly higher in 112, 150 and 187 kg/ha of N doses as compared to 0 kg/ha and there was no significant difference among the other nitrogen levels.

Mahat *et al.* (2023) while working at Lamjung Campus, Sundar Baza, China observed that the growth and productivity of maize improved with increasing dose of nitrogen. Significantly higher plant height, stem girth and grain yield were recorded with use of 240 kg/ha of N.

Sravankumar *et al.* (2023) experimented at ITM University, Madhya Pradesh and they observed that use of nitrogen @180 kg/ha in maize crop recorded highest plant height (172.19 cm), grain yield (40.26 q ha⁻¹) and harvest index of 32.69%.

A study conducted at Cairo University, Egypt by Gheith *et al.* (2022) revealed that plant height, ear length and number of grains per row were improved significantly with enhanced doses of nitrogen. Highest grain yield of 4.3 and 4.5 t/ha was recorded in nitrogen dose of 336 kg/ha during both years, respectively. NUE decreased with increasing nitrogen levels.

Hammad *et al.* (2022) studied impact of nitrogen doses on maize at COMSATS University Islamabad, Pakistan and observed that the use of nitrogen @ 300 kg/ha produced significantly higher crop dry weight and maximum grain yield in comparison to lower doses of N *i.e.* 0, 75, 150 and 225 kg/ha.

Tofa *et al.* (2022) reported that highest grain yield of 43.8 q/ha was recorded with use of 120 kg/ha of N which was followed by grain yield of 32.6 q/ha under 60 kg/ha of N. The grain yield was lowest under no nitrogen application (16.15 q/ha).

Maurya *et al.* (2021) while experimenting at SHUATS, Uttar Pradesh found that nitrogen application @120 kg ha⁻¹ + NAA 40 ppm in maize produced significantly higher plant height (181.6 cm) and grain yield (50.15 q/ha).

Adhikari *et al.* (2021) observed that application of nitrogen @ 220 kg/ha produced highest cob length (16.33 cm), grain yield (10.1 t/ha), stover yield (12.9 t/ha) and harvest index of 43.80% along with B:C ratio of 2.0.

A two-year study was carried out at BARC, Ethiopia by Abebe *et al.* (2017) who observed that application of nitrogen @ 115 kg/ha produced highest biological yield (21.2 t/ha) in 2013 and nitrogen @ 92 kg/ha produced highest yield in the year 2014.

A study was carried out at University of Agriculture, Pakistan by Ali *et al.* (2017) and they observed that use of nitrogen @ 180 kg/ha produced highest plant height (210.2 cm) and dry fodder yield (41.76 t/ha). All the growth and yield attributes were lowest under control treatment.

Matusso *et al.* (2016) found that nitrogen dose (46.8 kg ha^{-1}) significantly enhanced the plant height, stem girth, 1000 seed weight and grain yield of maize in comparison to other lower levels of nitrogen.

Khan *et al.* (2014) observed that plant height, 1000-grain weight, grains per cob and grain yield was improved significantly with different nitrogen levels. The application of 150 kg/ha of N produced better grain yield than 100 kg/ha of N and control (no nitrogen) treatments.

According to Dar *et al.* (2014), the use of N @ 180 kg/ha to baby corn results in highest plant height which was 163.05 cm at harvesting stage and it was 4.45 cm higher than N @ 150 kg/ha. Plant girth was 7.9 cm and 7.8 cm with the use of 180 and 150 kg/ha of N, respectively. The cob yield (75.2 q/ha) was highest with application of N @ 180 kg/ha.

A field trial was conducted by Jeet *et al.* (2012) at Varanasi and observed that use of 150 kg N /ha produced higher plant height and stem girth in comparison to other lower nitrogen doses. The mean grain yield of 67.30 q/ha was recorded with application of N @ 150 kg/ha which was highest among all N levels. The grain yield of maize was 4.15 q ha^{-1} lower with 100 kg N ha^{-1} as compared to 150 kg/ha.

Raskar *et al.* (2012) conducted an experiment to check the effect of different levels of nitrogen on maize at Vadodara, Gujarat and found that cob length and stover yield of maize increases significantly with increasing levels of nitrogen up to 120 kg N ha^{-1} but highest cob length and stover yield was recorded at 160 kg N ha^{-1} .

ha⁻¹. The grain yield of maize was 18.64% higher with the application of 160 kg N ha⁻¹ as compared with the application of 80 kg N ha⁻¹.

Singh *et al.* (2012) experimented on sweet corn to check the effect of different levels of nitrogen on sweet corn and reported that with increasing nitrogen level, the plant height was increased with application of 120 kg N ha⁻¹. Addition of 30 kg more N ha⁻¹ did not produce much difference.

2.6 Effect of organic manures, planting patterns and nitrogen levels on quality parameters of maize

Bhayankar *et al.* (2024) reported that the protein content in maize grain was 9.98 and 10.04% which was found in weed free treatment and it was significantly higher than weedy treatment (9.85 and 9.94%) during 2022 and 2023, respectively.

Langhari *et al.* (2024) reported that protein content was significantly influenced by different doses of nitrogen. The lowest protein content (8.12%) was recorded with 0 kg N ha⁻¹ whereas highest protein content of 10.48 % was observed with application of 150 kg N ha⁻¹ followed by protein content of 10.43 % under 120 kg N ha⁻¹.

Hammand *et al.* (2022) while working at COMSATS University Islamabad, Pakistan reported that the increasing level of nitrogen significantly improved the protein content of grains. The highest grain protein content (15%) was recorded in treatment with application of 300 kg ha⁻¹ of nitrogen dose as compared to other levels of nitrogen.

He *et al.* (2022) studied the substitution of chemical fertilizers with organic manures at Shihezi University, China and they reported that the application of organic manures improved the nutrient availability at the later stages of the maize crop which results in improving the grain nutritional quality.

Tiwari *et al.* (2022) while experimenting at AKS University Madhya Pradesh reported that protein content of maize was significantly improved with higher

levels of nitrogen application. The highest protein content (11.45%) was observed in nitrogen dose of 120 kg ha⁻¹.

Kumar *et al.* (2021) found that the protein content of maize grain under paired row plating was statistically at par with sole maize. The protein content was 9.52% under the sole maize and 9.51 % under the paired row planting. The N, P and K content in maize grain was at par due to planting pattern.

Ochieng *et al.* (2021) reported that the application of higher level of nitrogen also increased the grain protein content. The protein content of the maize grain was directly proportional to the increasing level of nitrogen. The highest grain protein (11.6%) was recorded with application of 100 kg N ha⁻¹.

Kandil *et al.* (2020) observed that the application of organic manures to maize crop improved the protein content of maize grain as compared to chemical fertilizers. The highest protein content was recorded in maize with the application of 10 t ha⁻¹ of compost as compared to inorganic treatments.

Ali *et al.* (2017) studied the effects of nitrogen levels on quality of maize crop at University of Agriculture, Pakistan and reported that the highest crude protein (10.75%), crude fibre (31.87%) and ash content (8.85%) with the application of 180 kg ha⁻¹ of nitrogen. The decreasing trend was seen in the quality parameters with decreasing nitrogen levels in maize crop with lowest quality of maize under the control treatment.

Hafez *et al.* (2015) conducted an experiment on the effect of nitrogen levels on the maize crop and found that the application of higher level of nitrogen to maize increases the grain protein (%) and crude fat (%) significantly. However, oil percentage and crude fibre (%) were not changed significantly with the increase in nitrogen level.

Zhang *et al.* (2015) reported that application of straw mulching significantly improved the chlorophyll content of maize plant which further improves the yield and protein content as compared to non-mulching treatments.

Awad *et al.* (2014) reported that the protein content of maize increased with the application of organic manures but the increase was not significant. However, with increased level of NPK through chemical fertilizers significantly improved the protein content of maize crop as compared to no fertilized crop.

Myandoab *et al.* (2011) conducted a study on corn and reported that the protein content differed significantly under different planting pattern. The protein content was higher under paired row planting as compared with normal planting.

Rafiq *et al.* (2010) conducted a study on autumn planted maize and reported that the increased level of nitrogen in maize crop enhanced the protein content (%). The highest protein content (9.96%) was observed under 250 kg N ha⁻¹ followed by 9.52% of protein content with application of 200 kg N ha⁻¹.

CHAPTER 3

MATERIALS AND METHODS

The field experiment entitled “**Maximizing yield of spring maize (*Zea mays* L.) with the manipulation of agronomic practices**” was carried out at Research Farm of Lovely Professional University, School of Agriculture, Phagwara, Punjab, India during spring season 2023 and 2024. The various details of the treatments, cultural practices adopted and procedures followed during the conduct of investigations are discussed below.

3.1 Experimental site and location

Two experiments were carried out at the Research Farm of the School of Agriculture, Lovely Professional University, Phagwara, Punjab (India) which comes under Trans Gangetic Plains. It is located geographically at 31°24’23.01” North latitude and 75°69’76.78” East longitude with 234 m average elevation above mean sea level. It falls under the sub-tropical region in the central plains of agro-climatic zone.

3.2 Climate and weather conditions

The experiment site falls under the subtropical region with hot summers and cold winters. The highest temperature recorded was 46° C during summer months of June. The optimum temperature for maize crop ranges from 25 – 33°C. If temperature drops to 8 °C during early spring, it can cause damage to the crop. Annual rainfall ranges from 460 – 960 mm.

Table 3.1 Weather parameters during 2023 and 2024

	Max. temp (°C)		Min. temp (°C)		Total Rainfall (mm)		Average relative humidity (%)	
	2023	2024	2023	2024	2023	2024	2023	2024
February	25.4	21.4	11.9	6.6	0.0	7.6	60.0	73.0
March	27.5	26.7	15.0	11.4	55.6	78.0	60.2	72.0
April	33.1	33.8	16.4	15.9	11.7	44.9	53.0	59.0
May	37.9	40.2	22.6	22.3	55.9	0.0	54.2	49.0
June	36.4	40.3	24.6	25.7	94.4	12.1	64.7	56.0

3.3 Soil properties

This region belongs to alluvial and sandy loam soil class. A representative soil sample was taken before sowing of experiment from 15 cm of depth and values are presented below.

Table 3.2 Physio-chemical properties of experimental field before sowing

Soil property	2023	2024	Evaluation method
Sand %	40.0	39.5	Bouyoucos hydrometer method (Bouyoucos, 1927)
Silt %	26.1	26.4	
Clay %	33.9	34.1	
Texture	Sandy loam	Sandy loam	
pH	7.70	7.80	Glass electrode pH meter (Jackson, 1973)
EC	0.20 mmhos cm ⁻¹	0.21 mmhos cm ⁻¹	Electrical conductivity (Miller and Curtin, 2006)
OC	0.39%	0.40%	Walkley and Black method (Walkley and Black, 1934)
Available N (low)	172.3 kg ha ⁻¹	171.8 kg ha ⁻¹	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P (medium)	25.7 kg ha ⁻¹	25.1 kg ha ⁻¹	Olsen's calorimetric method (Olsen, 1954)
Available K (high)	186.8 kg ha ⁻¹	182.5 kg ha ⁻¹	Flame photometer method (Jackson, 1973)

3.4 Technical programme of study

Experiment 1. Impact of planting patterns and weed control treatments on growth and development of spring maize

Main plots (Planting patterns)

M₁ = Flat sowing with single row (60 cm)

M₂ = Flat sowing with paired rows (90 cm + 30 cm)

M₃ = Ridge sowing (60 cm)

Sub-plots (Weed control treatments)

T₁ = Pendimethalin + atrazine (0.75 + 0.75 kg ha⁻¹), pre-emergence *fb* straw mulching (6 t ha⁻¹)

T₂ = Pendimethalin 0.6 kg ha⁻¹, pre-emergence + intercropping with cowpea *fb* earthing-up and straw mulching (6 t ha⁻¹)

T₃ = Intercropping *Sesbania aculeata fb* earthing-up and straw mulching (6 t ha⁻¹)

T₄ = Two hand weedings (4 and 6 WAS)

T₅ = Unweeded (control)

Note: Row to row spacing in flat sown was 60 cm in M₁ and 30 cm in M₂.

In M₃, ridges were made at 60 cm. Rice straw mulch was applied (6 t ha⁻¹).

Plant population was uniform in all planting patterns.

Experiment 2. Influence of organic and inorganic nutrition on growth and development of spring maize

Main Plots (Organic manures on air dry weight basis)

M₁ = No organic manure

M₂ = FYM (15 t ha⁻¹)

M₃ = Poultry manure (6.25 t ha⁻¹)

M₄ = Press mud (15 t ha⁻¹)

Sub-plots (N levels)

T₁ = Control (0% Recommended dose of nitrogen (RDN))

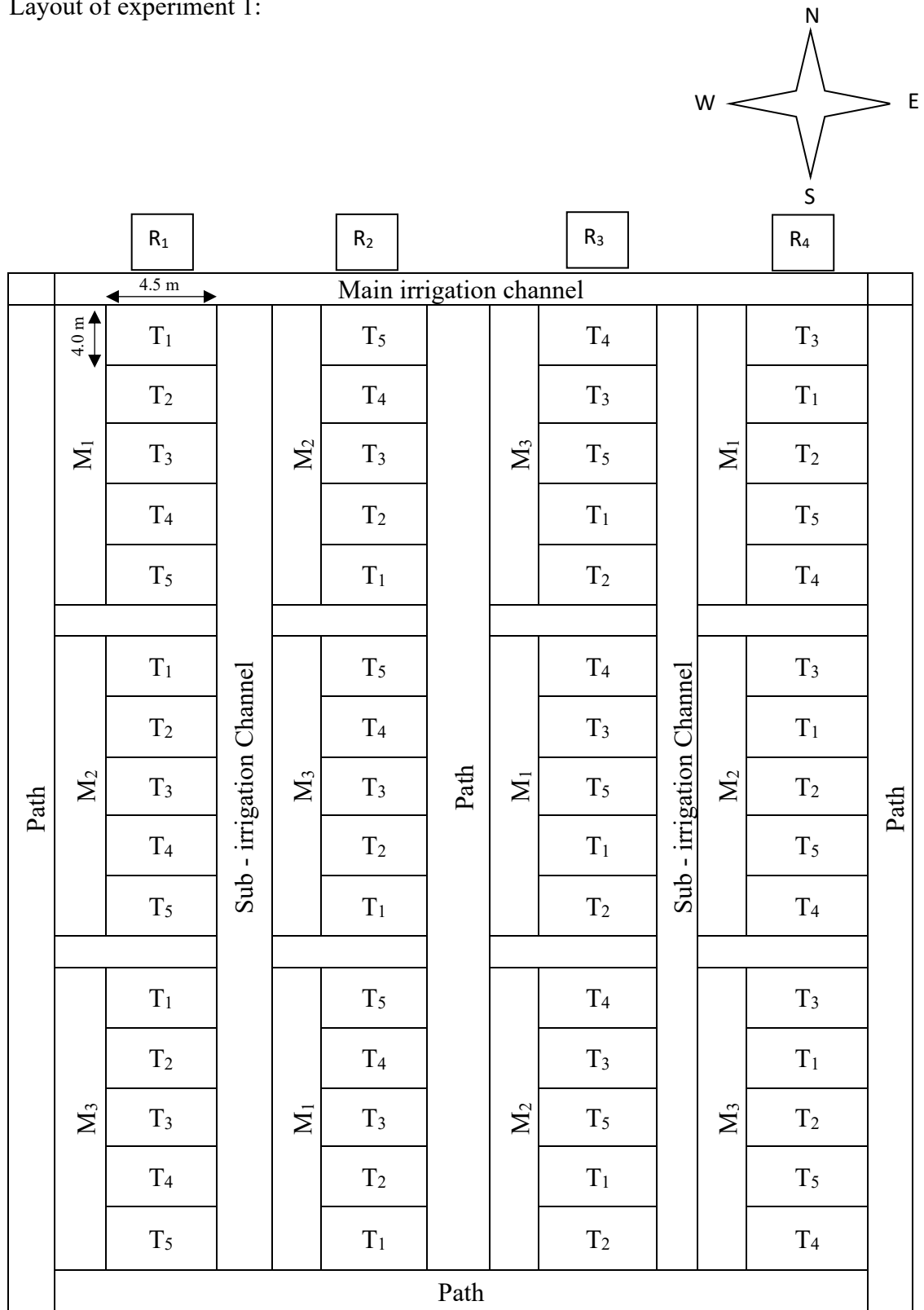
T₂ = 75% RDN

T₃ = 100% RDN

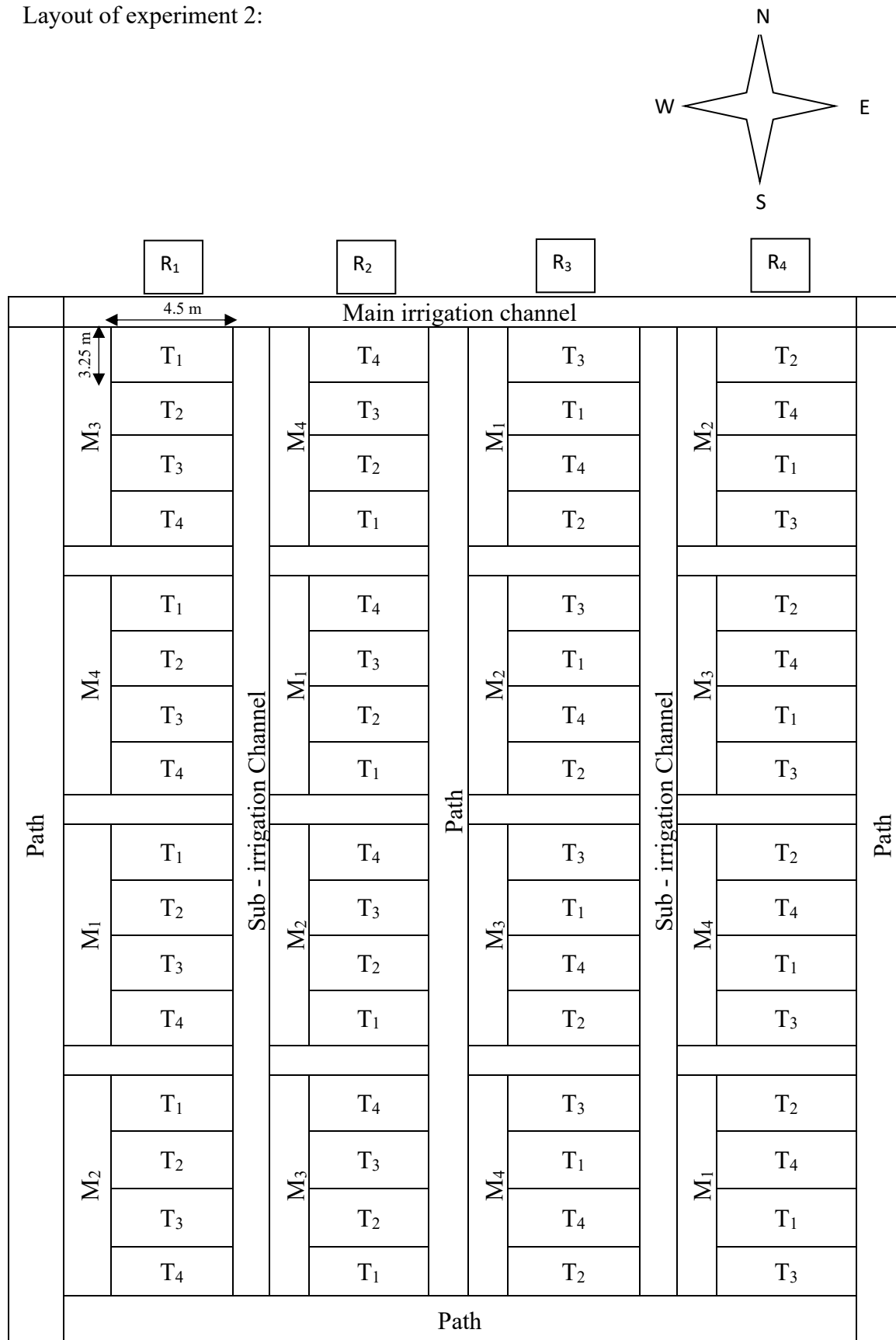
T₄ = 125 % RDN

Note: Uniform application of pre-emergence herbicides *i.e.* atrazine + pendimethalin at 0.75 + 0.75 kg ha⁻¹ was done in all experimental plots. Recommended dose of N is 125 kg/ha.

Layout of experiment 1:



Layout of experiment 2:



3.5 Experiment details:

Experiment 1

Year	2023 and 2024
Season	Spring
Crop	Maize (<i>Zea mays</i> L.)
Variety	PMH 10
Seed rate	25 kg ha ⁻¹
Spacing	60 × 20 cm ² or as per treatment
Time of sowing	24 February 2023 and 21 February 2024
Design	Split Plot Design
Main plots	3
Sub plots	5
Total no. of treatments	3×5 = 15
No. of replications	4
Total no. of plots	15×4 = 60
Gross plot size (sub)	4.5 m × 4 m = 18 m ²
Net harvested plot	2 m × 1.2 m = 2.4 m ²
Fertilizers	N – 125 kg ha ⁻¹ P ₂ O ₅ – 60 kg ha ⁻¹

Experiment 2

Year	2023 and 2024
Season	Spring
Crop	Maize (<i>Zea mays</i> L.)
Variety	PMH 10
Seed rate	25 kg ha ⁻¹
Spacing	60 × 20 cm ²
Time of sowing	21 February 2023 and 19 February 2024
Design	Split Plot Design
Main plots	4

Sub plots	4
Total no. of treatments	$4 \times 4 = 16$
No. of replications	4
Total number of plots	$16 \times 4 = 64$
Gross plot size (sub)	$4.5 \text{ m} \times 3.25 \text{ m} = 14.63 \text{ m}^2$
Net harvested plot	$2 \text{ m} \times 1.2 \text{ m} = 2.4 \text{ m}^2$
Fertilizers	N – As per treatments P_2O_5 - 60 kg ha ⁻¹

Note: Bajra (*Pennisetum glaucum*) was sown after harvesting of first year maize crop in organic manure experiment to maintain the fertility status of experimental plots during second year.

3.6 Cultural practices:

3.6.1 Periodic agronomic practices:

Experiment - 1

Name of the operation	Date	
Land preparation	22 February 2023	17 February 2024
Layout of experiment	23 February 2023	20 February 2024
Sowing	24 February 2023	21 February 2024
Pre-emergence herbicide application	25 February 2023	22 February 2024
Mulching	26 February 2023	24 February 2024
Irrigation	28 February 2023	26 February 2024
Gap filling	4 March 2023	5 March 2024
Intercrop sowing	10 March 2023	12 March 2024
First dose ($\frac{1}{3}$ rd urea)	15 March 2023	13-14 March 2024
Second irrigation	16 March 2023	10 March 2024
First hand weeding	24 March 2023	23 March 2024
Second dose ($\frac{1}{3}$ rd urea)	1 April 2023	27-28 March 2024
Observations at 45 DAS	2-5 April 2023	27-31 March 2024

Second hand weeding	8 April 2023	8 April 2024
Third irrigation	12 April 2023	10 April 2024
Coragen @0.4ml/l	14 April 2023	10 April 2024
Third dose (1/3 rd urea)	15 April 2023	13-14 April 2024
Fourth irrigation	25 April 2023	22 April 2024
Earthing up	29 April 2023	30 April 2024
Observation at 75 DAS	1-4 May 2023	27-30 April 2024
Fifth irrigation	9 May 2023	6 May 2024
Sixth irrigation	14 May 2023	13 May 2024
Seventh irrigation	22 May 2023	20 May 2024
Eighth irrigation	30 May 2023	28 May 2024
Observation at 105 DAS	2-6 June 2023	29 May - 2 June 2024
Ninth irrigation	9 June 2023	7 June 2024
Harvesting data	20-22 June 2023	15-17 June 2024
Harvesting	22 June 2023	17 June 2024
Plant Sample	26 June 2023	24 June 2024
Cob sample	27 June 2023	25 June 2024
Soil sampling	30 June 2023	28 June 2024

Experiment - 2

Name of the operation	Date	
Organic manure application	20 January 2023	16 January 2024
Irrigation	21 January 2023	18 January 2024
Land preparation	20 February 2023	15 February 2024
Layout of experiment	21 February 2023	17 February 2024
Sowing	21 February 2023	19 February 2024
General weed control (Pre-em. Pendimethalin + atrazine at 0.75 + 0.75 kg ha ⁻¹)	22 February 2023	20 February 2024
Irrigation	24 February 2023	22 February 2024

Gap filling	3 March 2023	1 March 2024
Thinning	12 March 2023	9 March 2024
First dose (1/3 rd urea)	15 March 2023	13-14 March 2024
Second irrigation	16 March 2023	10 March 2024
2,4-D application	30 March 2023	27 March 2024
Second dose (1/3 rd urea)	1 April 2023	27-28 March 2024
Observations at 45 DAS	2-5 April 2023	27-31 March 2024
Third irrigation	12 April 2023	7 April 2024
Coragen @0.4ml/l	14 April 2023	10 April 2024
Third dose (1/3 rd urea)	15 April 2023	13-14 April 2024
Fourth irrigation	25 April 2023	22 April 2024
Observation at 75 DAS	1-4 May 2023	27-30 April 2024
Fifth irrigation	9 May 2023	6 May 2024
Sixth irrigation	14 May 2023	13 May 2024
Seventh irrigation	22 May 2023	20 May 2024
Eighth irrigation	30 May 2023	28 May 2024
Observation at 105 DAS	2-6 June 2023	29 May - 2 June 2024
Ninth irrigation	9 June 2023	7 June 2024
Harvesting data	20-22 June 2023	15-17 June 2024
Harvesting	22 June 2023	17 June 2024
Plant Sample	26 June 2023	24 June 2024
Cob sample	27 June 2023	25 June 2024
Soil sampling	30 June 2023	28 June 2024
Bajra (exhaustive crop) sowing	15 July 2023	-
Harvesting of Bajra	3 September 2023	-

3.6.3 Preparation of experimental field:

After the harvesting of last year arhar crop, disking was done twice followed by cultivator. Then, after giving irrigation the rotavator was used for fine tilth before the layout preparation.

3.6.4 Organic manures:

FYM, poultry manure and press mud were arranged two month before sowing of the crop during both the years and left in open for air drying. The organic manures were applied one month prior to the sowing of maize crop. On an average, FYM contains 0.5% N, 0.25% P and 0.5% K, poultry manure 3.0% N, 2.6% P and 1.4% K and press mud 1.6% N, 1.1% P and 0.9% K, respectively.

3.6.5 Layout of field experiments:

After fine seed bed preparation by rotavator, the layout of the experiments was done firstly by making main plots and then subplots for both experiments. The irrigation channel and plots were prepared manually by the labour. Finally fine levelling of sub plots was done with the help of hand implement *i.e.* Zindra.

3.6.6 Fertilizer application:

A basal dose of phosphorus @ 60 kg ha⁻¹ was applied in the form of SSP (single super phosphate) in all the plots. The nitrogen dose in the form of urea was applied in three splits.

3.6.7 Sowing of maize:

The sowing of the maize crop in first experiments was done on 24 February 2023 and 21 February 2024. The sowing of second experiment was done on 21 February 2023 and 19 February 2024 at Research Farm of Department of Agronomy, LPU, Phagwara (Punjab) during the spring season. Two seeds were dibbled per hill and plant to plant spacing was kept at 20 cm. Row to row spacing was kept at 60 cm except in paired row planting where the two rows were sown at a spacing of 30 cm and pairs of rows were at 90 cm apart. Ridges were made at 60 cm apart and seeds were sown on the slope of ridge. Plant population in all the planting patterns was kept constant. Sowing of intercrops *i.e.* Dhaincha (*Sesbania aculeata*) and cowpea (*Vigna unguiculata*) were done 15 days after the sowing of main crop with hand hoe. In flat sown and ridge sowing, one row of cowpea in-between two rows of maize crop and two rows of Dhaincha in between two rows of maize were sown. However, in paired row

sowing, total 5 rows of cowpea and 10 rows of Dhaincha were sown in each plot. The number of rows of intercrops were same in all the planting patterns.

3.6.8 Pre-emergence application:

Application of pre-emergence herbicides *i.e.* pendimethalin and atrazine was done at $0.75 + 0.75 \text{ kg ha}^{-1}$ within two days after sowing in second experiment by dissolving in 500 litres of water/ha whereas in first experiment, atrazine + pendimethalin as pre-emergence was applied as per treatment.

3.6.9 Mulching:

Rice straw mulch was applied @ 6 t ha^{-1} in the subplots as per the treatments immediately after earthing up. It was spread uniformly in the plot.

3.6.10 Thinning and gap filling:

The gap filling was done 10 days after sowing and thinning of the crop was done after 15 days of sowing by keeping one healthy plant per hill.

3.6.11 Irrigation:

First irrigation was applied after application of pre-emergence herbicides. Next two irrigations were given at an interval of 15-20 days. Later, irrigations were given according to the moisture level of the soil and by observing visual drought symptoms of crop. In total, nine irrigations were applied up to maturity.

3.6.12 Hand weeding:

Two hand weedings were done on 24 March 2023 and 8 April 2023 during first year and 23 March 2024 and 8 April 2024 during second year.

3.6.13 Incorporation of intercrops and earthing up:

The intercrops were cut with a sickle and biomass laid down along the rows of the crop after 45 days of their sowing which was followed by earthing up and straw mulching as per the treatment.

3.6.14 Post emergence herbicide:

2,4-D was applied as a post emergence after 45 DAS in the second experiment only @ 1 litre ha⁻¹ by dissolving in 500 litres/ha of water in order to control *Cyperus rotundus* in this experiment.

3.6.15 Plant protection:

Proclaim (emamectin benzoate @ 0.4 ml/litre of water) was sprayed to control fall army worm and stem borer at 45 DAS. Later, Coragen (chlorantraniliprole) @ 0.4 ml/litre of water was applied to control the insect attack at 60 DAS.

3.6.16 Net harvested plot:

The net plot harvested was 2.4 m². The central two rows / plot with the length of 2 meters and width of 1.2 m was harvested from each experimental plot.

3.6.17 Harvesting time:

The crop was harvested on 22nd June 2023 and 17th June 2024 plot wise during both years by cutting the plants from ground level using a sickle, when the cobs turned yellow and mostly leaves of the crop dried up and grains became hard. The plants were sun dried for 7-10 days with regular turning of the plants for uniform drying.

3.6.18 Shelling:

The cobs along with sheath were removed from the plants and later on sheath was removed and cobs were sun dried. After complete drying, shelling of the cobs was done manually and grains were put into cotton cloth bags for weighing.

3.6.19 Biological yield (q/ha): The net plot of 2.4 m² was cut with the sickle and kept in sunlight for 5 days for sun drying. Then, weighing of the plants along with cobs was done with digital weighing machine. The observed values were then converted into q/ha.

3.6.20 Grain yield (q/ha): After shelling of cobs, grains of each plot were put in separate cotton bags and weighing was done with digital weighing balance. The values were then converted into q ha⁻¹.

3.6.21 Stover yield (q/ha): Stover yield was calculated by subtracting grain yield from the biological yield.

3.6.22 Harvest index (%): Harvest index was calculated by multiplying grain yield with 100 and dividing it by biological yield.

3.7 Soil sampling:

The soil samples were collected after harvesting the crop. The soil auger was used for soil sampling and soil samples were taken up to depth of 15 cm which were dried in shade followed by sieving (2 mm) to prepare them for further testing in the lab.

3.8 Observations:

3.8.1 Weed parameters of Experiment 1

3.8.1.1 Weed count (m⁻²): A quadrant of 0.3 x 0.3 m² was thrown twice in every sub-plot randomly and number of weeds were counted and average number of weeds per quadrant were noted at 45, 75, 105 DAS and at harvest. Later on, weed count was converted to number of weeds per sq. meter for final presentation. Square root transformation ($\sqrt{x + 1}$) was used for periodic weed count analysis.

3.8.1.2 Weed dry weight (q ha⁻¹): Weed dry matter was observed at 45, 75, 105 DAS and at harvest with a quadrant of 0.3 x 0.3 m² by randomly throwing it at two different places per plot. The weeds above ground level were cut with sickle and kept in brown bags and after sun drying. They were kept in hot air oven at 60°C temperature till complete drying. These samples were weighed on electronic balance and converted into q ha⁻¹ for presentation. Square root transformation ($\sqrt{x + 1}$) was used for statistical analysis of periodic dry matter of weeds.

3.8.1.3 Weed Control Efficiency (WCE) at harvest: The term weed control efficiency is expressed in percentage and calculated at harvest as follows.

$$WCE (\%) = \frac{X - Y}{X} \times 100$$

X= Weed dry weight (q ha⁻¹) in weedy check plot

Y= Weed dry weight (q ha⁻¹) in treatment for which WCE is to be calculated.

3.8.2 Weed parameters of Experiment 2

3.8.2.1 Weed count (m⁻²): A quadrant of 0.3 x 0.3 m² was thrown twice in every sub-plot randomly. Number of weeds were counted and their average was noted at 75, 105 DAS and at harvest. Finally, these were converted to number of weeds per sq. meter for presentation. Square root transformation ($\sqrt{x + 1}$) was used at all periodic intervals for statistical analysis.

3.8.2.2 Weed dry weight (q ha⁻¹): Weed dry matter was observed at 75, 105 DAS and at harvest with a quadrant of 0.3 x 0.3 m² by throwing it randomly at two different places per plot and weeds were cut from ground level and put in brown bags. Weed samples were drying in sun then kept in oven at 60°C temperature till complete dryness. Samples were weighed on electronic balance and then converted to q ha⁻¹ for final presentation. Square root transformation ($\sqrt{x + 1}$) was used at all periodic intervals for statistical analysis.

3.8.2.3 Weed Control Efficiency (WCE) at harvest: The term weed control efficiency is expressed in percentage and calculated at harvest as follows.

$$WCE (\%) = \frac{X - Y}{X} \times 100$$

X= Weed dry weight (q ha⁻¹) in weedy check plot

Y= Weed dry weight (q ha⁻¹) in treatment for which WCE is to be calculated.

3.8.3 Crop parameters (for both experiments)

3.8.3.1 Plant height (cm): The plant height was measured from ten randomly selected plants from each plot with the help of a measuring rod. The height was measured from ground level to base of the last fully opened leaf at 45, 75, 105 DAS and at harvest and average plant height was worked out in cm.

3.8.3.2 Plant dry matter per plant (g): Five randomly selected plants were cut with the help of sickle, and their fresh weight was taken and then those samples were cut into small pieces and kept in brown bags. After sun drying, samples

were oven dried in the hot air oven at 60⁰ C for 72 hours till constant weight is obtained. The observations were recorded at 45, 75, 105 DAS and at harvest.

3.8.3.3 Number of leaves per plant: Number of leaves per plant were also counted from five randomly selected plants in each plot at 45, 75, 105 DAS and at harvest and average number of leaves per plant were worked out for presentation.

3.8.3.4 Number of nodes per plant: The number of nodes were counted from five randomly selected plants from each plot at 45, 75, 105 DAS and at harvest and average number of nodes per plant were worked out for presentation.

3.8.3.5 Internodal length (cm): The internodal length was also taken from five randomly selected plants from each plot at 75, 105 DAS and at harvest. Three internodes were measured from each plant *i.e.* one from the bottom, in the middle and one from the top of the plant and then average was calculated to find out average internodal length. Measuring scale was used for the recording of internode length.

3.8.3.6 Stem girth (mm): The stem girth was measured from five randomly selected plants with the help of digital Vernier caliper and it was measured from three points in each plant *i.e.* from bottom, middle and top portion, then average was worked out for presentation. The observations were recorded at 75, 105 DAS and at harvest.

3.8.4 Yield parameters at harvest:

3.8.4.1 Number of cobs per plant: This observation was recorded from 20 harvested plants and then mean value was calculated to find the number of cobs per plant.

3.8.4.2 Cob length (cm): For cob length, five cobs were taken from the harvested cobs, then cob sheath was removed and length of each cob was measured with the help of measuring scale. Average cob length was worked out for presentation.

3.8.4.3 Cob girth (mm): The digital Vernier caliper was used from measuring cob girth. Five randomly selected cobs (without sheath) were taken, three readings

were taken from each cob *i.e.* from the base, middle and top portion of the cob and then average was calculated to work out cob girth in mm.

3.8.4.4 Number of rows per cob: The count of total rows per cob were also done from five randomly selected cobs and the average values were taken to work out number of rows per cob.

3.8.4.5 Number of grains per cob: Three cobs per plot were selected randomly and total number of grains were counted and later on average number of grains per cob were calculated.

3.8.4.6 Test weight (1000-grain weight): Sample of grains was taken from each harvested plot after manually shelling the cobs, then 1000 seeds were counted with digital seed counter machine and weighing of these 1000 seeds was done on a digital weighing machine.

3.8.4.7 Biological yield (q/ha): The net plot of 2.4 m² was cut with the sickle and kept in sunlight for 5 days for sun drying. Then, weighing of these harvested plants along with cobs was done with digital weighing machine. The observed values were then converted into q ha⁻¹.

3.8.4.8 Grain yield (q/ha): For grain yield, net plot was harvested with sickle and cobs were removed from the plants and cob sheath was also removed. Then, shelling of the cobs was done manually after sun drying. Then, weighing of the grains was done on the digital weighing machine. The values were converted into q ha⁻¹ for presentation.

3.8.4.9 Stover yield (q ha⁻¹): Stover yield was calculated by subtracting grain yield from the biological yield.

3.8.5 Quality parameters:

3.8.5.1 Nitrogen content in grains (%): A sample of seeds was ground using a grinder, and 0.2 g of the powdered sample was placed into a Kjeldahl digestion tube together with 20 ml of 98% H₂SO₄ and catalyst mixture of K₂SO₄ and CuSO₄, then subjected to digestion for 2-3 hours at an automatically set temperature. A 40% NaOH solution, 4% boric acid, and a mixed indicator were created for the distillation procedure. Upon the conclusion of the procedure conducted by Kel-Plus, the extracted samples

underwent titration with 0.1 N H₂SO₄. The values were recorded and expressed as a percentage.

$$N\% = \frac{14.01 \times 0.1N \times (T.V. - B.V.)}{1000 \times \text{Weight of sample}} \times 100$$

T.V. = Titrated value

B.V. = Blank value

3.8.5.2 Protein content in grains (%): For calculation of protein content, nitrogen content was multiplied by conversion factor *i.e.* 6.25.

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

3.8.5.3 Nitrogen content in stover (%): A sample of dried plants at harvest was ground using a grinder, and 0.2 g of the powdered sample was placed into a Kjeldahl digestion tube together with 20 ml of 98% H₂SO₄ and catalyst mixture of K₂SO₄ and CuSO₄, then subjected to digestion for 2-3 hours at an automatically set temperature. A 40% NaOH solution, 4% boric acid, and a mixed indicator were created for the distillation procedure. Upon the conclusion of the procedure conducted by Kel-Plus, the extracted samples underwent titration with 0.1 N H₂SO₄. The measurement was recorded and expressed as a percentage.

$$N\% = \frac{14.01 \times 0.1N \times (T.V. - B.V.)}{1000 \times \text{Weight of sample}} \times 100$$

T.V. = Titrated value

B.V. = Blank value

3.8.5.4 Nitrogen content in weeds (%): The harvested weed samples were oven-dried, then ground, and 0.2 g of the powdered sample was placed into a Kjeldahl digestion tube. Then, 20 ml of 98% H₂SO₄ and catalyst mixture of K₂SO₄ and CuSO₄ were added, and the mixture was digested for 2-3 hours at an automatically determined temperature. A solution of 40% NaOH, 4% boric acid, and a mixed indicator was created for the distillation procedure. Upon the conclusion of the procedure using Kel-Plus, the extracted samples

underwent titration with 0.1 N H₂SO₄. The reading was recorded and expressed as a percentage.

$$N\% = \frac{14.01 \times 0.1N \times (T.V. - B.V.)}{1000 \times \text{Weight of sample}} \times 100$$

T.V. = Titrated value

B.V. = Blank value

3.8.5.5 N uptake by grain

N uptake by grain (kg/ha) = nitrogen content % (grains) x grain yield (kg/ha)

3.8.5.6 N uptake by stover

N uptake by stover (kg/ha) = nitrogen content % (stover) x stover yield (kg/ha)

3.8.5.7 Total N uptake by crop (kg/ha)

N uptake by crop (kg/ha) = N uptake by grain (kg/ha) + N uptake by stover
(kg/ha)

3.8.5.8 N uptake by weed (kg/ha)

N uptake by weed (kg/ha) = nitrogen content (%) × weed dry matter (kg/ha)

3.8.5.9 Chlorophyll index (SPAD value): The SPAD meter was used for calculating chlorophyll index. The data was recorded from five randomly selected plants and three reading were taken from each plant from three different leaves and then average was calculated. The observations were taken at 45, 75 and 105 DAS.

3.8.6 Soil Parameters (Before sowing and at harvest):

3.8.6.1 Soil pH: 10 g soil sample was weighed and water (25 ml) was added into a 100 ml beaker. After stirring the sample for few minutes, sand particles were left to settle at bottom. The electrode was dipped in the solution and the reading was noted. The calibration of the pH was done with buffer solutions of pH 4, 7 and 9.2.

- 3.8.6.2 Soil EC:** Soil sample of 10 g was taken along with 25 ml of water in a 100 ml conical flask. It was then kept on mechanical shaker for 8-10 minutes. After shaking, sample was left for few minutes to settle down. Then, the reading was taken with electrical conductivity meter (dS/m).
- 3.8.6.3 Soil organic carbon (%):** Soil sample of 1 g was weighed into a 500 ml conical flask. 20 ml of $K_2Cr_2O_7$ and H_2SO_4 were added into the flask. Sample was stirred and left for 30 minutes. Afterwards, 200 ml distilled water along with 10ml ortho-phosphoric acid was added. Later, 4-5 drops of diphenylamine indicator were added then titrated with ferrous ammonium sulphate, the titrated values were recorded.
- 3.8.6.4 Available N ($kg\ ha^{-1}$):** 10 g of soil was taken in Kjeldahl flask and was kept in the distillation unit and alongside a conical flask was taken and 4-5 drops of mixed indicator were added. Then, the distillation unit was set to add 20 ml of boric acid (4%) in the conical flask and 25 ml of 0.32% $KMnO_4$, 25 ml of 2.5% of NaOH and 10 ml of distilled water in Kjeldahl flask. Distillation process took 7 minutes. The flask solution was taken and titrated with 0.02 N H_2SO_4 . When the colour of solution changed, the reading was noted.
- 3.8.6.5 Available P ($kg\ ha^{-1}$):** 2.5 g soil was taken and a pinch of activated charcoal along with 50 ml of 0.5 M $NaHCO_3$ was added into 150 ml conical flask. Sample was then kept on mechanical shaker for 30 minutes. The solution was then filtered with Whatman no. 1 filter paper, then 5 ml of extractant was poured into 25 ml volumetric flask and 5 ml $(NH_4)_6Mo_7O_{24}$ was added. Then, 10 ml distilled water with 1 ml stannous chloride solution was added and volume was made up to 25 ml. The readings were taken with spectrophotometer at a wavelength of 660 nm by making a standard curve for phosphorus.
- 3.8.6.6 Available K ($kg\ ha^{-1}$):** 5 g of soil was measured in a conical flask and 25 ml of 1 N $C_2H_7NO_2$ was added, then agitated manually for 5-7 minutes, and subsequently filtered the solution using Whatman no. 1 filter paper. The final readings were obtained on the flame photometer by constructing a standard curve that includes a blank sample using KCl.

3.9 Statistical Analysis: The aforementioned study data about various metrics of crops (growth, dry matter, yield qualities) and weeds (weed count and weed dry matter) were analyzed using OPSTAT software. The analysis of variance (ANOVA) was tested, and critical difference (CD) values were calculated at a 5% significance level, with non-significant data shown as NS. Standard error of the mean (SE(m) $\pm$) was also presented in the Tables.

3.9.1 ANOVA Table for experiment 1

Sources of Variation	Degree of freedom	Sum of squares	Mean sum of squares	F _{cal} (F – calculated)
Replication	$r-1 = 3$	RSS	RMS	RMS/EMS(a)
A (main plots)	$m-1 = 2$	ASS	AMS	AMS/EMS(a)
Error (a)	$(r-1)(m-1) = 6$	ESS(a)	EMS(a)	
B (sub plots)	$s-1 = 4$	BSS	BMS	BMS/EMS(b)
A x B (interaction)	$(m-1)(s-1) = 8$	ABSS	ABMS	ABMS/EMS(b)
Error (b)	$m(r-1)(s-1) = 36$	ESS(b)	EMS(b)	
Total	$rms-1 = 59$	TSS		

3.9.2 ANOVA Table for experiment 2

Sources of Variation	Degree of freedom	Sum of squares	Mean sum of squares	F _{cal} (F – calculated)
Replication	$r-1 = 3$	RSS	RMS	RMS/EMS(a)
A (main plots)	$m-1 = 3$	ASS	AMS	AMS/EMS(a)
Error (a)	$(r-1)(m-1) = 9$	ESS(a)	EMS(a)	
B (sub plots)	$s-1 = 3$	BSS	BMS	BMS/EMS(b)
A x B (interaction)	$(m-1)(s-1) = 9$	ABSS	ABMS	ABMS/EMS(b)
Error (b)	$m(r-1)(s-1) = 36$	ESS(b)	EMS(b)	
Total	$rms-1 = 63$	TSS		

Experiment 1

Planting patterns



Flat sowing with paired rows



Flat sowing with single row



Ridge sowing



Incorporation of intercrop



Earthing-up



Straw mulching

Experiment 2

Control (0% RDN) at 60 DAS



No organic manure



Poultry Manure @ 6.25 t ha⁻¹



FYM @ 15 t ha⁻¹



Press mud @ 15 t ha⁻¹

Poultry Manure @ 6.25 t ha⁻¹ (60 DAS)



0 kg N / ha



75 kg N / ha



125 kg N / ha



150 kg N / ha

FYM @ 15 t ha⁻¹ (60 DAS)



0 kg N / ha



75 kg N / ha



100 kg N / ha



125 kg N / ha

Nitrogen Analysis



Digestion



Distillation



Titration

Soil Testing



Available soil nitrogen



Soil organic carbon



Available soil potassium



Field visit



General Crop view

The results obtained from the research experiment entitled “**Maximizing yield of spring maize (*Zea mays* L.) with the manipulation of agronomic practices**” for weed parameters, crop growth, yield attributes and quality parameters are discussed below.

Experiment 1: Impact of planting patterns and weed control treatments on growth and development of spring maize

4.1 Weed density

Weed count and weed dry matter are the two important indices for determining the impact of weeds on crop growth and yield. Weed count indicates type of weed flora as well as their intensity which governs extent of losses due to weeds. As compared to weed dry weight, weed count is less reliable as sometimes their population may be high but extent of losses may be less due to their poor growth. Due to wide variations in the data of weed count and weed dry matter, it was subjected to square root transformation after adding one to original values at all periodic intervals.

4.1.1. Weed count (m^{-2})

Weed count indices indicates the number of weeds present in a unit area as well as type of weed flora infesting the field. The data on weed count (m^{-2}) at 45, 75, 105 DAS and at harvest as impacted by planting patterns and weed control treatments was presented in Table 4.1.1a. and 4.1.1b and depicted in Figure 4.1.1.

The data for weed count recorded 45 and 75 DAS presented in Table 4.1.1a. indicated that the difference in weed count (m^{-2}) among the planting patterns remained non-significant at 45 DAS during 2023 and 2024. Among sub-plot treatments, the significantly lower weed count was recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching; pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching; intercropping *Sesbania fb* earthing up & straw mulching and two hand weeding treatment as compared to unweeded (control) during

2023 and 2024. However, all the former treatments were found statistically at par among themselves.

At 75 DAS, weed count (m^{-2}) in ridge sowing was statistically at par with flat sowing with single row during both the years (Table 4.1.1a). The weed count in paired row planting was significantly higher than other planting methods during both the years. Among weed control treatments, the weed count during 2023 was significantly lower in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching as compared to pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments. The significantly higher weed count was observed in unweeded (control) at 75 DAS as compared to all other weed control treatments. These findings hold good for both years.

The weed count data recorded at 105 DAS and at harvest was found to be significant and presented in Table 4.1.1b. which showed that weed count in ridge sowing and single row flat sown were found at par during both the years. The weed count was significantly higher in the paired row sowing during both the years as compared to other planting patterns. Among the weed control treatments, significantly lower weed count was observed in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing & straw mulching in comparison to all other weed control treatments when recorded at 105 DAS. The weed count in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding was significantly lower as compared to unweeded (control). Weed count in unweeded (control) was significantly more as compared to all other weed control treatment. These results hold good for both years.

At harvest, the difference in weed count (m^{-2}) among the planting patterns was significant (Table 4.1.1b). The weed count was significantly lower in the ridge sowing and single row flat sown crop. The paired row sowing recorded significantly higher weed count than other planting patterns. These finding hold good for both years. Among the sub plot treatments, significantly lower weed count was observed in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching

and intercropping *Sesbania fb* earthing up & straw mulching as compared to other weed control treatments during 2023 and 2024. Pendimethalin + atrazine pre-emergence *fb* straw mulching recorded significantly less weed count as compared to two hand weeding treatment during 2023 and 2024. The weed count was significantly more in the unweeded (control) plot during both 2023 and 2024 as compared to all other weed control treatments.

The lower weed count in ridge sowing may be due to deep burying of weed seed under the ridges which were unable to germinate. Similar findings were reported by Anwar (2011). The cover crops like cowpea and *Sesbania* may reduce the weed germination by covering the soil surface quickly and minimizing the light penetration. Straw mulching covers the soil surface which may have resulted in lower weed population. Earthing up also reduces the weed populations due to uprooting and deep burying of the weeds (Saho *et al.*, 2024a).

The interactive effect of planting patterns and weed control treatments was non-significant at all growth stages during both years (Table 4.1.1a and Table 4.1.1b).

Table 4.1.1a. Effect of planting patterns and weed control treatments on weed count (m⁻²) at 45 and 75 DAS

	Weed count (m ⁻²)			
	45 DAS		75 DAS	
	2023	2024	2023	2024
Main plots (Planting patterns)				
Flat sowing with single row	3.7 (42)	3.6 (40)	7.9 (100)	7.3 (84)
Flat sowing with paired rows	3.8 (46)	3.9 (49)	8.8 (125)	8.4 (112)
Ridge sowing	3.7 (42)	3.5 (37)	7.8 (96)	6.9 (74)
SE(m) ±	0.05	0.09	0.08	0.13
C.D. (5%)	NS	NS	0.27	0.45
Sub-plots (Weed control treatments)				
Pendi.+Atz., pre-em <i>fb</i> SM	1.0 (0)	1.0 (0)	8.4 (70)	7.7 (59)
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Inter. <i>Sesbania fb</i> EU & SM	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Two hand weedings (4 and 6 WAS)	1.0 (0)	1.0 (0)	14.0 (196)	12.7 (163)
Unweeded (control)	14.7 (216)	14.5 (210)	16.4 (268)	15.1 (228)
SE(m) ±	0.06	0.09	0.12	0.13
C.D. (5%)	0.18	0.27	0.35	0.38
Interaction C.D. (5%)	NS	NS	NS	NS
Note: Values in parenthesis are original values and values without parenthesis are transformed values Square root transformation ($\sqrt{x + 1}$) was used SM stands for straw mulching, EU for earthing up, Pendi. for pendimethalin, Atz. for atrazine, Inter. for intercropping and WAS for weeks after sowing				

Table 4.1.1b. Effect of planting patterns and weed control treatments on weed count (m⁻²) at 105 DAS and at harvest

	Weed count (m ⁻²)			
	105 DAS		At harvest	
	2023	2024	2023	2024
Main plots (Planting patterns)				
Flat sowing with single row	8.7 (119)	7.8 (96)	13.7 (205)	12.2 (160)
Flat sowing with paired rows	10.0 (157)	8.9 (126)	14.6 (227)	13.0 (178)
Ridge sowing	8.4 (110)	7.1 (80)	13.2 (190)	11.4 (136)
SE(m) ±	0.17	0.22	0.31	0.17
C.D. (5%)	0.61	0.77	1.08	0.61
Sub-plots (Weed control treatments)				
Pendi.+Atz., pre-em <i>fb</i> SM	10.6 (113)	8.4 (71)	15.7 (246)	13.1 (171.7)
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	1.0 (0)	1.0 (0)	8.9 (79)	8.4 (70)
Inter. <i>Sesbania fb</i> EU & SM	1.0 (0)	1.0 (0)	9.2 (87)	8.6 (73)
Two hand weedings (4 and 6 WAS)	15.2 (232)	13.5 (182)	16.8 (283)	14.7 (217)
Unweeded (control)	17.3 (299)	15.7 (249)	18.5 (341)	16.1 (260)
SE(m) ±	0.16	0.17	0.30	0.25
C.D. (5%)	0.47	0.50	0.86	0.73
Interaction C.D. (5%)	NS	NS	NS	NS
Note: Values in parenthesis are original values and values without parenthesis are transformed values Square root transformation ($\sqrt{x + 1}$) was used SM stands for straw mulching and EU stands for earthing up				

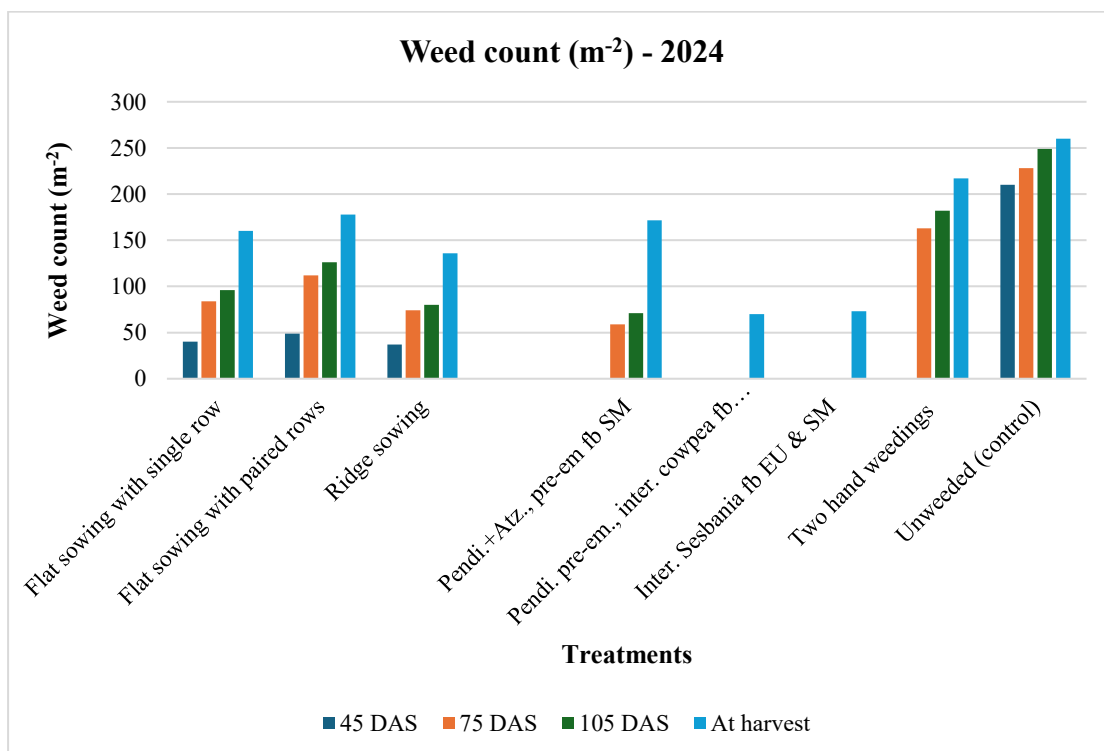
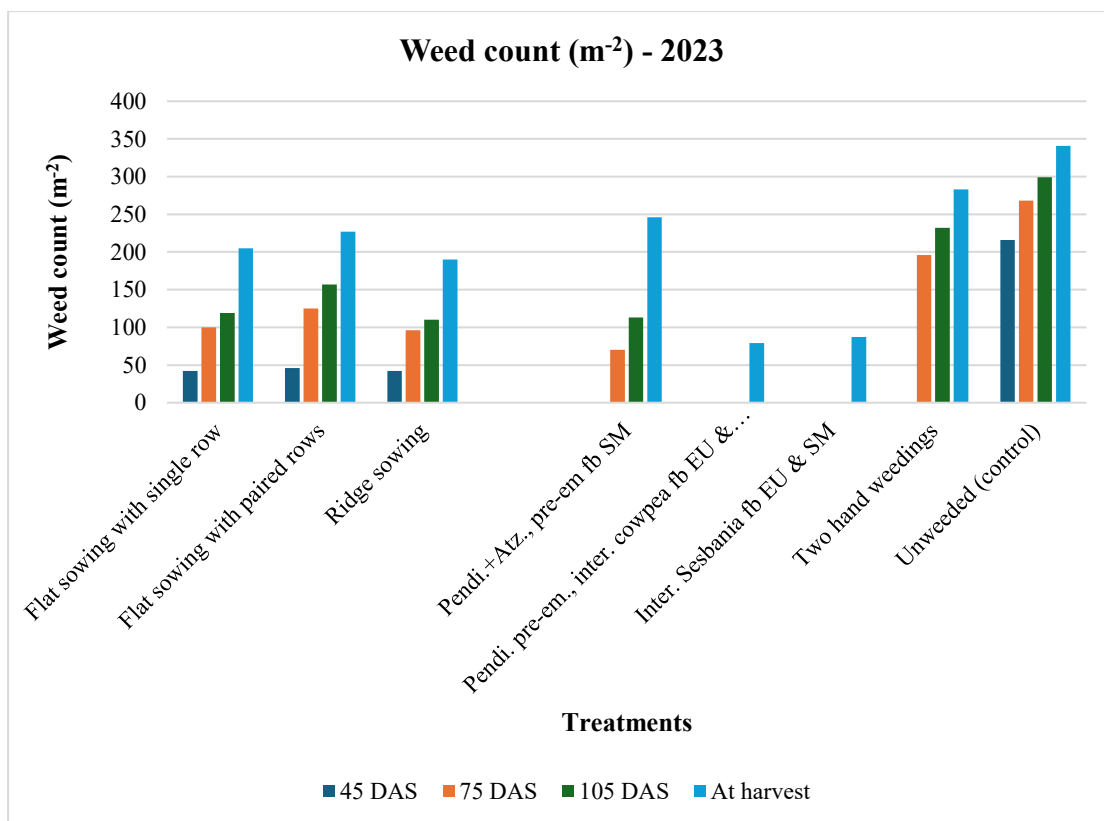


Figure 4.1.1 Effect of planting patterns and weed control treatments on weed count (m⁻²) for 2023 and 2024

4.1.2 Weed dry weight (q ha^{-1})

Weed dry matter is the most appropriate indices which indicates exact losses of crop yield due to weeds. The higher dry matter accumulation by weeds means more nutrient and water uptake by weeds and hindering the crop growth and ultimately lowering crop yield. The weed dry weight data as influenced by various treatments observed at 45, 75, 105 DAS and at harvest was presented in Table 4.1.2a and Table 4.1.2b and graphically depicted in Figure 4.1.2.

The differences in weed dry weight (q ha^{-1}) recorded 45 DAS during 2023 and 2024 was found to be non-significant among various planting patterns (Table 4.1.2a). Among weed control treatments, weed dry weight at 45 DAS was significantly lower in pendimethalin + atrazine pre-emergence *fb* straw mulching and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching, intercropping *Sesbania fb* earthing up & straw mulching and two hand weedings as compared to unweeded (control) during 2023 and 2024. However, all former weed control treatments were found at par with each other during 2023 and 2024.

At 75 DAS, significantly lower weed dry weight (q ha^{-1}) was recorded in ridge sowing as compared to other planting patterns. Flat sowing with single row recorded significantly less weed dry weight as compared to paired row planting. The weed count was significantly more in the paired row sowing as compared to all other planting patterns during 2023 and 2024 (Table 4.1.2a). Among the weed control treatments, significantly lower weed dry weight was recorded in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching than other weed control treatments. Pendimethalin + atrazine pre-emergence *fb* straw mulching recorded significantly less weed dry weight as compared to two hand weedings. The significantly more weed dry weight was recorded in unweeded (control) as compared to all other weed control treatments. The findings hold good for both years.

The weed dry weight (q ha^{-1}) data presented in Table 4.1.2b indicated that the differences in weed dry weight were significant at 105 DAS and at harvest during 2023 and 2024. The weed dry weight in ridge sowing and flat sowing with single row

was found to be statistically at par with each other when recorded at 105 DAS during 2023 and 2024. The paired row sowing recorded significantly higher weed dry weight as compared to other planting patterns. The findings hold good for both years. Among the weed control treatments, significantly lower weed dry matter was recorded in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching as compared to other treatments during 2023 and 2024. Weed dry weight was significantly less in pendimethalin + atrazine pre-emergence *fb* straw mulching as compared to two hand weedings. Significantly higher weed dry matter accumulation was recorded in unweeded (control) during both years as compared to all other treatments.

At harvest, the weed dry weight (q ha^{-1}) was significantly lower in ridge sowing as compared to other planting patterns during 2023 and 2024 (Table 4.1.2b). Flat sowing with single row recorded significantly less weed dry weight as compared to paired row sowing. The significantly more weed dry weight was found in paired row planting as compared to all other planting patterns during both years. Among the sub plots, weed dry weight in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching was statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. The weed dry weight recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching was significantly less than two hand weedings and both these treatments recorded significantly less dry matter of weeds as compared to unweeded (control) during 2023 and 2024. The unweeded (control) recorded significantly more weed dry weight at harvest as compared to all other weed control treatments. The findings hold good for both years.

Less weed dry weight in ridge sowing may be due to the deep burial of weed seeds under the ridges in ridge planting pattern which resulted in low weed seed germination and hence growth. The cover crops suppress the weed growth which may have resulted in lower weed dry weight in the intercropping treatments. The straw mulching may have acted as an advantage in lowering the weed dry weight by reducing the weed density due to soil surface coverage with the straw mulch. Yeganehpour *et al.* (2015) and Fernando *et al.* (2023) reported similar findings. Uprooting of weed in the process of earthing up also reduced the weed density.

The interactive effect of plating patterns and weed control treatment on weed dry weight at harvest was significant during 2023 and 2024 and data being presented in Table 4.1.3. Weed dry weight in ridge sowing with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching was at par with flat sown single row with intercropping *Sesbania fb* earthing up & straw mulching and both these above-mentioned planting patterns recorded significantly less weed dry matter than pre-emergence application of pendimethalin + atrazine *fb* straw mulching in ridge sown crop (Table 4.1.3). The results hold good for both years. Dry matter accumulation by weeds in single row flat sown maize treated with pendimethalin pre-emergence, intercropping of cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching treatments was significantly less than pre-emergence application of atrazine + pendimethalin *fb* straw mulching during both the years in same planting pattern. During both years, pre-emergence application of pendimethalin + atrazine followed by straw mulching in ridge sown crop produced significantly more dry matter of weeds compared to pendimethalin pre-emergence, intercropping cowpea *fb* earthing up and straw mulching in single row flat sowing crop.

Table 4.1.2a. Weed dry weight accumulation (q ha⁻¹) at 45 and 75 DAS as influenced by planting patterns and weed control treatments

	Weed dry weight (q ha ⁻¹)			
	45 DAS		75 DAS	
	2023	2024	2023	2024
Main plots (Planting patterns)				
Flat sowing with single row	1.7 (4.0)	1.4 (1.5)	2.2 (6.4)	2.1 (5.0)
Flat sowing with paired rows	1.6 (3.3)	1.6 (2.9)	2.4 (8.1)	2.2 (5.7)
Ridge sowing	1.7 (3.5)	1.4 (1.5)	2.1 (5.7)	2.0 (4.6)
SE(m) ±	0.03	0.02	0.02	0.02
C.D. (5%)	NS	NS	0.06	0.05
Sub-plots (Weed control treatments)				
Pendi.+Atz., pre-em <i>fb</i> SM	1.0 (0)	1.0 (0)	1.8 (2.2)	1.7 (1.8)
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0.0)
Inter. <i>Sesbania fb</i> EU & SM	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0.0)
Two hand weedings (4 and 6 WAS)	1.0 (0)	1.0 (0)	2.0 (3.0)	2.2 (3.8)
Unweeded (control)	4.3 (18.0)	3.3 (9.8)	5.4 (28.4)	4.6 (20.0)
SE(m) ±	0.05	0.03	0.03	0.03
C.D. (5%)	0.15	0.08	0.08	0.08
Interaction C.D. (5%)	NS	NS	NS	NS
Note: Values in parenthesis are original values and values without parenthesis are transformed values Square root transformation ($\sqrt{x + 1}$) was used SM stands for straw mulching and EU stands for earthing up				

Table 4.1.2b. Weed dry weight accumulation (q ha⁻¹) at 105 DAS and at harvest as influenced by planting patterns and weed control treatments

	Weed dry weight (q ha ⁻¹)			
	105 DAS		At harvest	
	2023	2024	2023	2024
Main plots (Planting patterns)				
Flat sowing with single row	2.6 (9.2)	2.4 (8.1)	3.4 (13.8)	3.2 (12.0)
Flat sowing with paired rows	2.8 (11.6)	2.7 (10.5)	3.7 (16.1)	3.5 (14.8)
Ridge sowing	2.5 (8.2)	2.4 (7.6)	3.2 (12.1)	3.0 (10.3)
SE(m) ±	0.03	0.06	0.03	0.05
C.D. (5%)	0.10	0.20	0.10	0.16
Sub-plots (Weed control treatments)				
Pendi.+Atz., pre-em <i>fb</i> SM	2.0 (3.1)	1.7 (1.9)	3.0 (7.9)	2.7 (6.1)
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	1.0 (0.0)	1.0 (0.0)	2.0 (3.1)	1.9 (2.7)
Inter. <i>Sesbania fb</i> EU & SM	1.0 (0.0)	1.0 (0.0)	2.1 (3.3)	2.0 (2.9)
Two hand weedings (4 and 6 WAS)	2.8 (6.8)	2.7 (6.4)	3.4 (10.4)	3.2 (9.5)
Unweeded (control)	6.3 (38.4)	6.0 (35.3)	6.8 (45.3)	6.4 (40.7)
SE(m) ±	0.06	0.05	0.08	0.06
C.D. (5%)	0.16	0.15	0.23	0.16
Interaction C.D. (5%)	NS	NS	0.39	0.29
Note: Values in parenthesis are original values and values without parenthesis are transformed values Square root transformation ($\sqrt{x + 1}$) was used SM stands for straw mulching and EU stands for earthing up				

Table 4.1.3. Interactive effect of planting patterns and weed control treatments on weed dry weight (q ha⁻¹) at harvest during 2023 and 2024

2023

	Pendi.+Atz., pre-em <i>fb</i> SM	Pendi. pre- em., inter. cowpea <i>fb</i> EU & SM	Inter. <i>Sesbania fb</i> EU & SM	Two hand weedings	Unweeded (control)	Mean A
Flat sowing with single row	3.0	2.0	2.1	3.4	6.7	3.4
Flat sowing with paired rows	3.0	2.2	2.2	3.4	7.4	3.6
Ridge sowing	2.8	1.8	2.0	3.3	6.2	3.2
Mean B	3.0	2.0	2.1	3.4	6.8	
SE(m) ±	0.06					
C.D. (5%)	0.39					

2024

	Pendi.+Atz., pre-em <i>fb</i> SM	Pendi. pre- em., inter. cowpea <i>fb</i> EU & SM	Inter. <i>Sesbania fb</i> EU & SM	Two hand weedings	Unweeded (control)	Mean A
Flat sowing with single row	2.6	1.9	1.9	3.2	6.4	3.2
Flat sowing with paired rows	2.8	2.1	2.2	3.4	7.1	3.5
Ridge sowing	2.6	1.8	1.8	3.1	5.8	3.0
Mean B	2.7	1.9	2.0	3.2	6.4	
SE(m) ±	0.10					
C.D. (5%)	0.29					

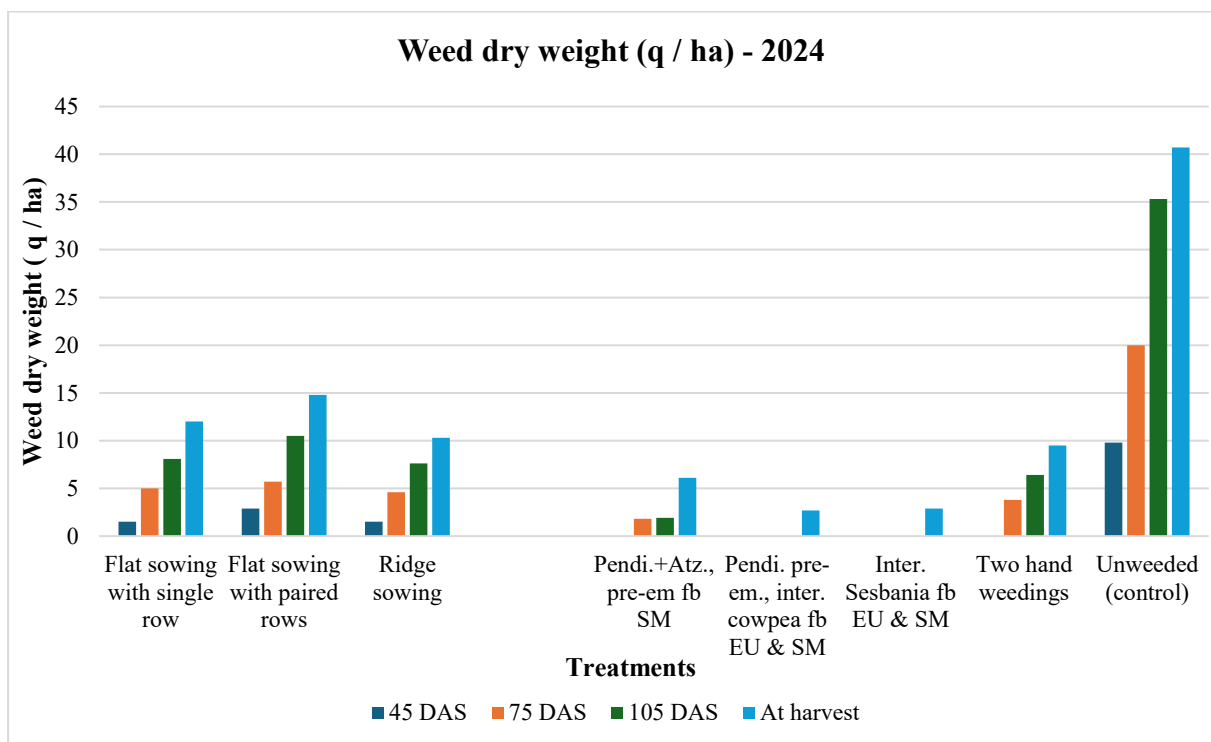
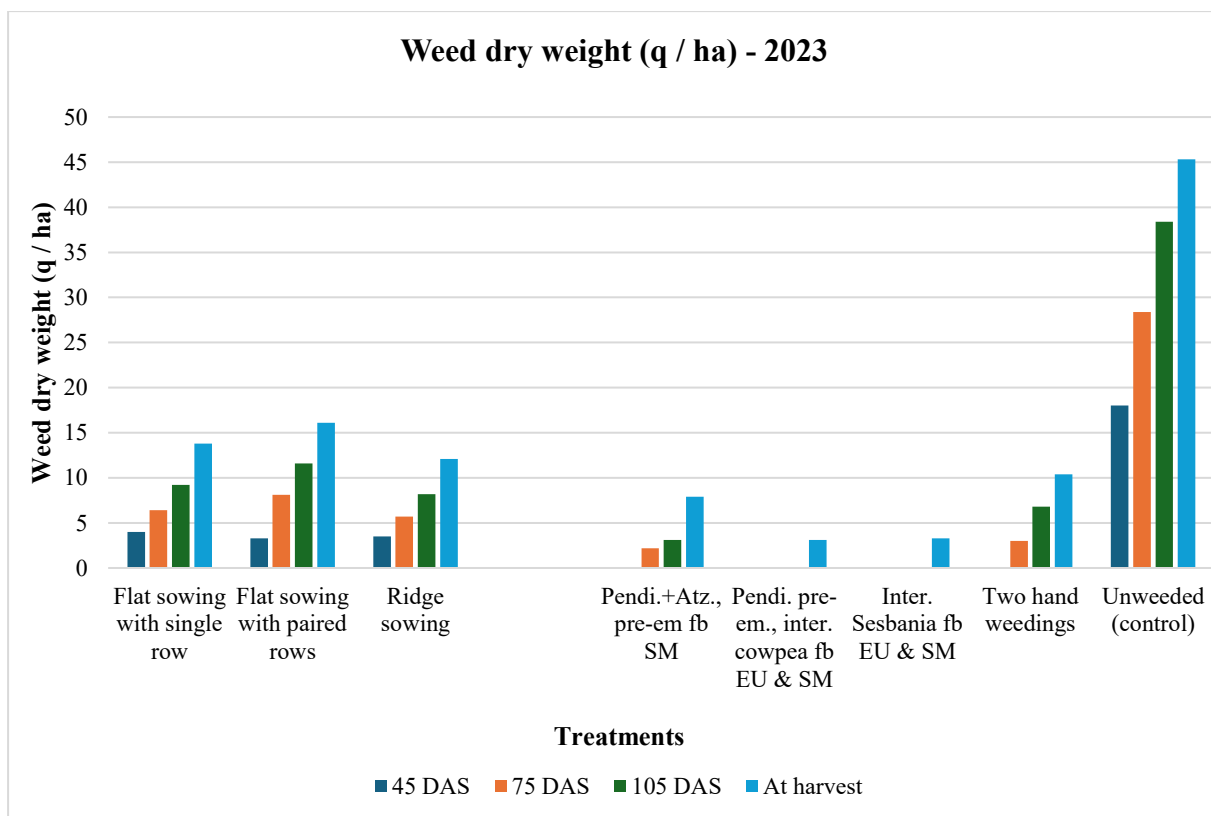


Figure 4.1.2 Effect of planting patterns and weed control treatments on weed dry weight (q ha⁻¹) for 2023 and 2024

4.1.3 Weed control efficiency (%)

The weed control efficiency data calculated at harvest was presented in Table 4.1.4 which indicates that among the planting patterns, highest weed control efficiency was observed in ridge sowing (73.95 and 74.69%) followed by single row flat sowing and paired row sowing during both years. Among the weed control treatments, highest weed control efficiency (93.16 and 93.37%) was recorded in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching followed by intercropping *Sesbania fb* earthing up & straw mulching (92.72 and 92.87%), respectively during both years. The weed control efficiency in pendimethalin + atrazine pre-emergence *fb* straw mulching was higher than two hand weeding. The lowest weed control efficiency was observed in two hand weedings treatment during 2023 and 2024.

The higher weed control efficiency under ridge sowing and intercropping treatments was due to lower weed density and weed suppression by intercrops which might have resulted from lesser light availability and better crop growth. Similar findings were reported by Lavanya *et al.* (2024), Sahoo *et al.* (2024b) and Soltani *et al.* (2016).

Table 4.1.4 Effect of planting patterns and weed control treatments on weed control efficiency (%) at harvest

	Weed control efficiency (%)	
	2023	2024
Main plots (Planting patterns)		
Flat sowing with single row	69.54	70.52
Flat sowing with paired rows	64.46	63.64
Ridge sowing	73.95	74.69
Sub-plots (Weed control treatments)		
Pendi.+Atz., pre-em <i>fb</i> SM	82.56	85.01
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	93.16	93.37
Inter. <i>Sesbania fb</i> EU & SM	92.72	92.87
Two hand weedings (4 and 6 WAS)	77.04	76.66
Unweeded (control)	-	-
*Weed control efficiency was calculated from original values of weed dry weight at harvest.		

4.2 Crop growth parameters

4.2.1 Plant height (cm)

Plant height (cm) is the most important crop parameter which determines the crop growth and crop competitive or suppressing ability towards weeds. Plant height is mainly governed by the genetic makeup of the crop as well as the adopted agronomic practices. The data on influence of planting patterns and weed control treatments on periodic plant height (cm) recorded at 45, 75, 105 DAS and at harvest during both years was presented in Table 4.2.1 and depicted in Figure 4.2.1.

The differences in plant height (cm) was significant among planting patterns at 45 DAS (Table 4.2.1). Plant height in ridge sowing and flat sown single row crop was statistically at par during 2023. The significantly lower plant height was recorded in the paired row as compared to ridge sowing during 2023. Among the weed control treatments, plant height was statistically at par among intercropping *Sesbania fb* earthing up & straw mulching, pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching treatments during 2023. Plant height in two hand weeding was found to be statistically at par with pendimethalin + atrazine pre-emergence *fb* straw mulching. The significantly lower plant height was recorded in unweeded (control) as compared to other weed control treatments during 2023. During 2024, plant height was statistically at par among ridge sowing and single row flat sown crop and both these planting patterns recorded significantly more plant height than paired row sowing (Table 4.2.1). Among the weed control treatments, plant height (cm) was statistically at par among intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. Pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding were found statistically at par among themselves. Significantly lower plant height was recorded in unweeded (control) during 2024 than all other weed control treatments.

At 75 DAS observation, plant height (cm) was statistically at par in the ridge sowing and flat sowing with single row during 2023 (Table 4.2.1). Significantly lower plant

height was recorded in the paired row sowing as compared to other planting patterns. Among the weed control treatments, plant height recorded at 75 DAS in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was found to be statistically at par. Plant height in pendimethalin + atrazine pre-emergence *fb* straw mulching was significantly less than both the intercropping treatments. Significantly less plant height was recorded in two hand weedings compared to all other treatments except unweeded (control). The plant height was significantly lower in unweeded (control) as compared to all other weed control treatments. During 2024, the plant height (cm) was statistically at par in the ridge sowing and flat sowing with single row (Table 4.2.1). Significantly lower plant height was recorded in the paired row sowing as compared to other planting patterns. Among the weed control treatments, plant height recorded 75 DAS in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was found to statistically at par with pendimethalin + atrazine pre-emergence *fb* straw mulching. Plant height in pendimethalin + atrazine pre-emergence *fb* straw mulching was at par with two hand weeding treatment. The plant height was significantly less in unweeded (control) as compared to all other weed control treatments.

The data presented in Table 4.2.1 indicated that the differences in plant height (cm) was significant when recorded at 105 DAS during 2023. Plant height in ridge sowing and flat sowing with single row was statistically at par among themselves. The paired row planting recorded significantly lower plant height as compared to ridge sowing but it was at par with flat sowing with single row. Among the weed control treatments, the plant height in pendimethalin pre-emergence, intercropping cowpea *fb* earthing & straw mulching was found to be statistically at par with intercropping *Sesbania fb* earthing up & straw mulching during 2023. Significantly more plant height was recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching as compared to two hand weedings. The unweeded (control) recorded significantly lower plant height as compared to other weed control treatments. During 2024, plant height (cm) in ridge sowing and flat sown with single row was statistically at par among

themselves (Table 4.2.1). The paired row planting recorded significantly lower plant height as compared to ridge sowing and single row flat sown crop and the latter methods were at par. Among weed control treatments, the plant height in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching, intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching was found to be statistically at par but were significantly better than two hand weeding treatment. Significantly less plant height was recorded in unweeded (control) as compared to all other weed control treatments during 2024.

During 2023 at harvest, plant height (cm) in ridge sowing was statistically at par with flat sowing with single row (Table 4.2.1). The paired row planting produced significantly less plant height as compared to other planting patterns. Among the weed control treatments, plant height in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching was found to be statistically at par with intercropping *Sesbania fb* earthing up & straw mulching during first year. Pendimethalin + atrazine pre-emergence *fb* straw mulching and intercropping *Sesbania fb* earthing up & straw mulching were also statistically at par with each other. Significantly more plant height was recorded in two hand weeding as compared to unweeded (control). Plant height was significantly less in unweeded (control) as compared to all other weed control treatments. During 2024, the plant height (cm) in ridge sowing and single row flat sowing was statistically at par (Table 4.2.1). The paired row planting produced significantly lower plant height as compared to other planting patterns. Among the weed control treatments, plant height in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching, intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching treatments were statistically at par among each other. The two hand weedings recorded significantly more plant height as compared to unweeded (control). The significantly lower plant height was recorded in unweeded (control) as compared to all other weed control treatments.

It can be concluded that plant height in ridge sowing (cm) was higher at all growth stages as compared to flat planting patterns. The improved plant height under the

ridge sowing might be due to improved soil physical conditions and less weed intensities. The plant height in intercropping and mulching treatments was also higher than other treatments due to suppression of weeds and availability of nutrients. The spraying of pre-emergence herbicides reduced weed competition and leguminous cover crops may have provided additional nutrition to crop which might have resulted in better crop growth as compared to unweeded (control) treatment. Ma *et al.* (2022) and Rahman *et al.* (2022) reported similar findings.

The interactive effect of planting patterns and weed control treatments on plant height remained non-significant at all growth stages during 2023 and 2024 (Table 4.2.1).

Table 4.2.1 Effect of planting patterns and weed control treatments on plant height (cm) at 45, 75, 105 DAS and at harvest

	Plant height (cm)							
	45 DAS		75 DAS		105 DAS		At harvest	
	2023	2024	2023	2024	2023	2024	2023	2024
Main plots (Planting patterns)								
Flat sowing with single row	53.9	56.6	163.1	160.7	172.6	181.5	179.0	183.1
Flat sowing with paired rows	51.4	54.3	158.4	155.4	169.9	172.3	174.1	172.8
Ridge sowing	55.6	56.0	164.2	163.8	175.9	183.0	181.2	184.4
SE(m) $\pm$	0.87	0.45	1.30	1.08	1.23	1.21	1.35	0.55
C.D. (5%)	3.07	1.60	4.59	3.82	4.33	4.26	4.76	1.95
Sub-plots (Weed control treatments)								
Pendi.+Atz., pre-em <i>fb</i> SM	55.0	57.6	168.0	164.3	178.3	185.3	183.7	185.9
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	56.1	60.3	173.9	167.4	181.8	188.0	187.6	188.8
Inter. <i>Sesbania fb</i> EU & SM	56.4	58.8	173.0	167.2	180.1	187.6	186.2	188.4
Two hand weedings (4 and 6 WAS)	53.5	56.2	158.0	163.5	171.4	177.3	177.1	179.3
Unweeded (control)	47.2	45.5	136.5	137.5	152.4	156.4	155.8	158.2
SE(m) $\pm$	0.66	0.74	1.06	1.19	1.17	1.26	0.99	1.22
C.D. (5%)	1.91	2.12	3.05	3.43	3.36	3.63	2.84	3.51
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS	NS	NS

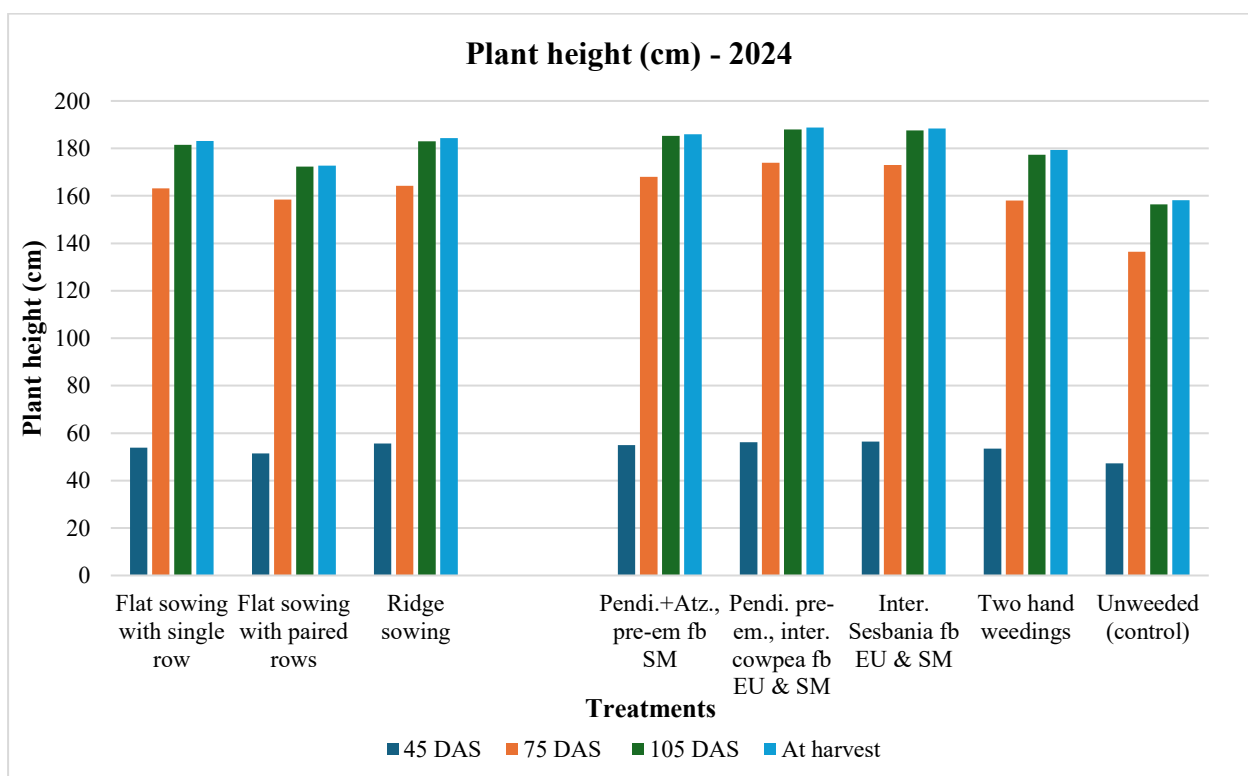
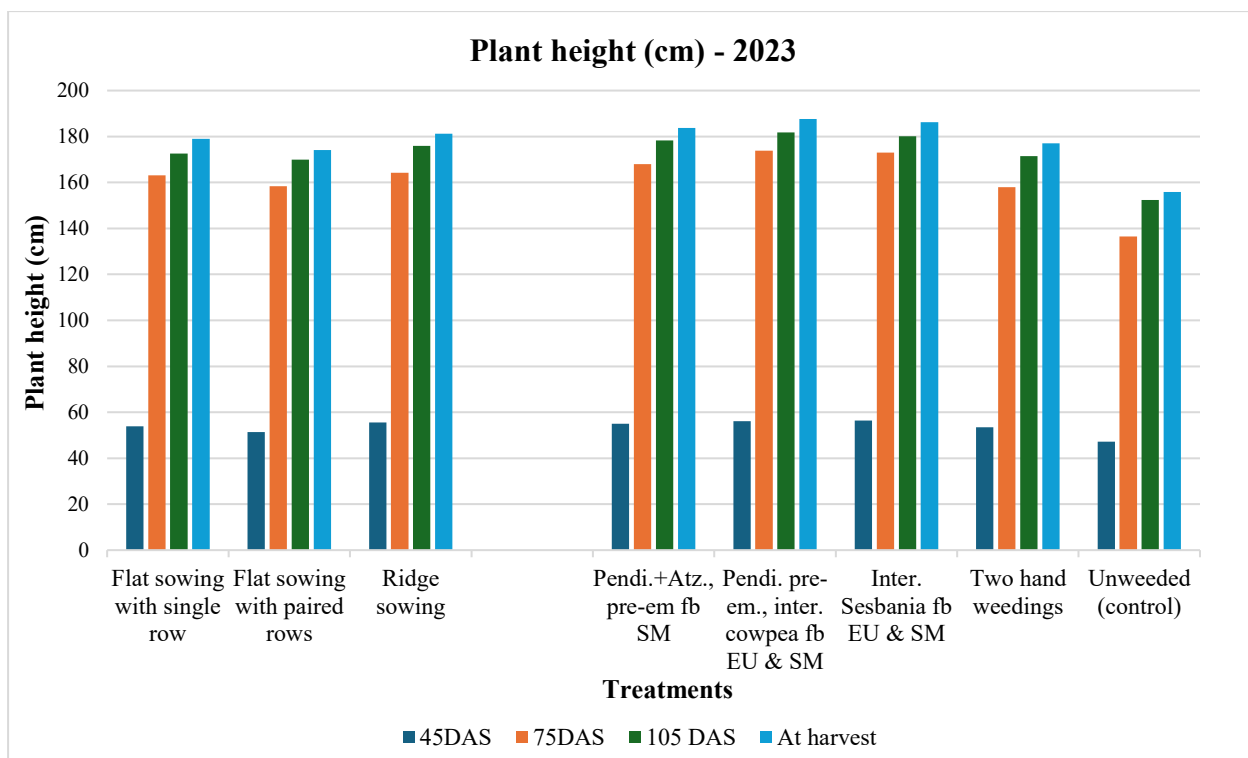


Figure 4.2.1 Effect of planting patterns and weed control treatments on plant height (cm) during 2023 and 2024

4.2.2 Plant dry weight (g plant⁻¹)

Plant dry weight indicates the dry matter accumulation of the plant. It gives reliable measure of actual biomass of crop that allows more accurate comparisons among different treatments. It also enables to assess crop growth and yield performance. The plant dry weight data recorded at 45, 75 and 105 DAS has been presented in Table 4.2.2 and Figure 4.2.2.

The differences in plant dry weight was significant among planting patterns at 45 DAS (Table 4.2.2). Plant dry weight in ridge sowing and single row flat sown was statistically at par during 2023. The significantly less plant dry weight was observed in the paired row and single row flat sowing methods as compared to ridge sowing. Among the weed control treatments, crop dry weight per plant was statistically at par among pendimethalin + atrazine pre-emergence *fb* straw mulching and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching during 2023. Plant dry weight (g plant⁻¹) in two hand weeding treatment was found to be statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. Significantly lower plant dry weight was recorded in unweeded (control) as compared to other weed control treatments. During 2024, plant dry weight was statistically at par among ridge sowing and flat sown single row crop and both these planting patterns recorded significantly more plant dry weight than paired row sowing (Table 4.2.2). Among weed control treatments, plant dry weight was statistically at par among intercropping *Sesbania fb* earthing up & straw mulching, pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and pendimethalin + atrazine, pre-emergence *fb* straw mulching during 2024. Pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding were found statistically at par among themselves. Significantly lower plant dry weight was recorded in unweeded (control) during 2024 than all other weed control treatments.

At 75 DAS, the plant dry weight was statistically at par in the ridge sowing and flat sowing with single row during 2023 (Table 4.2.2). Significantly lower plant dry weight was recorded in the paired row sowing as compared to other planting patterns. Among weed control treatments, plant dry weight recorded at 75 DAS in

pendimethalin, pre-emergence + intercropping cowpea *fb* earthing up & straw mulching was significantly higher than all other weed control treatments. Plant dry weight in intercropping *Sesbania fb* earthing up & straw mulching was significantly more than all weed control treatments except pendimethalin pre-emergence with intercropping cowpea *fb* earthing up & and straw mulching. Plant dry weight in pendimethalin + atrazine pre-emergence *fb* straw mulching was significantly less than both the intercropping treatments. Significantly less plant dry weight was recorded in two hand weeding treatment compared to all other treatments except unweeded (control). The plant dry weight was significantly lower in unweeded (control) as compared to all other weed control treatments. During 2024, plant dry weight per plant (g plant^{-1}) in ridge sowing and flat sown single row treatment was statistically at par (Table 4.2.2). The paired row sowing produced significantly lower plant dry weight as compared to other planting patterns. Among the weed control treatments, plant dry weight in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching, intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching treatments were statistically at par. The two hand weedings recorded significantly more plant dry weight as compared to unweeded (control). Significantly lower plant dry weight was observed in unweeded (control) as compared to all other weed control treatments.

The data presented in Table 4.2.2 indicated that the differences in plant dry weight were significant when recorded at 105 DAS during 2023. Plant dry weight in ridge sowing and flat sowing with single row was statistically at par among themselves. The paired row planting recorded significantly lower plant dry weight as compared to other planting patterns. Among the weed control treatments, the plant dry weight in pendimethalin pre-emergence, intercropping cowpea *fb* earthing-up & straw mulching was statistically at par with intercropping *Sesbania fb* earthing-up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching treatments. Significantly more plant dry weight was recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments as compared to unweeded (control). The unweeded (control) recorded significantly lower plant dry weight as compared to other weed control treatments. During 2024, plant dry weight

in ridge sowing and flat sown with single row was statistically at par among themselves (Table 4.2.2). The paired row planting recorded significantly less plant dry weight as compared to other planting patterns at 105 DAS. Among weed control treatments, the plant dry weight in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was found at par. Plant dry weight recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching was significantly more than two hand weeding treatment. Significantly lower plant dry weight was recorded in unweeded (control) as compared to all other weed control treatments.

It can be concluded that dry weight per plant in ridge sowing was significantly higher at all growth stages as compared to other planting patterns. The improved crop weight under the ridge sowing might be due to better soil physical conditions, crop growth and less weed intensities (Ma *et al.*, 2022). The crop dry weight in intercropping and mulching treatments was also better than other treatments due to availability of nutrients. The spraying of pre-emergence herbicides reduced the weed competition and leguminous cover crops may have provided additional nutrition to crop which might have resulted in better crop growth leading to higher dry matter accumulation (Rahman *et al.*, 2022).

The interactive effect of planting patterns and weed control treatments on plant dry weight remained non-significant at all growth stages during 2023 and 2024 (Table 4.2.2).

Table 4.2.2. Effect of planting patterns and weed control treatments on plant dry weight (g plant⁻¹) at 45, 75 and 105 DAS

	Plant dry weight (g plant ⁻¹)					
	45 DAS		75 DAS		105 DAS	
	2023	2024	2023	2024	2023	2024
Main plots (Planting patterns)						
Flat sowing with single row	59.8	47.5	155.1	144.2	257.9	290.4
Flat sowing with paired rows	55.8	44.9	143.6	131.5	238.1	268.7
Ridge sowing	62.2	48.3	156.4	146.2	261.9	298.2
SE(m) ±	1.02	0.71	1.98	3.35	5.04	5.32
C.D. (5%)	3.59	2.52	6.99	11.83	17.77	18.76
Sub-plots (Weed control treatments)						
Pendi.+Atz., pre-em <i>fb</i> SM	62.9	50.6	154.4	149.3	261.2	303.6
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	60.5	52.4	174.2	153.7	281.3	321.0
Inter. <i>Sesbania fb</i> EU & SM	58.4	52.2	162.7	150.8	272.4	321.8
Two hand weedings (4 and 6 WAS)	57.2	46.3	144.3	139.6	252.0	291.2
Unweeded (control)	51.1	32.8	122.9	109.6	196.1	191.2
SE(m) ±	1.09	2.02	2.86	3.14	7.20	3.74
C.D. (5%)	3.14	5.83	8.25	9.05	20.72	10.77
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

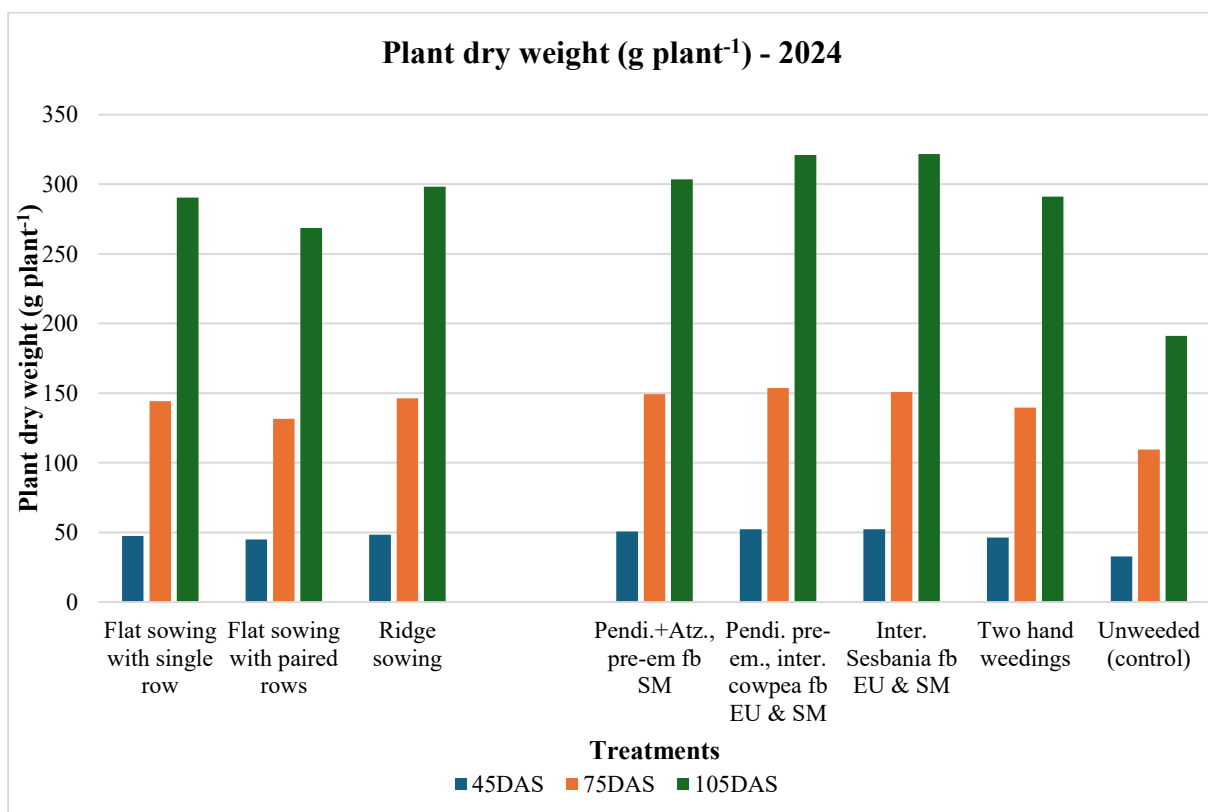
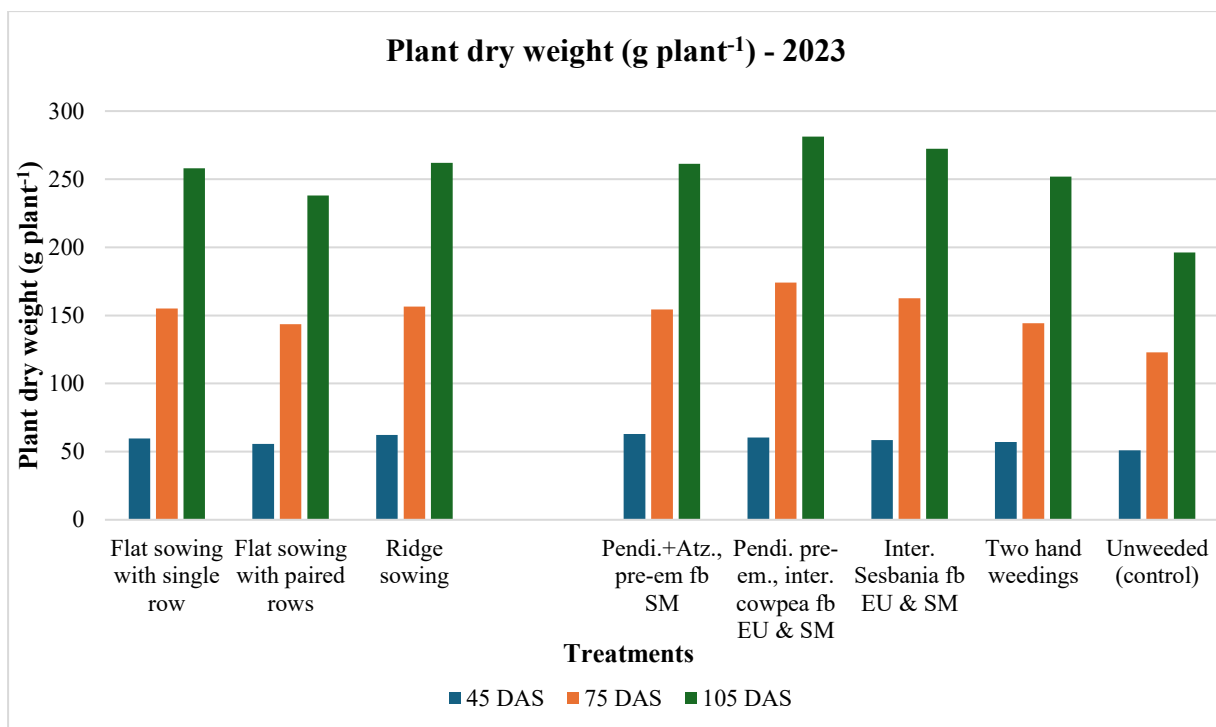


Figure 4.2.2 Effect of planting patterns and weed control treatments on plant dry weight (g plant⁻¹) during 2023 and 2024

4.2.3 Number of leaves per plant

The number of leaves per plant are also important as photosynthesis is performed by leaves which determines the food production potential of a crop. Data on periodic number of leaves observed at 45, 75, 105 DAS and at harvest during 2023 and 2024 has been presented in Table 4.2.3 and graphically depicted in Figure 4.2.3.

The differences in number of leaves per plant when recorded at 45 DAS during 2023 were found to be non-significant among various planting patterns (Table 4.2.3). Among the weed control treatments, number of leaves per plant in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching were statistically at par with intercropping *Sesbania fb* earthing up & straw mulching, pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments. The significantly lower number of leaves per plant were recorded in unweeded (control) as compared to all other planting patterns. Similar results were also obtained during 2024.

At 75 DAS, number of leaves per plant remained non-significant among various planting patterns during 2023 (Table 4.2.3). Among weed control treatments, number of leaves per plant in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching were at par. Number of leaves per plant in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings were also statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. Significantly lower number of leaves were recorded in unweeded (control) as compared to all other weed control treatments. During 2024, differences in number of leaves recorded at 75 DAS among planting patterns remained non-significant (Table 4.2.3). Among the weed control treatments, number of leaves per plant in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching, intercropping *Sesbania fb* earthing up & straw mulching, pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding were statistically at par among themselves. Number of leaves per plant were significantly lower in unweeded (control) as compared to all the other weed control treatments during second year.

The data recorded at 105 DAS presented in Table 4.2.3 indicated that the number of leaves per plant remained non-significant among the various planting patterns during 2023. Among weed control treatments, the number of leaves per plant in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching were found to be statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. The number of leaves in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding were statistically at par among themselves. Significantly lower number of leaves per plant were recorded in unweeded (control) as compared to all other weed control treatments. During 2024, number of leaves per plant when recorded at 105 DAS remained non-significant among the various planting patterns (Table 4.2.3). Among the weed control treatments, the number of leaves per plant in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching were statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. The number of leaves per plant were significantly more in pendimethalin + atrazine pre-emergence *fb* straw mulching as compared to two hand weedings. The significantly lower number leaves were recorded in unweeded (control) as compared to other weed control treatments during second year.

The effect of planting patterns on number of leaves per plant remained non-significant at harvest during 2023 (Table 4.2.3). Among the weed control treatments, the number of leaves per plant in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching were found to be statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. The number of leaves in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings were statistically at par among themselves. Significantly lower number of leaves per plant were recorded in unweeded (control) as compared to all other weed control treatments. During 2024, differences in number of leaves per plant were non- significant among the various planting patterns (Table 4.2.3). Among the weed control treatments, the number of leaves per plant remained significantly higher in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching. The number of leaves per plant in pendimethalin + atrazine pre-emergence *fb* straw mulching were significantly more than two hand

weeding. Significantly lower number of leaves per plant were observed in unweeded (control) as compared to all other weed control treatments at harvest during 2024.

Periodic count of number of leaves per plant were not influenced by planting patterns. Improved number of leaves under intercropping and earthing up treatments might be due to better physical conditions of soil and suppression of weeds by surface cover due to live mulching and earthing up and hence better crop growth (Rout *et al.*, 2022) and Shashikanth *et al.*, 2022).

The interactive effect of planting patterns and weed control treatments on number of leaves per plant remained non-significant at all growth stages during 2023 and 2024 (Table 4.2.3).

Table 4.2.3. Number of leaves per plant at 45, 75, 105 DAS and at harvest as influenced by planting patterns and weed control treatments

	Number of leaves per plant							
	45 DAS		75 DAS		105 DAS		At harvest	
	2023	2024	2023	2024	2023	2024	2023	2024
Main plots (Planting patterns)								
Flat sowing with single row	7.73	7.17	12.2	11.8	12.7	12.6	3.63	3.29
Flat sowing with paired rows	7.79	7.03	12.0	11.4	12.5	11.9	3.58	3.05
Ridge sowing	7.97	7.33	12.3	11.9	12.8	12.6	3.66	3.32
SE(m) $\pm$	0.10	0.09	0.24	0.14	0.07	0.18	0.02	0.07
C.D. (5%)	NS	NS	NS	NS	NS	NS	NS	NS
Sub-plots (Weed control treatments)								
Pendi.+Atz., pre-em <i>fb</i> SM	7.93	7.27	12.3	12.0	12.8	12.6	3.65	3.27
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	8.07	7.47	12.9	12.2	13.6	13.2	3.88	3.43
Inter. <i>Sesbania fb</i> EU & SM	8.05	7.52	12.6	12.2	13.3	13.1	3.78	3.43
Two hand weedings (4 and 6 WAS)	7.83	7.25	12.2	11.9	12.5	12.1	3.58	3.17
Unweeded (control)	7.25	6.43	10.7	10.3	11.3	10.8	3.23	2.80
SE(m) $\pm$	0.15	0.12	0.17	0.13	0.12	0.11	0.04	0.03
C.D. (5%)	0.43	0.34	0.49	0.36	0.35	0.31	0.11	0.09
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS	NS	NS

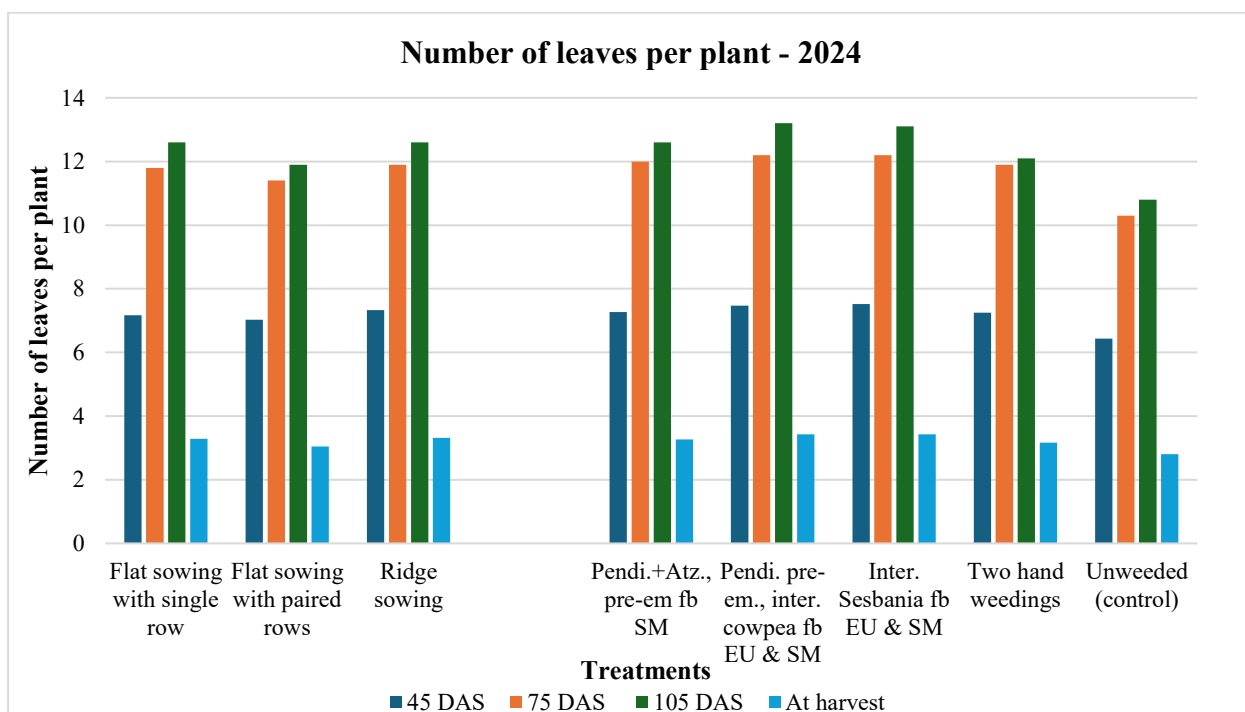
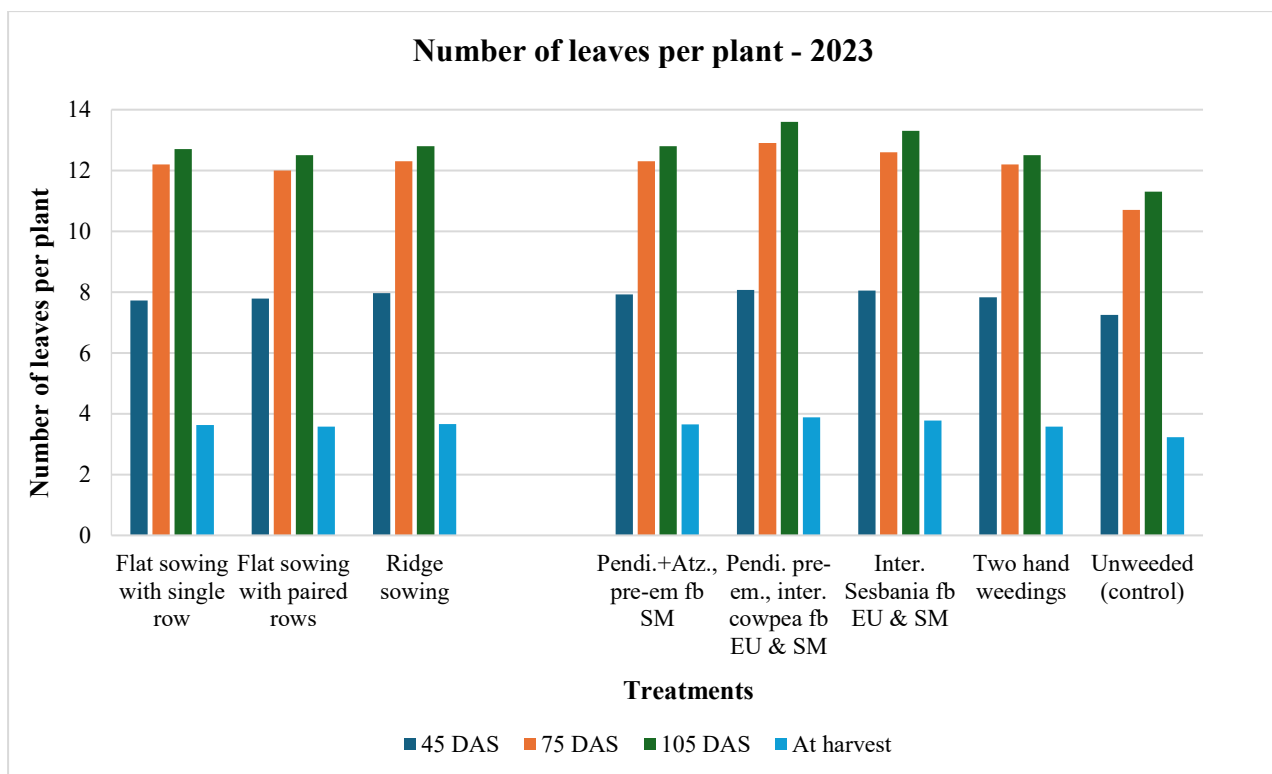


Figure 4.2.3 Effect of planting patterns and weed control treatments on number of leaves per plant during 2023 and 2024

4.2.4 Number of nodes per plant

A node on a plant stem is the structure that connects the petiole to the stem. The plant leaves in maize originate from nodes itself. It becomes an important parameter to record number of nodes per plant. The data on periodic number of nodes per plant at 45, 75 DAS and at harvest has been presented in Table 4.2.4.

At 45 DAS, the differences in number of nodes per plant due to various planting patterns remained non-significant during 2023 (Table 4.2.4). Among the weed control treatments, number of nodes per plant in intercropping *Sesbania fb* earthing up & straw mulching was statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching, pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments. Significantly lower number of nodes per plant were observed in unweeded (control) as compared to all other weed control treatments. During 2024, the number of nodes per plant were non-significant in various planting patterns when recorded at 45 DAS. Among the weed control treatments, number of nodes per plant in intercropping *Sesbania fb* earthing up & straw mulching, pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and two hand weedings were statistically at par among each other. Number of nodes per plant in pendimethalin + atrazine pre-emergence *fb* straw mulching were statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and two hand weeding treatments. Significantly less number of nodes per plant were recorded in unweeded (control) as compared to all other weed control treatments.

The number of nodes per plant at 75 DAS also remained non-significant among various planting patterns during 2023 (Table 4.2.4). Among the weed control treatments, number of nodes per plant in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching were found to be statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. The number of nodes per plant in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings were statistically at par among themselves. Number of nodes were significantly lower in unweeded (control) as compared to all the other weed control

treatments. During 2024, the differences in number of nodes per plant were non-significant among various planting patterns (Table 4.2.4). Among weed control treatments, number of nodes per plant at 75 DAS in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching, intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching were statistically at par among each other. Number of nodes per plant in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings were statistically at par among themselves. Significantly lower number of nodes per plant were recorded in unweeded (control) as compared to other weed control treatments.

At harvest during 2023, number of nodes per plant remained non-significant among the various planting patterns (Table 4.2.4). Among weed control treatments, number of nodes per plant in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching were statistically at par. Number of nodes per plant in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings were statistically at par among themselves. Significantly lower number of nodes per plant were recorded in unweeded (control) as compared to all other weed control treatments. During 2024, number of nodes per plant remained non-significant among various planting patterns (Table 4.2.4). Among weed control treatments, number of nodes per plant in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching were found at par with intercropping *Sesbania fb* earthing up & straw mulching. Number of nodes per plant in pendimethalin + atrazine pre-emergence *fb* straw mulching were statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. The number of nodes per plant at harvest were significantly less in two hand weeding as compared to all other treatments except unweeded (control). Significantly lower number of nodes per plant were recorded in unweeded (control) as compared to all other weed control treatments.

Number of nodes in the treatments of intercropping, mulching and herbicide spray were more than two hand weedings and control as green manuring provided additional nutrition during its growth as well as after incorporation in the field which

may have resulted in higher number of nodes in green manuring treatments. Also crop growth was better in earthing up and straw mulching treatments which led to more number of nodes per plant in these treatments (Rahman *et al.*, 2022).

The interactive effect of planting patterns and weed control treatments on number of nodes per plant remained non-significant at all growth stages during 2023 and 2024 (Table 4.2.4).

Table 4.2.4. Number of nodes per plant at 45, 75 DAS and at harvest as influenced by planting patterns and weed control treatments

	Number of nodes per plant					
	45 DAS		75 DAS		At harvest	
	2023	2024	2023	2024	2023	2024
Main plots (Planting patterns)						
Flat sowing with single row	7.77	7.22	12.2	11.9	13.6	12.6
Flat sowing with paired rows	7.85	7.08	12.0	11.5	13.3	12.0
Ridge sowing	8.00	7.38	12.3	12.0	13.6	12.6
SE(m) $\pm$	0.09	0.09	0.20	0.13	0.08	0.16
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (Weed control treatments)						
Pendi.+Atz., pre-em <i>fb</i> SM	7.97	7.27	12.3	12.1	13.6	12.7
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	8.11	7.52	13.0	12.3	14.4	13.2
Inter. <i>Sesbania fb</i> EU & SM	8.12	7.57	12.7	12.3	14.1	13.0
Two hand weedings (4 and 6 WAS)	7.88	7.30	12.2	11.9	13.3	12.1
Unweeded (control)	7.28	6.48	10.7	10.3	12.0	10.8
SE(m) $\pm$	0.14	0.10	0.16	0.12	0.11	0.11
C.D. (5%)	0.39	0.29	0.45	0.35	0.33	0.33
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

4.2.5 Stem girth (mm)

The strength of the crop lies in the diameter of the stem and it can also be indicative of the plant health and strength. The data on periodic stem girth (mm) at 75, 105 DAS and at harvest has been presented in Table 4.2.5.

The differences in stem girth (mm) among planting patterns was significant when recorded at 75 DAS during 2023 and the data revealed that stem girth in ridge sowing was statistically at par with single row flat sown crop (Table 4.2.5). The significantly lower stem girth was recorded in paired row planting as compared to other planting patterns. Among weed control treatments, stem girth in intercropping *Sesbania fb* earthing up & straw mulching was found to be statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing-up & straw mulching, pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments. Unweeded (control) recorded significantly lower stem girth as compared to all other weed control treatments. During 2024, stem girth of maize plant in ridge sowing was statistically at par with flat sown single row (Table 4.2.5). Paired row planting recorded significantly lower stem girth as compared to other planting patterns. Among the weed control treatments, stem girth in intercropping *Sesbania fb* earthing up & straw mulching was found to be statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. Stem girth in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments were statistically at par among themselves. Significantly lower stem girth was recorded in unweeded (control) as compared to all other weed control treatments.

At 105 DAS, the stem girth in the ridge sowing was statistically at par with flat sown single row planting pattern during 2023 (Table 4.2.5). The paired row planting produced significantly less stem girth as compared to ridge sowing. Among the weed control treatments, stem girth in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching was statistically at par with intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching (Table 4.2.5). Stem girth in two hand weedings was found to be statistically at par with pendimethalin + atrazine pre-emergence *fb* straw mulching. Significantly

lower stem girth was recorded in unweeded (control) as compared to all other weed control treatments. During 2024, stem girth in ridge sowing and flat sown single row method was statistically at par (Table 4.2.5). The paired row planting recorded significantly lower stem girth as compared to all other planting patterns. Among the weed control treatments, stem girth in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching, intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching was statistically at par among themselves. The two hand weeding recorded significantly more stem girth as compared to unweeded (control). Significantly lower stem girth was recorded in unweeded (control) as compared to all the other weed control treatments.

At harvest during 2023, the stem girth (mm) recorded in ridge sowing and flat sown single row crop was found to be statistically at par. However, paired row planting recorded significantly lower stem girth as compared to other planting patterns. Among the weed control treatments, the stem girth in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching was found to be statistically at par with intercropping of *Sesbania fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching during 2023. Two hand weeding treatment recorded significantly more stem girth as compared to unweeded (control). Unweeded (control) recorded significantly lower stem girth as compared to all other weed control treatments. During 2024, ridge sowing and flat sown single row were statistically at par (Table 4.2.5). Significantly lower stem girth was recorded in paired row sowing as compared to all other planting patterns. Among the weed control treatments, stem girth in intercropping *Sesbania fb* earthing up & straw mulching was found to be at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. Significantly more stem girth was recorded in pendimethalin + atrazine *fb* straw mulching as compared to two hand weeding treatment. The stem girth was significantly lower in unweeded (control) as compared to all the other weed control treatments.

Better physical conditions under ridge sowing may have resulted in higher stem girth under the ridge sowing (Khan *et al.*, 2022). The treatments in which spray of pre-

emergence herbicides was followed by straw mulching or earthing up or both reduced the crop weed competition which may have resulted in higher stem girth (Bakht *et al.*, 2011).

The interactive effect of planting patterns and weed control treatments on stem girth of maize plant remained non-significant at all growth stages during 2023 and 2024 (Table 4.2.5).

Table 4.2.5. Effect of planting patterns and weed control treatments on stem girth (mm) at 75, 105 DAS and at harvest

	Stem girth (mm)					
	75 DAS		105 DAS		At harvest	
	2023	2024	2023	2024	2023	2024
Main plots (Planting patterns)						
Flat sowing with single row	14.7	14.6	15.9	15.7	15.7	14.9
Flat sowing with paired rows	13.9	14.0	15.3	15.0	14.9	14.4
Ridge sowing	14.7	14.8	16.2	15.8	15.9	15.1
SE(m) $\pm$	0.16	0.14	0.18	0.14	0.20	0.12
C.D. (5%)	0.55	0.48	0.63	0.49	0.71	0.44
Sub-plots (Weed control treatments)						
Pendi.+Atz., pre-em <i>fb</i> SM	15.0	14.7	16.2	16.1	15.9	15.2
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	15.0	15.4	16.6	16.5	16.3	15.7
Inter. <i>Sesbania fb</i> EU & SM	15.0	15.5	16.5	16.5	16.2	15.9
Two hand weedings (4 and 6 WAS)	14.6	14.4	15.8	15.1	15.5	14.4
Unweeded (control)	12.6	12.2	14.0	13.2	13.6	12.7
SE(m) $\pm$	0.15	0.20	0.15	0.21	0.14	0.14
C.D. (5%)	0.42	0.57	0.43	0.62	0.40	0.40
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

4.2.6 Internodal length (cm)

Internodal length (cm) is related with the plant height as increase in internode length can lead to more plant height. It also determines the distance among the leaves. The data on effect of planting patterns and weed control treatments on internodal length (cm) at 75, 105 DAS and at harvest has been presented in Table 4.2.6.

At 75 DAS, the differences in internodal length was non-significant among the various planting patterns during 2023 (Table 4.2.6). Among the weed control treatments, the internodal length at 75 DAS in pendimethalin + atrazine pre-emergence *fb* straw mulching was statistically at par with intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and all these treatments recorded significantly more internodal length than two hand weeding treatment. The significantly lower internodal length was recorded in unweeded (control) as compared to all other weed control treatments. During 2024, internodal length among various planting patterns at 75 DAS was non-significant (Table 4.2.6). Among the weed control treatments, internodal length in intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching were found at par. Internodal length in pendimethalin + atrazine *fb* straw mulching and two hand weeding treatments were statistically at par among themselves. Significantly lower internodal length was observed in unweeded (control) as compared to all other weed control treatments.

At 105 DAS, internodal length remained non-significant among various planting patterns during 2023 (Table 4.2.6). Among the weed control treatments, internodal length in intercropping *Sesbania fb* earthing up & straw mulching, pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching was found to be statistically at par. Two hand weedings recorded significantly less internodal length than all straw mulching treatments. Significantly lower internodal length recorded in unweeded (control) as compared to all other weed control treatments. During 2024, the differences in internodal length among planting patterns was non-significant (Table 4.2.6). Among

the weed control treatments, internodal length in intercropping *Sesbania fb* earthing up & straw mulching was statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching treatment. Internodal length in pendimethalin + atrazine pre-emergence *fb* straw mulching was statistically at par with two hand weeding treatment. Significantly lower internodal length was recorded in unweeded (control) as compared to other weed control treatments.

At harvest, the internodal length was non-significant among the various planting patterns during 2023 (Table 4.2.6). Among the weed control treatments, the internodal length in intercropping *Sesbania fb* earthing up & straw mulching was found to be statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and pendimethalin + atrazine *fb* straw mulching. During 2024, internodal length was found to be non-significant among various planting patterns (Table 4.2.6). Among the weed control treatments, internodal length in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching were found to be statistically at par. The internodal length in two hand weeding treatment and pendimethalin + atrazine pre-emergence *fb* straw mulching was statistically at par among themselves. Significantly lower internodal length was recorded in unweeded (control) as compared to all to other weed control treatments at harvest.

Overall better internodal length under intercropping treatments may be because of leguminous green manuring crops which provides additional nutrient to the main crop which may have improved the internodal length (Begam *et al.*, 2024). Even, earthing up improves the root aeration providing better root anchorage which may act positively on the crop growth (Sakadzo *et al.*, 2019).

The interactive effect of planting patterns and weed control treatments for internodal length remained non-significant at all growth stages during both 2023 and 2024 (Table 4.2.6).

Table 4.2.6 Effect of planting patterns and weed control treatments on internodal length (cm) at 75, 105 DAS and at harvest

	Internodal length (cm)					
	75 DAS		105 DAS		At harvest	
	2023	2024	2023	2024	2023	2024
Main plots (Planting patterns)						
Flat sowing with single row	9.53	10.24	9.94	10.52	10.18	11.03
Flat sowing with paired rows	9.27	9.91	9.70	10.10	9.90	10.57
Ridge sowing	9.53	10.23	9.91	10.53	10.19	10.99
SE(m) $\pm$	0.26	0.10	0.20	0.10	0.18	0.12
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (Weed control treatments)						
Pendi.+Atz., pre-em <i>fb</i> SM	10.13	10.24	10.23	10.41	10.50	10.94
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	9.75	10.76	10.33	11.14	10.59	11.60
Inter. <i>Sesbania fb</i> EU & SM	9.88	10.88	10.35	11.16	10.61	11.59
Two hand weedings (4 and 6 WAS)	9.31	10.20	9.68	10.6	9.85	11.03
Unweeded (control)	8.14	8.56	8.64	8.63	8.89	9.16
SE(m) $\pm$	0.15	0.10	0.13	0.11	0.12	0.15
C.D. (5%)	0.44	0.29	0.38	0.31	0.35	0.43
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

4.2.7 Chlorophyll index (SPAD value)

Chlorophyll index gives the indication about the health of the plant as it provides the estimate of nitrogen sufficiency or deficiency in the crop plant which impacts growth and productivity of the crop. The data on impact of planting patterns and weed control treatments on chlorophyll index recorded at 45, 75 and 105 DAS has been presented in Table 4.2.7.

At 45 DAS, the effect of planting patterns on chlorophyll index was non-significant during 2023 (Table 4.2.7). Among the weed control treatments, the chlorophyll index was significantly higher in pendimethalin + atrazine pre-emergence *fb* straw mulching than all other weed control treatments. Chlorophyll index in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching, intercropping *Sesbania fb* earthing up & straw mulching and two hand weeding treatments were statistically at par with each other. Significantly lower chlorophyll index was recorded in unweeded (control) as compared to all other weed control treatments. During 2024, chlorophyll index was found to be non-significant among the various planting patterns (Table 4.2.7). Among the weed control treatments, chlorophyll index in pendimethalin + atrazine pre-emergence *fb* straw mulching was statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching (Table 4.2.7). Significantly more chlorophyll index was recorded in intercropping *Sesbania fb* earthing up & straw mulching as compared to two hand weedings. Unweeded (control) recorded significantly lower chlorophyll index as compared to all the other weed control treatments.

At 75 DAS, chlorophyll index remained non-significant among various planting patterns during 2023 (Table 4.2.7). Among the weed control treatments, chlorophyll index in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching was found to be statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. Chlorophyll index in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatment was statistically at par among themselves. Significantly lower chlorophyll index was recorded in unweeded (control) as compared to all other weed control treatments. During 2024, among various

planting patterns, chlorophyll index was found to be non-significant (Table 4.2.7). Among the weed control treatments, chlorophyll index in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was found to be statistically at par with each other. Also, chlorophyll index in pendimethalin + atrazine pre-emergence *fb* straw mulching was statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. Two hand weeding recorded significantly less chlorophyll index as compared to all other weed control treatments except unweeded (control). Chlorophyll index was significantly lower in unweeded (control) as compared to all other weed control treatments.

At harvest, the effect of planting patterns on chlorophyll index was non-significant during 2023 (Table 4.2.7). Among the weed control treatments, the chlorophyll index in intercropping *Sesbania fb* earthing up & straw mulching was found to be statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching. Chlorophyll index in two hand weeding treatment was significantly more as compared to unweeded (control). Significantly lower chlorophyll index was recorded in unweeded (control) as compared to all other weed control treatments. During 2024, chlorophyll index was non-significant among the various planting patterns (Table 4.2.7). Among the weed control treatments, chlorophyll index in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching was statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. Pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings were statistically at par with each other. Chlorophyll index was significantly lower in unweeded (control) as compared to all other weed control treatments.

The better soil nutrition was provided by green manures and reduction in the weed competition may have resulted in improved nutrient absorption leading to higher chlorophyll index. Uprooting and burying of weeds while earthing up may have also resulted in better crop growth and reduced nutrient losses (Zamir *et al.*, 2012 and Zhang *et al.*, 2015).

The interactive effect of planting methods and weed control measures on chlorophyll index remained non-significant throughout crop growth during 2023 and 2024 (Table 4.2.7).

Table 4.2.7 Chlorophyll index at 45, 75 and 105 DAS as influenced by planting patterns and weed control treatments

	Chlorophyll index (SPAD value)					
	45 DAS		75 DAS		105 DAS	
	2023	2024	2023	2024	2023	2024
Main plots (Planting patterns)						
Flat sowing with single row	46.5	48.5	51.6	49.7	51.4	48.4
Flat sowing with paired rows	48.5	46.9	50.9	46.5	49.9	44.7
Ridge sowing	48.1	48.3	52.2	49.6	50.6	48.6
SE(m) $\pm$	1.01	0.39	0.61	0.80	0.77	0.99
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (Weed control treatments)						
Pendi.+Atz., pre-em <i>fb</i> SM	52.5	51.4	52.2	50.0	52.7	47.4
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	48.3	50.8	54.8	51.8	53.9	51.2
Inter. <i>Sesbania fb</i> EU & SM	47.5	49.3	54.4	51.3	54.1	50.8
Two hand weedings (4 and 6 WAS)	46.9	47.8	52.1	48.4	52.0	47.2
Unweeded (control)	44.3	40.0	44.1	41.5	40.6	39.5
SE(m) $\pm$	0.99	0.35	0.53	0.48	0.73	0.60
C.D. (5%)	2.86	1.01	1.55	1.39	2.09	1.74
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

4.3 Yield and yield attributes

4.3.1 Number of cobs per plant, cob length (cm) and cob girth (mm)

Number of cobs per plant adds to the grain yield. Number of seeds per row depends on the length of the cob and cob girth which are important yield attributes. The data on effect of planting patterns and weed control treatments on number of cobs per plant, cob length (cm) and cob girth (mm) during 2023 and 2024 has been presented in Table 4.3.1 and depicted in Figure 4.3.1.

The number of cobs per plant were non- significant among the various planting patterns during 2023 (Table 4.3.1). Among the weed control treatments, number of cobs per plant in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching were significantly higher than other weed control treatments. Also, pendimethalin + atrazine pre-emergence *fb* straw mulching was statistically at par with two hand weeding treatment. Significantly less number of cobs per plant were recorded in unweeded (control) as compared to pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching. During 2024, the differences in number of cobs per plant were non-significant among various planting patterns (Table 4.3.1). Among the weed control treatments, number of cobs per plant were statistically at par among pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching treatments. Also, pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings were found at par. Significantly less number of cobs per plant were recorded in unweeded (control) as compared to all other treatments.

The differences in cob length (cm) was found to be significant among planting patterns and weed control treatments during 2023 and 2024 (Table 4.3.1). Among the planting patterns, cob length in ridge sowing was statistically at par with flat sown single row crop during 2023. The paired row planting produced significantly lower cob length as compared to other planting patterns. Among the weed control treatments, cob length in intercropping *Sesbania fb* earthing up & straw mulching was

found to be statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. Significantly less cob length was recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments as compared to earthing up and straw mulching treatments. Cob length was significantly lower in unweeded (control) as compared to all other weed control treatments during 2023. The findings hold good for both years.

The differences in cob girth (mm) was found to be significant during 2023 (Table 4.3.1). Among the planting patterns, cob girth in ridge sowing was found to be statistical at par with single row flat sown method. However, paired row planting recorded significantly lower cob girth as compared to other planting patterns. Among weed control measures, cob girth in intercropping *Sesbania fb* earthing-up & straw mulching was statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing-up & straw mulching. Significantly more cob girth was recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching than two hand weeding treatment. Cob girth was significantly lower in unweeded (control) in comparison to other weed control methods. The findings hold good for both years.

The yield attributes *viz.* number of cobs per plant, cob length and cob girth were better under ridge sowing and intercropping + mulching treatments. The improved soil aeration under ridge sowing and weed suppression in intercropping and earthing up treatments resulted in enhanced crop growth which may lead to better yield attributes (Tao *et al.*, 2015). Straw mulching improves the water holding capacity and reduce the weed competition (Deng *et al.*, 2019).

The interactive effect of planting patterns and weed control treatments for number of cobs per plant, cob length (cm) and cob girth (mm) were found to be non-significant during 2023 and 2024 (Table 4.3.1).

Table 4.3.1. Effect of planting patterns and weed control treatments on number of cobs per plant, cob length (cm) and cob girth (mm)

	No. of cobs per plant		Cob length (cm)		Cob girth (mm)	
	2023	2024	2023	2024	2023	2024
Main plots (Planting patterns)						
Flat sowing with single row	1.04	1.03	15.7	16.3	43.4	43.4
Flat sowing with paired rows	1.03	1.02	15.2	15.9	42.2	42.6
Ridge sowing	1.05	1.04	15.9	16.5	43.6	43.7
SE(m) $\pm$	0.01	0.01	0.14	0.12	0.26	0.22
C.D. (5%)	NS	NS	0.49	0.42	0.90	0.76
Sub-plots (Weed control treatments)						
Pendi.+Atz., pre-em <i>fb</i> SM	1.03	1.03	15.4	16.2	43.6	43.8
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	1.08	1.06	16.2	16.9	44.1	44.2
Inter. <i>Sesbania fb</i> EU & SM	1.08	1.05	16.4	17.0	44.7	45.0
Two hand weedings (4 and 6 WAS)	1.02	1.03	15.3	16.1	42.1	42.2
Unweeded (control)	1.00	1.00	14.6	15.0	40.9	40.9
SE(m) $\pm$	0.01	0.01	0.20	0.16	0.31	0.38
C.D. (5%)	0.04	0.05	0.57	0.46	0.88	1.09
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

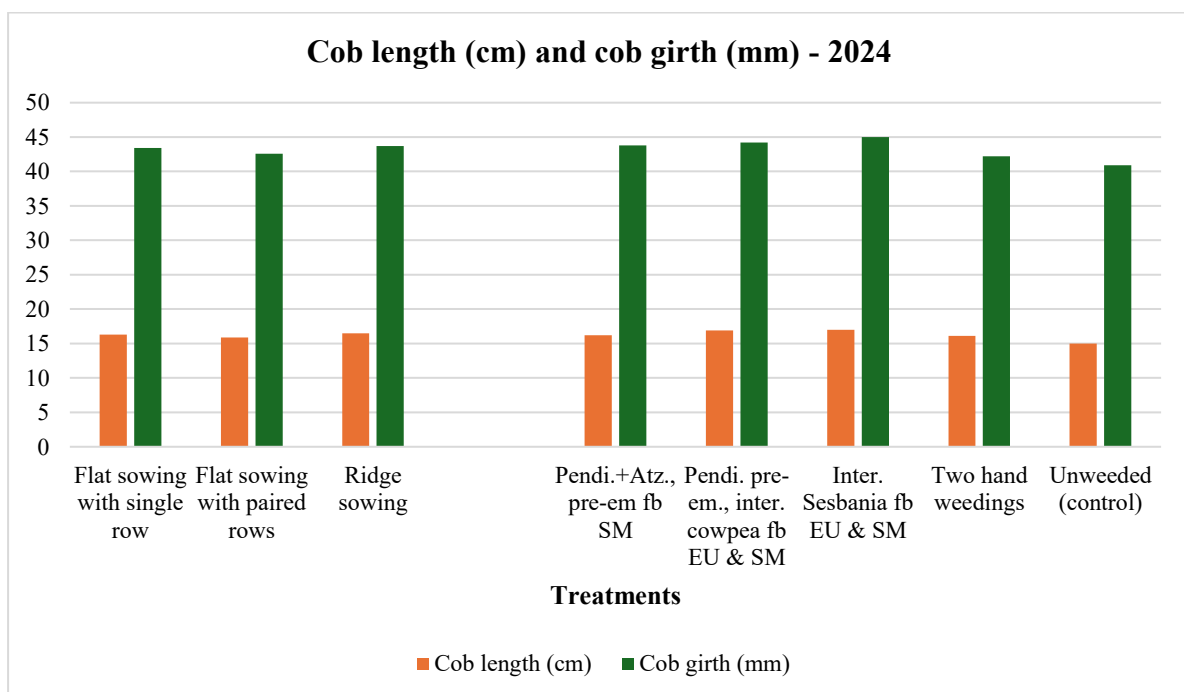
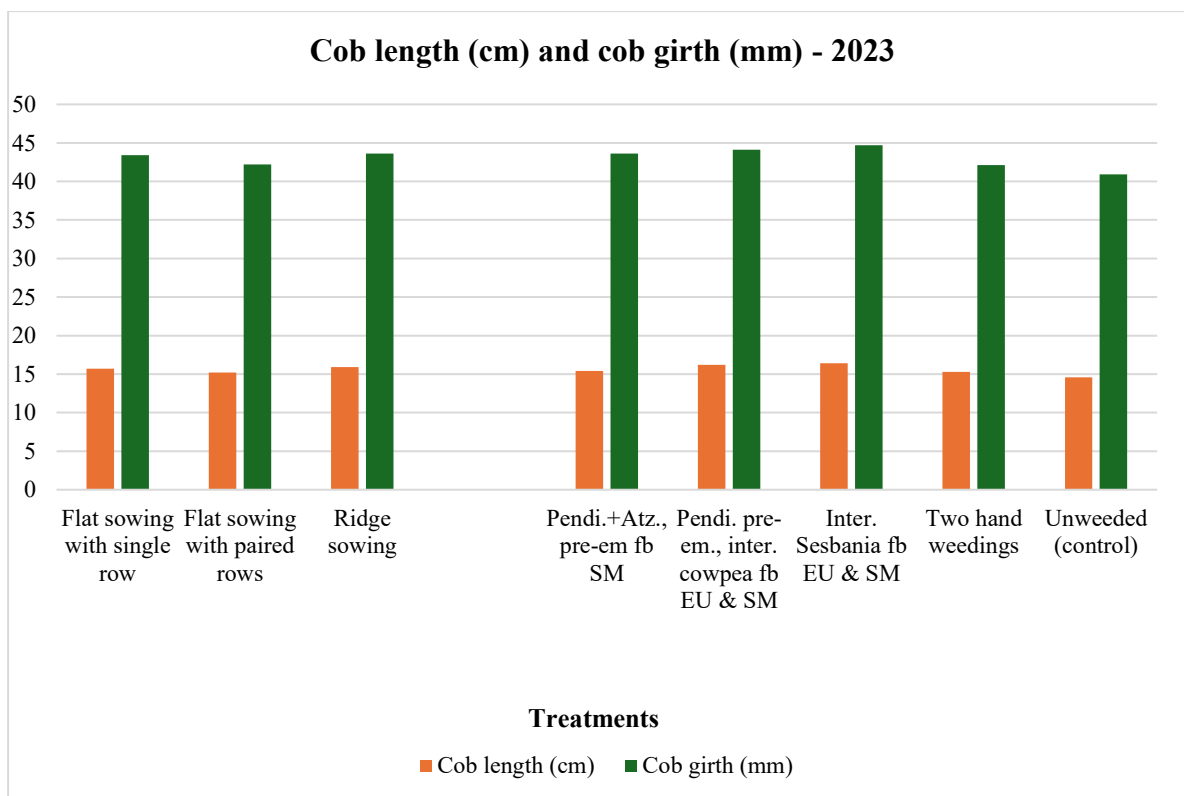


Figure 4.3.1 Effect of planting patterns and weed control treatment on cob length (cm) and cob girth (mm) during 2023 and 2024

4.3.2 Number of rows / cob, number of grains / cob and 1000 grain weight (g)

The yield characteristics, such as the number of rows per cob, the number of grains per cob, and the weight of 1000 seeds, contribute to the crop's grain output. Test weight serves as a metric for overall grain quality. The data about the impact of planting patterns and weed control methods on the number of rows per cob, the number of grains per cob, and the 1000 seed weight for 2023 and 2024 is reported in Table 4.3.2 and shown in Figure 4.3.2.

The differences in number of rows per cob were significantly influenced by planting patterns and weed control treatments (Table 4.3.2). Among the planting patterns, number of rows per cob in ridge sowing and flat sown with single row was found to be statistically at par with each other during 2023. The number of rows per cob were significantly lower in paired row planting as compared to ridge sowing (Table 4.3.2). Among the weed control treatments, number of rows per cob in intercropping with *Sesbania fb* earthing up & straw mulching were statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. Significantly less number of rows per cob were recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching as compared to earthing up and straw mulching treatments. Number of rows per cob were significantly lower in unweeded (control) as compared to all other weed control treatments. During 2024, among the planting patterns, number of rows per cob in ridge sowing were at par with flat sown single row method (Table 4.3.2). Paired row sowing produced significantly lower number of rows per cob as compared to all other planting patterns. Among the weed control treatments, number of cobs per plant in intercropping with *Sesbania fb* earthing up & straw mulching and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching were statistically at par. Number of rows per cob in pendimethalin + atrazine pre-emergence *fb* straw mulching were statistically at par with two hand weeding treatment. Significantly lower number of rows per cob were recorded in unweeded (control) as compared to all other weed control treatments.

The number of grains per cob were also significantly influenced by planting patterns and weed control treatments (Table 4.3.2) during both years. Among the planting

patterns, number of grains per cob in ridge sowing were statistically at par with single row flat sowing during 2023. Paired row planting recorded significantly less number of grains per cob as compared to all other planting patterns. Among weed control treatments, number of grains per cob in intercropping with *Sesbania fb* earthing up & straw mulching and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching were found to be statistically at par with each other. The number of grains per cob in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatment were statistically at par. The unweeded (control) recorded significantly less number of grains per cob as compared to all other weed control treatments. During 2024, among the planting patterns, number of grains per cob in ridge sowing were statistically at par with single row flat sowing method (Table 4.3.2). Paired row planting recorded significantly low number of grains per cob as compared to other planting methods. Among weed control treatments, number of grains per cob in intercropping with *Sesbania fb* earthing up & straw mulching were statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. The number of grains per cob were statistically at par in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments. Significantly lower number of grains per cob were recorded in unweeded (control) as compared to all other weed control treatments.

The differences in 1000 grain weight (test weight) was significant among various planting patterns and weed control treatments (Table 4.3.2) during both years. Among the planting patterns during 2023, 1000 grain weight (g) in ridge sowing was at par with single row flat sown crop. Significantly lower 1000 grain weight (g) was recorded in paired row sowing as compared to other planting patterns. Among weed control treatments, 1000 grain weight in intercropping with *Sesbania fb* earthing up & straw mulching was statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. Significantly less 1000 grain weight was recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatment as compared to former earthing up and straw mulching treatments. Test weight was significantly lower in unweeded (control) as compared to all other weed control treatments. During 2024, 1000 grain weight (g) in

ridge sown crop was statistically at par with single row flat sown crop (Table 4.3.2). Paired row planting recorded significantly lower 1000 grain weight as compared to ridge sowing. Among the weed control treatments, 1000 grain weight (g) in intercropping with *Sesbania fb* earthing up & straw mulching was found to be statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. The 1000 grain weight (g) in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatment was statistically at par with each other. Unweeded (control) recorded significantly lower 1000 grain weight as compared to all other weed control treatments.

The improved crop growth under ridge sowing led to better yield attributes like number of rows per cob, number of grains per cob and 1000 grain weight (Raihan *et al.*, 2017). The earthing up followed by straw mulching reduces the weed competition and improves the soil aeration which results in positive impact on these yield attributes (Ali *et al.*, 2022).

The interactive effect of planting patterns and weed control treatments on number of rows per cob, number of grains per cob and 1000 grain weight was non-significant during 2023 and 2024 (Table 4.3.2).

Table 4.3.2 Effect of planting patterns and weed control treatments on number of rows per cob, number of grains per cob and 1000 grain weight (g)

	Number of rows per cob		Number of grains per cob		1000 grain weight (g)	
	2023	2024	2023	2024	2023	2024
Main plots (Planting patterns)						
Flat sowing with single row	14.2	14.3	493.8	500.5	287.1	289.2
Flat sowing with paired rows	13.9	13.9	470.4	473.7	281.2	282.7
Ridge sowing	14.3	14.3	500.1	508.1	288.4	291.3
SE(m) $\pm$	0.09	0.08	5.29	5.57	1.14	1.93
C.D. (5%)	0.30	0.27	18.65	19.63	4.02	6.79
Sub-plots (Weed control treatments)						
Pendi.+Atz., pre-em <i>fb</i> SM	14.1	14.1	491.2	490.2	289.1	290.9
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	14.4	14.4	516.3	523.9	295.7	298.2
Inter. <i>Sesbania fb</i> EU & SM	14.5	14.6	527.8	532.9	296.4	297.8
Two hand weedings (4 and 6 WAS)	13.9	14.1	483.6	484.3	286.5	288.1
Unweeded (control)	13.6	13.7	421.7	439.4	260.2	263.8
SE(m) $\pm$	0.10	0.08	5.29	4.14	2.65	2.43
C.D. (5%)	0.28	0.22	15.24	11.93	7.64	7.00
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

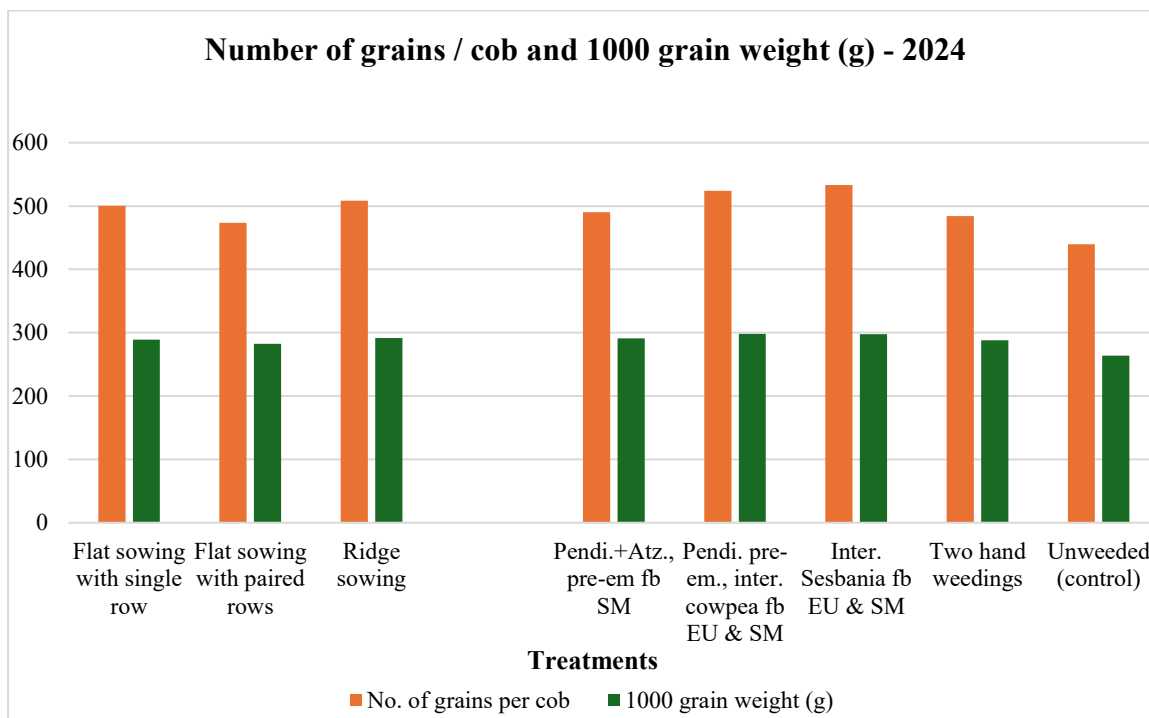
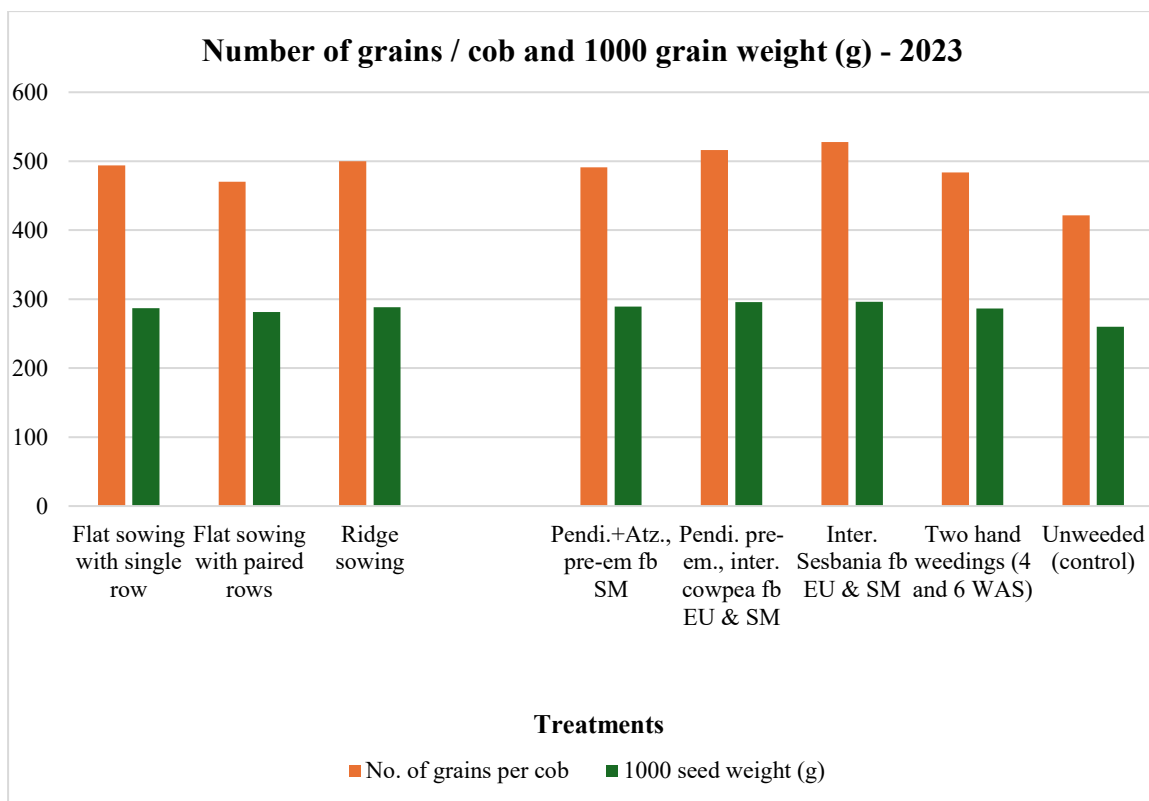


Figure 4.3.2 Effect of planting patterns and weed control treatments on number of grains per cob and 1000 seed weight (g) during 2023 and 2024

4.3.4 Grain yield and stover yield (q ha⁻¹)

The grain yield is the economic part of the crop which is ultimate product of crop growth factors and yield attributes. The treatment with higher grain yield is considered to be the best treatment. The data on grain yield and stover yield has been reported in Table 4.3.3 and shown in Figure 4.3.3.

The differences in grain yield was found to be significant during 2023 due to planting patterns and weed control treatments (Table 4.3.3). Among planting patterns, grain yield in ridge planting was statistical at par with flat sown single row crop. Significantly lower grain yield was recorded in paired row planting as compared to all other planting patterns. Among weed control treatments, grain yield was statistically at par among intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching (Table 4.3.3). Pendimethalin + atrazine pre-emergence *fb* straw mulching recorded significantly less grain yield than the former intercropping treatments but it was significantly more as compared to two hand weeding treatment. Significantly lower grain yield was recorded in unweeded (control) as compared to all other weed control treatments. During 2024, among planting patterns, grain yield in ridge planting and flat sown single row crop was found to be statistically at par (Table 4.3.3). Significantly lower grain yield was recorded in paired row planting as compared to other planting patterns. Among weed control treatments, grain yield in intercropping *Sesbania fb* earthing up & straw mulching was statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching treatment. Grain yield in pendimethalin + atrazine pre-emergence *fb* straw mulching was significantly less than intercropping treatments but it was found to be statistically at par with hand weeding treatment. Significantly lower grain yield was recorded in unweeded (control) as compared to all other weed control treatments.

Pooled grain yield data presented in Table 4.3.3 indicated that the grain yield was significantly impacted by various planting patterns and weed control treatments. Grain yield in ridge sowing and flat sown single row crop was statistically at par. Significantly lower grain yield was obtained in paired row sowing as compared to

other planting patterns. Similar findings were reported by Dong *et al.* (2017) and Bhayankar *et al.* (2024). Among the weed control treatments, grain yield in intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching was statistically at par among themselves. Pendimethalin + atrazine pre-emergence *fb* straw mulching recorded significantly more grain yield than two hand weeding treatment. Significantly lower grain yield was recorded in unweeded (control) as compared to all other weed control treatments. Similar findings were reported by Xing *et al.* (2024) and Rahman *et al.* (2022). Higher grain yield in ridge sowing and single row sowing on flat bed may be due to better weed control (Table 4.1.1a, 4.1.1b, 4.1.2a, 4.1.2b and 4.1.3), growth factors (Table 4.2.1 to 4.2.7) and yield attributes (Table 4.3.1 and 4.3.2) as compared to double row sown crop. On the basis of pooled data, ridge sown and single row flat sown crop increased grain yield by 9.61 and 7.92 percent than paired row sown crop. Among weed control treatments, more grain yield in intercropping *Sesbania fb* earthing up & straw mulching, pendimethalin pre-emergence with intercropping of cowpea *fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching treatments may be due to effective weed control (Table 4.1.1a, 4.1.1b, 4.1.2a, 4.1.2b and 4.1.3), good crop growth parameters (Table 4.2.1 to 4.2.7) and better yield attributes (Table 4.3.1 and 4.3.2) as compared to two hand weeding and unweeded (control) treatments. On an average of two years, intercropping *Sesbania fb* earthing up & straw mulching, pendimethalin pre-emergence with intercropping of cowpea *fb* earthing up & straw mulching, pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding increased the grain yield of maize crop by 44.71, 41.07, 31.44 and 26.54 percent, respectively as compared to unweeded (control) treatment.

The interactive effect of planting pattern and weed control treatments for grain yield was found to be significant during 2023 (Table 4.3.4). The grain yield in ridge sowing in combination with pre-emergence pendimethalin + atrazine *fb* straw mulching was statistically at par with paired row sowing with intercropping treatments either with *Sesbania* intercropping *fb* earthing up and straw mulching or pendimethalin, cowpea *fb* earthing up and straw mulching. Ridge sowing with two hand weeding treatment

produced significantly less grain yield as compared to paired row sowing with pre-emergence pendimethalin, cowpea *fb* earthing up and straw mulching. The grain yield in single row flat sown with two hand weeding treatment was statistically at par with paired row sowing with pendimethalin + atrazine pre-emergence *fb* straw mulching. During 2024, the interactive effect of planting patterns and weed control treatments for grain yield was found to be non-significant.

Stover yield (q / ha) is important component of biological yield. Stover can be used as cattle feed or can be incorporated in the field which on decomposition may improve the organic matter, nutrients content of the soil and soil physical conditions. The differences in stover yield was found to be significant for planting patterns and weed control treatments and data has been presented in Table 4.3.3. During 2023, stover yield recorded in ridge planting was statistical at par with flat sown single row crop. Significantly lower stover yield was recorded in paired row planting as compared to other planting patterns. Among weed control treatments, stover yield in intercropping *Sesbania fb* earthing up & straw mulching was statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. Stover yield recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatment was statistically at par with each other. Significantly lower stover yield was recorded in unweeded (control) as compared to other weed control treatments. During 2024, stover yield in ridge sowing and single row flat sown crop was statistically at par with each other (Table 4.3.3). Paired row planting recorded significantly less stover yield as compared to other planting patterns. Among the weed control treatments, stover yield recorded in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching was found to be statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. Stover yield in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding was statistically at par among themselves. Significantly less stover yield was recorded in unweeded (control) as compared to other weed control treatments.

The interactive effect of planting pattern and weed control treatments for stover yield was found to be significant during 2023 (Table 4.3.4). The stover yield in ridge sowing treated with pendimethalin + atrazine pre-emergence *fb* straw mulching was

statistically at par with paired row sowing with intercropping *Sesbania fb* earthing up and straw mulching. Ridge sowing with two hand weeding treatment produced statistically at par stover yield as compared to paired row sowing with both intercropping treatments of *Sesbania* and cowpea. The stover yield in single row flat sown with two hand weeding treatment was significantly more than paired row sowing with pendimethalin + atrazine pre-emergence *fb* straw mulching. During 2024, the interactive effect of planting patterns and weed control treatments for stover yield was found to be non-significant.

Improved soil physical condition and better crop growth characteristics leads to higher grain and stover yield under ridge sowing. The proper space and light availability under flat sown single row as compared to paired row sowing may be the reason for the difference in the grain and stover yield among them (Yousuf *et al.*, 2023 and Langhari *et al.*, 2024). Legumes provide additional nitrogen to crop and improved water holding capacity due to straw mulching which may add to better grain and stover yield. Less crop weed competition in the critical period under pre-emergence herbicide spraying and mulching also may have the positive impact on the grain yield and stover yield (Begam *et al.*, 2024 and Xing *et al.*, 2024).

Table 4.3.3. Grain yield (q ha⁻¹) and stover yield (q ha⁻¹) as influenced by planting patterns and weed control treatments

	Grain yield (q ha ⁻¹)			Stover yield (q ha ⁻¹)	
	2023	2024	Pooled	2023	2024
Main plots (Planting patterns)					
Flat sowing with single row	82.1	84.0	83.1	105.0	109.5
Flat sowing with paired rows	76.0	78.0	77.0	97.3	99.9
Ridge sowing	83.2	85.6	84.4	107.4	111.9
SE(m) ±	1.19	1.42	1.13	1.56	0.68
C.D. (5%)	4.18	5.02	3.99	5.49	2.41
Sub-plots (Weed control treatments)					
Pendi.+Atz., pre-em <i>fb</i> SM	81.8	84.7	83.2	99.9	105.3
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	89.2	89.4	89.3	112.6	116.0
Inter. <i>Sesbania fb</i> EU & SM	90.7	92.4	91.6	113.3	115.8
Two hand weedings (4 and 6 WAS)	77.4	82.7	80.1	98.7	104.3
Unweeded (control)	63.0	63.7	63.3	91.7	94.2
SE(m) ±	0.78	1.28	0.79	1.54	1.62
C.D. (5%)	2.24	3.69	2.62	4.44	4.67
Interaction C.D. (5%)	4.30	NS	NS	8.21	NS

Table 4.3.4. Interactive effect of planting patterns and weed control treatments on grain yield (q ha⁻¹) and stover yield (q ha⁻¹) during 2023

Grain yield (q ha⁻¹) - 2023

	Pendi.+Atz., pre-em <i>fb</i> SM	Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	Inter. <i>Sesbania fb</i> EU & SM	Two hand weedings	Unweeded (control)	Mean A
Flat sowing with single row	83.9	89.0	91.1	79.7	66.9	82.1
Flat sowing with paired rows	75.4	86.8	87.9	71.1	58.5	76.0
Ridge sowing	85.9	91.8	93.2	81.5	63.6	83.2
Mean B	81.8	89.2	90.7	77.4	63.0	
SE(m) ±	2.65					
C.D. (5%)	4.30					

Stover yield (q ha⁻¹) - 2023

	Pendi. +Atz., pre-em. <i>fb</i> SM	Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	Inter. <i>Sesbania fb</i> EU & SM	Two hand weedings	Unweeded (control)	Mean A
Flat sowing with single row	101.7	116.8	116.8	102.1	87.9	105.0
Flat sowing with paired rows	90.9	104.9	109.4	88.9	92.5	97.3
Ridge sowing	107.2	116.1	113.6	105.1	94.7	107.3
Mean B	99.9	112.6	113.3	98.7	91.7	
SE(m) ±	3.48					
C.D. (5%)	8.21					

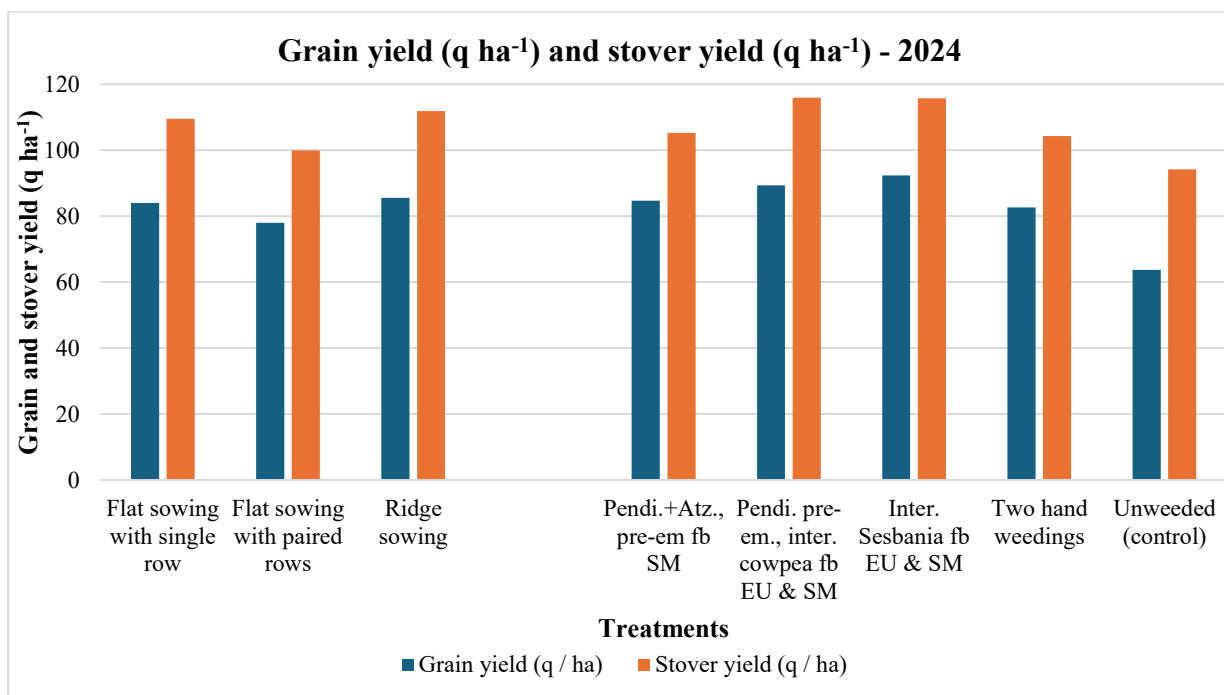
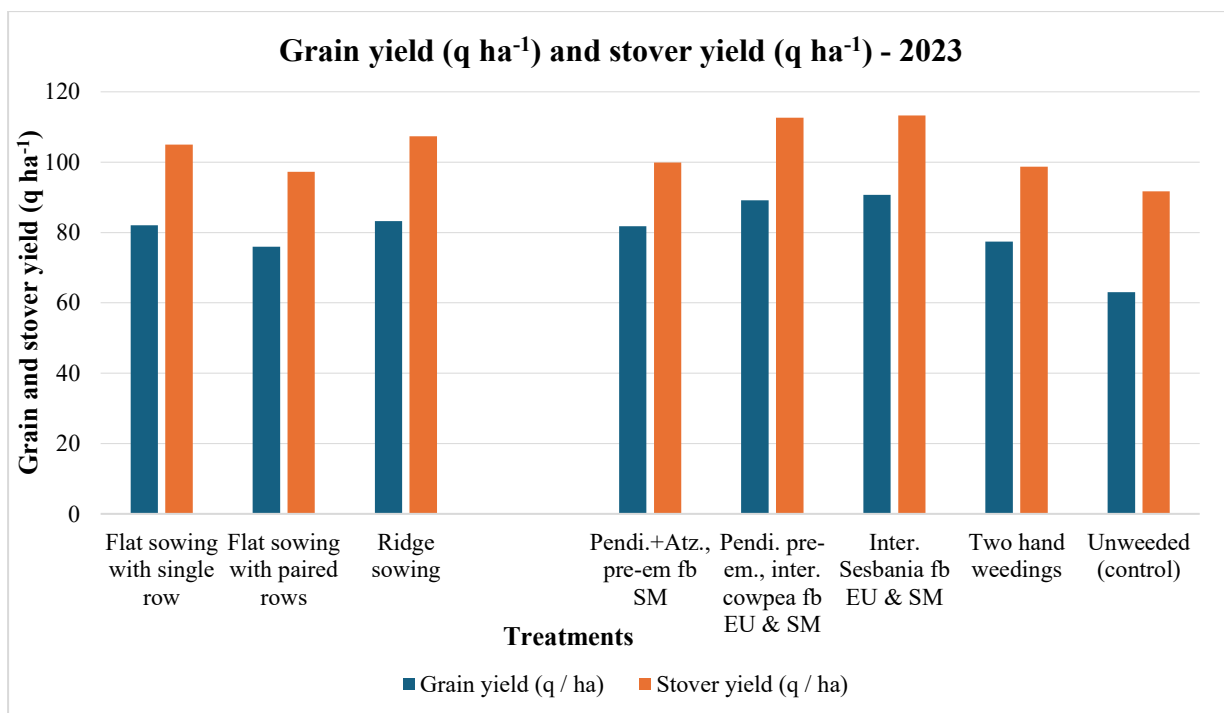


Figure 4.3.3 Effect of planting patterns and weed control treatments on grain yield (q/ha) and stover yield (q/ha) of maize during 2023 and 2024

4.3.4. Biological yield (q ha^{-1}) and harvest index (%)

Biological yield (q ha^{-1}) is the indicative of biomass production of the crop whereas harvest index gives the percentage of economic part produced from the whole produce or indicate the efficiency of partitioning of dry matter to the economic parts of the crop. The data on the effect of planting patterns and weed control treatments on biological yield and harvest index has been presented in Table 4.3.4.

The differences in biological yield during 2023 was significant (Table 4.3.4). Among planting patterns, biological yield in ridge planting was statistical at par with single row flat sown crop. The significantly less biological yield was recorded in paired row planting as compared to other planting patterns. Among weed control treatments, biological yield in intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching was found to be statistically at par with each other. Significantly less biological yield was recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments as compared to earthing up and straw mulching treatments. The significantly lower biological yield was recorded in unweeded (control) as compared to other weed control treatments. During 2024, among the planting patterns, ridge sowing and flat sown single row crop recorded statistically at par biological yield (Table 4.3.4). Paired row sowing recorded significantly lower biological yield as compared to other planting methods. Among weed control treatments, biological yield in intercropping *Sesbania fb* earthing up & straw mulching was statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. Biological yield in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings was found to be statistically at par with each other. Unweeded (control) produced significantly less biological yield as compared to other weed control treatments.

The data on harvest index has been presented in Table 4.3.4 indicated that the harvest index was not significantly influenced by various planting patterns during both years of the study. However, among the weed control treatments, harvest index recorded in pendimethalin + atrazine, pre-emergence *fb* straw mulching was statistically at par

with intercropping *Sesbania fb* earthing up & straw mulching and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. The harvest index in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and two hand weeding treatment was statistically at par with intercropping *Sesbania fb* earthing up & straw mulching during 2023. Significantly lower harvest index was recorded in unweeded (control) as compared to other weed control treatments. During 2024, harvest index was found to be non-significant among various planting patterns (Table 4.3.4). Among the weed control treatments, harvest index in pendimethalin + atrazine pre-emergence *fb* straw mulching was statistically at par with intercropping *Sesbania fb* earthing up & straw mulching, two hand weeding and pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching. The harvest index was significantly lower in unweeded (control) as compared to all other weed control treatments.

Less weed competition under ridge sowing may be due to burial of weed seeds and availability of better soil physical condition which might have resulted in higher biological yield under this method (Bhayankar *et al.*, 2024 and Yousuf *et al.*, 2023). The straw mulching improves the water holding capacity of soil which impacted the crop positively. Hand weeding and earthing up treatments, not only uprooted the weeds but also loosens the soil which improves physical conditions for root growth and development. The spraying of pre-emergence herbicides reduces the weed competition during the critical period of crop weed competition and leguminous live cover crops provides additional nutrition to the crop which may have led to better biological yield and improved harvest index under these treatments as compared to unweeded (control) (Shashikanth *et al.*, 2022 and Lukangila *et al.*, 2024).

The interactive effect of planting patterns and weed control treatments for biological yield and harvest index was non-significant during 2023 and 2024 (Table 4.3.4).

Table 4.3.4. Biological yield (q ha⁻¹) and harvest index (%) as influenced by planting patterns and weed control treatments

	Biological yield (q/ha)		Harvest index (%)	
	2023	2024	2023	2024
Main plots (Planting patterns)				
Flat sowing with single row	187.2	193.5	43.88	43.33
Flat sowing with paired rows	173.3	177.9	43.72	43.69
Ridge sowing	190.5	197.5	43.53	43.24
SE(m) ±	2.52	1.85	0.32	0.35
C.D. (5%)	8.90	6.54	NS	NS
Sub-plots (Weed control treatments)				
Pendi.+Atz., pre-em fb SM	181.7	189.9	45.04	44.64
Pendi. pre-em., inter. cowpea fb EU & SM	201.8	205.5	44.26	43.50
Inter. <i>Sesbania</i> fb EU & SM	204.0	208.2	44.49	44.35
Two hand weedings (4 and 6 WAS)	176.1	187.0	43.99	44.30
Unweeded (control)	154.7	157.8	40.75	40.31
SE(m) ±	2.00	2.23	0.35	0.46
C.D. (5%)	5.78	6.43	1.02	1.33
Interaction C.D. (5%)	NS	NS	NS	NS

4.4 Economics

Data on economics of maize is presented in Table 4.4.1. Average of two years data 2023 and 2024, among planting patterns, flat sowing with single row and ridge sowing gave better net return as well as better benefit cost ratio as compared to flat sowing with paired rows. The highest net return (96,275 ₹ ha⁻¹) were recorded in flat sowing with single row. The benefit cost ratio recorded in flat sowing with single row (1.49) and ridge sowing (1.42) was better than flat sowing with paired row (1.31). Among weed control treatments, highest net returns were recorded in intercropping *Sesbania fb* earthing up and straw mulching followed by pre-emergence pendimethalin + intercropping cowpea *fb* earthing up and straw mulching. Benefit cost ratio recorded in intercropping *Sesbania fb* earthing up and straw mulching (1.66) was highest followed by pre-emergence pendimethalin + intercropping cowpea *fb* earthing up and straw mulching with B:C ratio of 1.54. The net returns recorded in two hand weedings and unweeded (control) were lower than other treatments because of more weed infestation leading to significant loss in grain yield.

Table 4.4.1 Effect of planting patterns and weed control treatments on economics of spring maize (average of two years)

Treatments	Cost of cultivation (₹ ha ⁻¹)	Gross return (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	B:C ratio
Main plots (Planting patterns)				
Flat sowing with single row	64520	160795	96275	1.49
Flat sowing with paired rows	64520	149300	84780	1.31
Ridge sowing	67520	163360	95840	1.42
Sub-plots (Weed control treatments)				
Pendi.+Atz., pre-em fb SM	66100	161175	95075	1.44
Pendi. pre-em., inter. cowpea fb EU & SM	68000	172670	104670	1.54
Inter. <i>Sesbania</i> fb EU & SM	66500	176945	110445	1.66
Two hand weedings (4 and 6 WAS)	66000	155095	89095	1.35
Unweeded (control)	61000	122865	61865	1.01

4.5 Quality parameters

4.5.1 N content in grains (%), N content in stover (%) and protein content (%)

N content in grains is one of the important quality parameter and protein content of grain depends on N content in grain. The data on effect of planting patterns and weed control treatments on N content in grain, N content in stover and protein content in grains during 2023 and 2024 has been presented in Table 4.5.1.

The differences in N content in grains (%) as influenced by planting pattern and weed control treatments were found to be significant (Table 4.5.1). Among the planting patterns, the N content in grains in single row flat sown crop was significantly higher as compared to other planting patterns. Under ridge sowing, N content in grains (%) was significantly more than paired row planting. Significantly lower N content in grains was recorded in paired row sowing as compared to all other planting patterns during 2023 (Table 4.5.1). Among the weed control treatments, N content in grains in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching were statistically at par with each other and were significantly superior to pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings. Significantly lower N content in grains was recorded in unweeded (control) as compared to all other weed control treatments. During 2024, the N content in grains (%) was statistically at par in ridge sowing and flat sown single row method. Paired row sowing recorded significantly lower N content in grains as compared to all other planting patterns. Among the weed control treatments, the N content in grains (%) under pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and pendimethalin + atrazine pre-emergence *fb* straw mulching was statistically at par with each other. The N content of grains in pendimethalin + atrazine pre-emergence *fb* straw mulching was statistically at par with intercropping *Sesbania fb* earthing up & straw mulching. Also, intercropping *Sesbania fb* earthing up & straw mulching and two hand weedings were found at par. Significantly lower N content in grains was recorded in unweeded (control) as compared to all weed control treatments.

The differences in N content in stover (%) among various planting patterns and weed control treatments were found to be non-significant during 2023 (Table 4.5.1). During 2024, N content in stover (%) in ridge sowing was significantly higher than all other planting patterns. The N content in stover was found to be statistically at par among flat sown single row crop and paired row planting. Among the weed control treatments, N content in stover (%) in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching were statistically at par with each other. Pendimethalin + atrazine pre-emergence *fb* straw mulching produced at par N content in stover with two hand weeding treatment. Significantly lower N content in stover (%) was recorded in unweeded (control) as compared to pendimethalin pre-emergence, intercropping cowpea *fb* earthing up and straw mulching.

The differences in protein content in grains (%) was found to be significant as influenced by planting pattern and weed control treatments (Table 4.5.1). Among the planting patterns, the protein content in grain in flat sown single row crop was significantly higher than all other planting patterns. Ridge sowing produced significantly more N content in grains (%) as compared to paired row planting. Significantly low protein content in grains was recorded in paired row sowing as compared to all other planting patterns during 2023 (Table 4.5.1). Among the weed control treatments, protein content in grains (%) in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching were statistically at par with each other. Protein content of grain in pendimethalin + atrazine pre-emergence *fb* straw mulching was significantly more than two hand weeding treatment. Significantly lower protein content in grain (%) was recorded in unweeded (control) as compared to all other weed control treatments. During 2024, the protein content in grain was statistically at par in ridge sowing and flat sown single row. Paired row sowing recorded significantly low protein content in grain (%) as compared to all other planting patterns. Among the weed control treatments, the protein content in grain under pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching, pendimethalin + atrazine pre-emergence *fb* straw mulching and

intercropping *Sesbania fb* earthing up & straw mulching were found to be statistically at par with each other. Significantly lower protein content in grains was recorded in unweeded (control) as compared to intercropping treatments.

Better grain quality under ridge sowing may be due to better soil aeration and good growth characters which likely improved the nitrogen uptake of grains leading to higher N (%) and protein content of grains (Bhayankar *et al.*, 2024). The intercropping and mulching treatments produced better quality grains which may be due to better crop growth and N uptake and lesser competition from weeds (Singh *et al.*, 2024).

The interactive effect of planting patterns and weed control treatments for N content in grains, N content in stover and protein content in grains were non-significant during 2023 and 2024 (Table 4.5.1).

Table 4.5.1: Effect of planting pattern and weed control treatments on N content in grains (%), N content in stover (%) and protein content (%)

	N content in grains (%)		N content in stover (%)		Protein content in grains (%)	
	2023	2024	2023	2024	2023	2024
Main factor (Planting patterns)						
Flat sowing with single row	0.93	0.96	0.35	0.350	5.81	6.01
Flat sowing with paired rows	0.86	0.88	0.34	0.359	5.37	5.48
Ridge sowing	0.91	0.97	0.38	0.383	5.66	6.03
SE(m)±	0.003	0.004	0.02	0.01	0.019	0.027
C.D. (5%)	0.013	0.017	NS	0.024	0.078	0.109
Sub factor (Weed control treatments)						
Pendi.+Atz., pre-em <i>fb</i> SM	0.89	0.96	0.34	0.36	5.54	6.01
Pendi., pre-em+inter. cowpea <i>fb</i> EU and SM	0.96	0.97	0.38	0.41	6.00	6.07
inter. <i>Sesbania fb</i> EU and SM	0.95	0.95	0.38	0.38	5.93	5.93
Two hand weedings (4 and 6 WAS)	0.87	0.94	0.35	0.34	5.41	5.88
Unweeded (control)	0.83	0.85	0.35	0.33	5.18	5.31
SE(m)±	0.005	0.006	0.02	0.01	0.031	0.036
C.D. (5%)	0.014	0.017	NS	0.030	0.092	0.105
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

4.5.2 N uptake by grains (kg ha⁻¹), N uptake by stover (kg ha⁻¹) and total N uptake by crop (kg ha⁻¹)

The differences in N uptake by grains (kg ha⁻¹) as influenced by planting pattern and weed control treatments were found to be significant (Table 4.5.2). Among the planting patterns, the N uptake by grains under ridge sowing was found to be statistically at par with flat sown single row sown crop. Significantly lower N uptake by grains was recorded in paired row sowing as compared to all other planting patterns during 2023 (Table 4.5.2). Among weed control treatments, N uptake by grains in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching were statistically at par with each other. The N uptake by grains in pendimethalin + atrazine pre-emergence *fb* straw mulching was significantly more as compared to two hand weeding treatment. Significantly lower N uptake by grains was recorded in unweeded (control) as compared to all other weed control treatments. During 2024, the N uptake by grains was statistically at par in ridge sowing and flat sown single row among themselves. Paired row sowing recorded significantly less N uptake by grains as compared to all other planting patterns. Among the weed control treatments, the N uptake by grains under pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was statistically at par with each other. The N uptake by grains in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings was found to be at par with each other. Significantly lower N uptake by grains was recorded in unweeded (control) as compared to all weed control treatments.

The differences in N uptake by stover (kg ha⁻¹) were found to be non-significant as influenced by planting pattern during 2023 (Table 4.5.2). Among the weed control treatments, N uptake by stover in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching were statistically at par with each other. The N uptake by stover in pendimethalin + atrazine pre-emergence *fb* straw mulching was found to be statistically at par with two hand weedings. Significantly lower N uptake by stover was recorded in unweeded (control) as compared to all other weed control treatments.

During 2024, the N uptake by stover was significantly higher in ridge sowing as compared to other planting patterns. Flat sown single row crop recorded significantly more N uptake by stover as compared to paired row planting method. Paired row sowing recorded significantly lower N uptake by stover as compared to all other planting patterns. Among the weed control treatments, the N uptake by stover under pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was statistically at par with each other. The N uptake by stover in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings was found to be at par with each other. Significantly lower N uptake by stover was recorded in unweeded (control) as compared to all weed control treatments.

The differences in total N uptake by crop (kg ha^{-1}) were found to be significant as influenced by planting pattern and weed control treatments (Table 4.5.2). Among planting patterns, N uptake by crop under ridge sowing was found to be statistically at par with flat sown single row crop. Significantly lower N uptake by crop was recorded in paired row sowing as compared to all other planting patterns during 2023 (Table 4.5.2). Among the weed control treatments, N uptake by crop in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching were statistically at par with each other. The N uptake by crop in pendimethalin + atrazine pre-emergence *fb* straw mulching was found to be significantly more than two hand weeding treatment. Significantly lower N uptake by crop was recorded in unweeded (control) as compared to all other weed control treatments. During 2024, the N uptake by crop was statistically at par in ridge sowing and flat sown single row among themselves. Paired row sowing recorded significantly less N uptake by crop as compared to all other planting patterns. Among the weed control treatments, the N uptake by crop under pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was statistically at par with each other. The N uptake by crop in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weedings was found to be at par with

each other. Significantly lower N uptake by crop was recorded in unweeded (control) as compared to all weed control treatments.

Better nitrogen uptake in ridge sowing may be attributed to improved soil aeration and less weed competition (Liu *et al.*, 2023). The intercropping treatments had better nitrogen uptake than other treatments which may be due to additional nitrogen fixation by the legume crops and proper soil cover by straw mulching which may have reduced the crop-weed competition in these treatments (Bhayankar *et al.*, 2024).

The interactive effect of planting patterns and weed control treatments for N uptake by grains, N uptake by stover and N uptake by crop were non-significant during 2023 and 2024 (Table 4.5.2).

Table 4.5.2 Effect of planting patterns and weed control treatments on N uptake by grains (kg ha⁻¹), N uptake by stover (kg ha⁻¹) and total N uptake by crop (kg ha⁻¹)

	N uptake by grains (kg ha ⁻¹)		N uptake by stover (kg ha ⁻¹)		Total N uptake by crop (kg ha ⁻¹)	
	2023	2024	2023	2024	2023	2024
Main factor (Planting patterns)						
Flat sowing with single row	77.8	83.0	36.7	38.4	114.5	121.3
Flat sowing with paired rows	65.6	67.8	33.4	35.7	99.0	103.5
Ridge sowing	75.7	83.6	39.9	43.1	115.5	126.7
SE(m)±	1.32	1.11	1.58	0.60	2.44	1.42
C.D. (5%)	5.33	4.46	NS	2.42	9.85	5.71
Sub factor (Weed control treatments)						
Pendi.+Atz., pre-em <i>fb</i> SM	72.6	82.4	35.9	38.5	108.4	120.9
Pendi., pre-em+inter. cowpea <i>fb</i> EU and SM	85.8	87.6	39.7	46.7	125.5	134.3
inter. <i>Sesbania fb</i> EU and SM	86.7	88.2	41.8	43.8	128.5	132.0
Two hand weedings (4 and 6 WAS)	67.5	79.0	34.3	35.7	101.8	114.8
Unweeded (control)	52.5	53.4	31.7	30.6	84.2	84.0
SE(m)±	0.92	1.59	0.90	1.17	1.42	2.11
C.D. (5%)	2.71	4.67	2.63	3.44	4.17	6.20
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

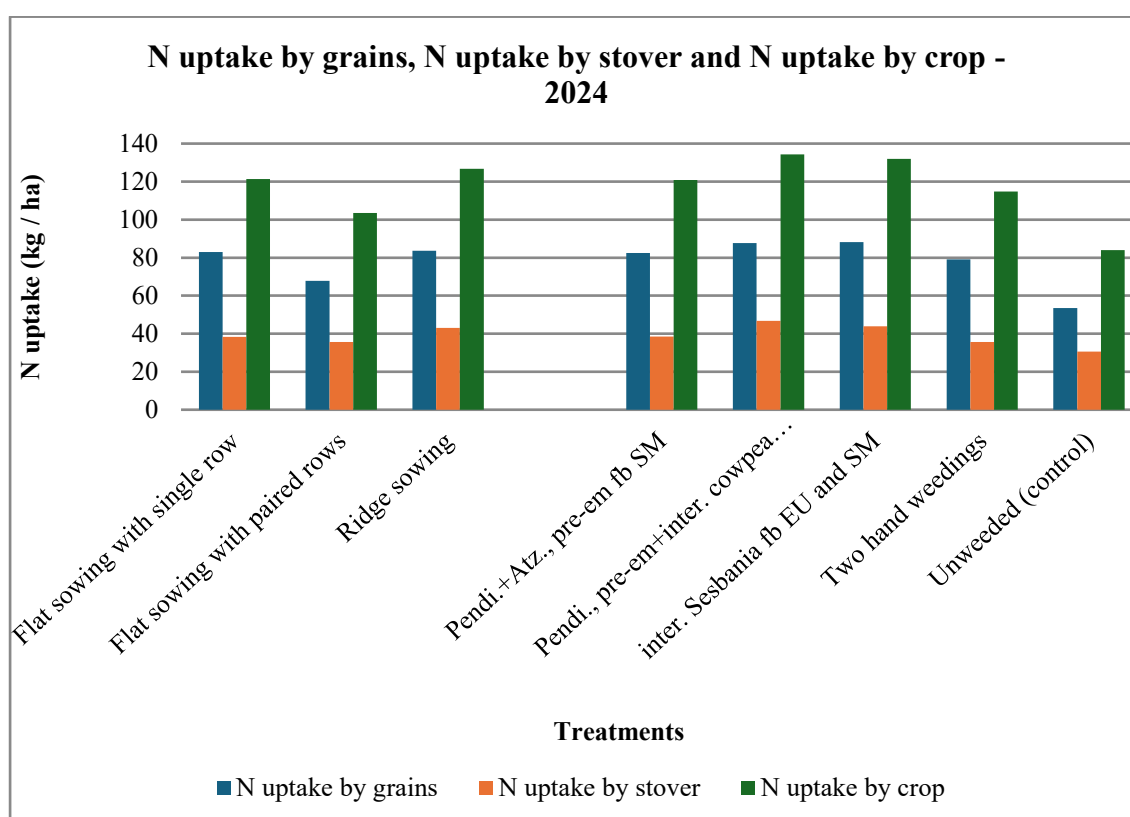
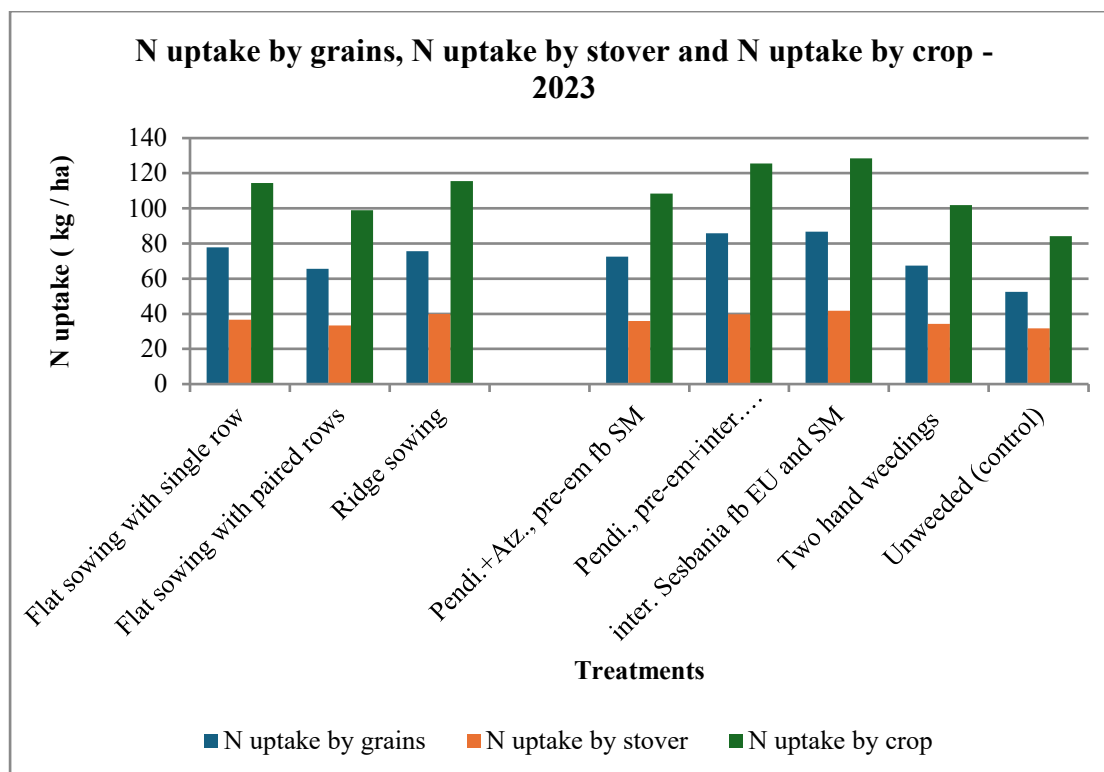


Figure 4.5.1 Effect of planting patterns and weed control treatments on N uptake by grains, N uptake by stover & N uptake by crop during 2023 & 2024

4.5.3 N content in weeds (%) and N uptake by weeds (kg ha⁻¹)

The differences in N content in weeds (%) was found to be significant as influenced by various planting patterns and weed control treatments during 2023 (Table 4.5.3). Among the planting patterns, significantly higher N content in weeds was recorded in ridge sowing as compared to all planting patterns. Paired row sowing recorded significantly more N content in weeds as compared to flat sown single row crop. Flat sown single row treatment recorded significantly less N content in weeds as compared to all other planting patterns. Among the weed control treatments, N content in weeds recorded in unweeded (control) was significantly higher as compared to all other weed control treatments. N content in weeds recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching was statistically at par with pendimethalin pre-emergence, intercropping cowpea *fb* earthing up and straw mulching treatment. Significantly less N content in weeds was recorded in intercropping *Sesbania fb* earthing up and straw mulching as compared to other weed control treatments. During 2024, the differences in N content in weeds (%) was found to be non-significant as influenced by various planting patterns. Among weed control treatments, significantly higher N content in weeds was recorded in unweeded (control) as compared to all other weed control treatments. N content in weeds recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching, two hand weedings and intercropping *Sesbania fb* earthing up and straw mulching was statistically at par with each other. Significantly lower N content in weeds was recorded in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up and straw mulching treatments as compared to all other weed control treatments.

The differences in N uptake by weeds (kg ha⁻¹) was found to be significant among various planting patterns and weed control treatments during 2023 (Table 4.5.3). The N uptake by weeds was significantly higher in paired row planting as compared to other planting patterns. The N uptake by weeds recorded in flat sowing single row and ridge planting was found to be at par with each other and significantly lower than paired row planting. Among the weed control treatments, significantly higher N uptake by weeds was recorded in unweeded (control) as compared to all other weed control treatments. Significantly less N uptake by weeds was recorded in

pendimethalin + atrazine, pre-emergence *fb* straw mulching as compared to two hand weedings and unweeded (control) treatments. The N uptake by weeds recorded in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up and straw mulching was found to be at par and significantly lower than all other weed control treatments. These findings hold good for 2024 also.

Higher nitrogen uptake by weeds in paired row planting may be attributed to poor crop growth and proper light and space available for the weeds. The nitrogen uptake by weeds in weed control treatments was less as compared to unweeded (control) treatment which may be due to uprooting of weeds during earthing up operation or hand weeding and better crop growth characters (Suresha *et al.*, 2015 and Deewan *et al.*, 2018).

The interactive effect of planting patterns and weed control treatments for N content in weeds and N uptake by weeds were non-significant during 2023 and 2024 (Table 4.5.3).

Table 4.5.3 Effect of planting pattern and weed control treatments on N content in weeds (%) and N uptake by weeds (kg ha⁻¹)

	N content in weeds (%)		N uptake by weeds (kg ha ⁻¹)	
	2023	2024	2023	2024
Main factor (Planting patterns)				
Flat sowing with single row	0.90	0.95	13.99	12.39
Flat sowing with paired rows	0.94	0.96	17.70	16.10
Ridge sowing	0.96	0.98	13.47	11.29
SE(m)±	0.003	0.007	0.50	0.62
C.D. (5%)	0.010	NS	2.015	2.510
Sub factor (Weed control treatments)				
Pendi.+Atz., pre-em <i>fb</i> SM	0.88	0.93	6.80	5.61
Pendi., pre-em+inter. cowpea <i>fb</i> EU and SM	0.87	0.88	2.63	2.37
inter. <i>Sesbania fb</i> EU and SM	0.85	0.92	2.88	2.61
Two hand weedings (4 and 6 WAS)	0.91	0.93	10.03	8.91
Unweeded (control)	1.16	1.16	52.92	46.79
SE(m)±	0.007	0.005	0.81	0.86
C.D. (5%)	0.020	0.016	2.389	2.521
Interaction C.D. (5%)	NS	NS	NS	NS

4.6 Soil properties

The important soil properties that influence crop growth and yield are soil pH, EC, OC (%), available N, P and K (kg ha^{-1}). The capacity of soil to provide nutrition to the crop is of prime importance.

4.6.1 Soil pH, EC and OC (%)

Soil pH describes the nature of the soil and it can be acidic, basic or neutral. Most of the crops prefer soil with neutral pH for better growth and production. Soil EC is one of the key indicators of soil health which provides information on nutrient availability in the soil. Soil OC (%) is also an indicator of soil health. It acts as reservoir for carbon sequestration and supports microbial activity. The data on soil pH, EC and OC after harvest of experimental crop has been presented in Table 4.6.1.

The differences in soil pH after harvest were found to be non-significant among the planting patterns (Table 4.6.1). Among weed control treatments, the differences in soil pH were also found to be non-significant during 2023 and 2024. The soil pH varied from 7.73 to 7.92.

The soil electrical conductivity (EC) after harvest was found to be non-significant during 2023 and 2024 among various planting patterns (Table 4.6.1). Among the weed control treatment, soil EC did not differ significantly during both years. The EC of the experimental soil ranged from 0.19 to 0.21 dS m^{-1} .

The soil organic carbon (OC) after harvest was found to be non-significant among various planting patterns during both years which varied from 0.39 to 0.42 percent. The weed control treatments also did not influence soil OC significantly after harvest during 2023 & 2024 and the soil organic carbon ranged from 0.38 to 0.42%.

The interactive effect of planting patterns and weed control treatments on soil pH, EC and OC (%) were found to be non-significant during 2023 and 2024 (Raghuwanshi *et al.*, 2024 and Gaurav *et al.*, 2018).

Table 4.6.1 Effect of planting patterns and weed control treatments on soil pH, EC and OC after harvest

	pH		EC (dS m ⁻¹)		OC (%)	
	2023	2024	2023	2024	2023	2024
Main plots (Planting patterns)						
Flat sowing with single row	7.75	7.83	0.21	0.21	0.42	0.41
Flat sowing with paired rows	7.82	7.90	0.20	0.20	0.39	0.40
Ridge sowing	7.89	7.86	0.21	0.21	0.42	0.41
SE(m)±	0.08	0.15	0.01	0.01	0.01	0.01
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (Weed control treatments)						
Pendi.+Atz., pre-em <i>fb</i> SM	7.73	7.86	0.20	0.21	0.41	0.42
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	7.73	7.88	0.21	0.22	0.42	0.41
Inter. <i>Sesbania fb</i> EU & SM	7.82	7.86	0.21	0.21	0.42	0.41
Two hand weedings (4 and 6 WAS)	7.92	7.85	0.19	0.19	0.41	0.41
Unweeded (control)	7.89	7.86	0.22	0.20	0.38	0.39
SE(m)±	0.11	0.10	0.01	0.01	0.02	0.02
C.D. (5%)	NS	NS	NS	NS	NS	NS
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS
Initial values	7.70	7.80	0.20	0.21	0.39	0.40

4.6.2 Soil available N, P and K (kg ha⁻¹)

NPK are essential primary nutrients for plants. The level of availability of these influences the productivity of the crop in certain soil. The data on available N, P and K of soil after harvest has been presented in Table 4.6.2.

The differences in available soil nitrogen were non-significant among various planting patterns (Table 4.6.2). The available soil nitrogen was found to be non-significant among various weed control treatments. These findings hold good for both the years. The range of available nitrogen varies from 186.5 to 175.1 kg ha⁻¹.

The available soil P (kg ha⁻¹) among the various planting patterns differed non-significantly (Table 4.6.2). Among weed control treatments, the differences in available soil P were also non-significant. The findings hold good for both the years. The range of available P varies from 25.2 to 26.2 kg ha⁻¹.

Among the various planting patterns, available soil K (kg ha⁻¹) was found to be non-significant each year (Table 4.6.2). Available soil K differed non-significantly among various weed control treatments. The findings were similar during both the years. The range for available K varied from 177.4 to 187.2 kg ha⁻¹.

The interactive effect of planting pattern and weed control treatments on available N, P and K were found to be non-significant during 2023 and 2024 (Govaerts *et al.*, 2007 and Raghuwanshi *et al.*, 2024).

Table 4.6.2 Effect of planting patterns and weed control treatments on available N, available P and available K (kg ha⁻¹) of soil after harvest

	Available N (kg ha ⁻¹)		Available P (kg ha ⁻¹)		Available K (kg ha ⁻¹)	
	2023	2024	2023	2024	2023	2024
Main plots (Planting patterns)						
Flat sowing with single row	173.2	172.3	25.6	25.2	184.0	182.0
Flat sowing with paired rows	173.2	171.9	25.7	25.9	182.8	179.8
Ridge sowing	171.2	172.1	25.9	25.7	185.3	180.2
SE(m)±	2.32	0.92	0.29	0.29	1.46	1.90
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (Weed control treatments)						
Pendi.+Atz., pre-em <i>fb</i> SM	171.4	171.8	25.4	24.8	183.8	181.9
Pendi. pre-em., inter. cowpea <i>fb</i> EU & SM	175.1	173.7	25.4	26.2	187.2	182.0
Inter. <i>Sesbania fb</i> EU & SM	174.5	172.0	25.8	25.8	186.0	183.4
Two hand weedings (4 and 6 WAS)	173.1	172.1	26.1	25.4	182.2	178.7
Unweeded (control)	168.5	170.9	25.9	25.8	181.0	177.4
SE(m)±	1.72	1.76	0.78	0.84	1.93	1.85
C.D. (5%)	NS	NS	NS	NS	NS	NS
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS
Initial values	172.3	171.8	25.7	25.1	186.8	182.5

Experiment 2: Influence of organic and inorganic nutrition on growth and development of spring maize

The results of this experiment are being discussed under the following subheads.

4.1 Weed density

Weed count and weed dry matter are the two important indices for determining the impact of weeds on crop growth and yield. Weed count indicates type of weed flora as well as their intensity which governs extent of losses due to weeds. As compared to weed dry weight, weed count is less reliable as sometimes their population may be high but extent of losses may be less due to their poor growth.

4.1.1 Weed count (m^{-2})

Weeds count (m^{-2}) represents the competitive potential between the crop and weeds. Weed count measures the number of weeds present in a unit area as well as type of weed flora. The data on weed count recorded at 75, 105 DAS and at harvest has been presented in Table 4.1.1 and depicted in Figure 4.1.1.

The differences in weed count recorded at 75 DAS among the organic manure treatments was found to be non-significant (Table 4.1.1) during 2023 and 2024. Among the nitrogen levels, weed count in 125% RDN (recommended dose of nitrogen) and 100% RDN was statistically at par with 75% RDN during 2023. Significantly lower weed count was recorded in 0% RDN (control) as compared to all other nitrogen levels. These findings hold good for second year also.

At 105 DAS during 2023, the weed count (m^{-2}) remained non-significant among the various organic manure treatments (Table 4.1.1). Among the nitrogen levels, the weed count recorded in 125% RDN was statistically at par with 100% RDN and 75% RDN. Weed count in 75% RDN was statistically at par with 0% RDN. Significantly lower weed count was recorded in 0% RDN (control) as compared to 100% RDN and 125% RDN during 2023. During 2024, weed count among the organic manures was found to be non-significant (Table 4.1.1). Among the nitrogen levels, weed count in 125% RDN was statistically at par with 100% RDN and 75% RDN. Significantly lower

weed count was recorded in 0% RDN (control) as compared to all other nitrogen levels.

At harvest, weed count (m^{-2}) among various organic manures was non-significant during 2023 (Table 4.1.1). Among the nitrogen levels, weed count in 125% RDN was statistically at par with 100 % RDN. Weed count recorded in 75% RDN was found to be statistically at par with 100% RDN. Significantly lower weed count was recorded in 0% RDN as compared to all other nitrogen levels. During 2024, the differences in weed count was non-significant among various organic manures (Table 4.1.1). Among the nitrogen levels, weed count in 125% RDN was statistically at par with 100 % RDN. Weed count recorded in 75% RDN was found to be statistically at par with 100% RDN. Significantly lower weed count was recorded in 0% RDN as compared to all other nitrogen levels.

Different organic manures showed no effect on weed count at all periodic intervals. Further it can also be concluded that weed count (m^{-2}) increased with increase in dose of nitrogen which might be due to less mortality of germinated weed seedlings with the availability of proper nutrition for the weeds to grow (Raniro *et al.*, 2023).

The interactive effect of organic manures and nitrogen levels on weed count was found to be non-significant at all growth stages during 2023 and 2024 (Table 4.1.1).

Table 4.1.1. Weed count (m⁻²) at 75, 105 DAS and at harvest as influenced by organic manures and nitrogen levels

	Weed count (m ⁻²)					
	75 DAS		105 DAS		At harvest	
	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)						
No organic manure	11.7 (137)	12.0 (145)	12.4 (152)	13.0 (168)	13.0 (169)	13.7 (187)
FYM (15 t ha ⁻¹)	12.2 (147)	12.9 (166)	13.0 (167)	13.5 (181)	13.5 (182)	14.2 (201)
Poultry manure (6.25 t ha ⁻¹)	12.1 (146)	12.6 (158)	12.6 (158)	13.2 (175)	13.3 (175)	14.0 (196)
Press mud (15 t ha ⁻¹)	12.0 (144)	12.6 (157)	12.6 (157)	13.1 (170)	13.2 (173)	14.3 (204)
SE(m) ±	0.16	0.04	0.14	0.13	0.14	0.18
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (N levels)						
Control (0 kg N ha ⁻¹)	11.5 (131)	11.6 (132)	12.3 (151)	12.8 (163)	12.8 (162)	13.4 (178)
75% RDN (100 kg N ha ⁻¹)	12.0 (143)	12.4 (153)	12.6 (157)	13.2 (173)	13.2 (173)	14.0 (194)
100% RDN (125 kg N ha ⁻¹)	12.2 (149)	12.8 (163)	12.7 (160)	13.3 (176)	13.4 (178)	14.4 (206)
125% RDN (150 kg N ha ⁻¹)	12.3 (152)	13.3 (176)	12.9 (166)	13.5 (181)	13.6 (185)	14.5 (211)
SE(m) ±	0.14	0.08	0.13	0.12	0.11	0.15
C.D. (5%)	0.41	0.23	0.39	0.35	0.31	0.43
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS
Note: Values in parenthesis are original values and values without parenthesis are transformed values. Square root transformation ($\sqrt{x + 1}$) was used						

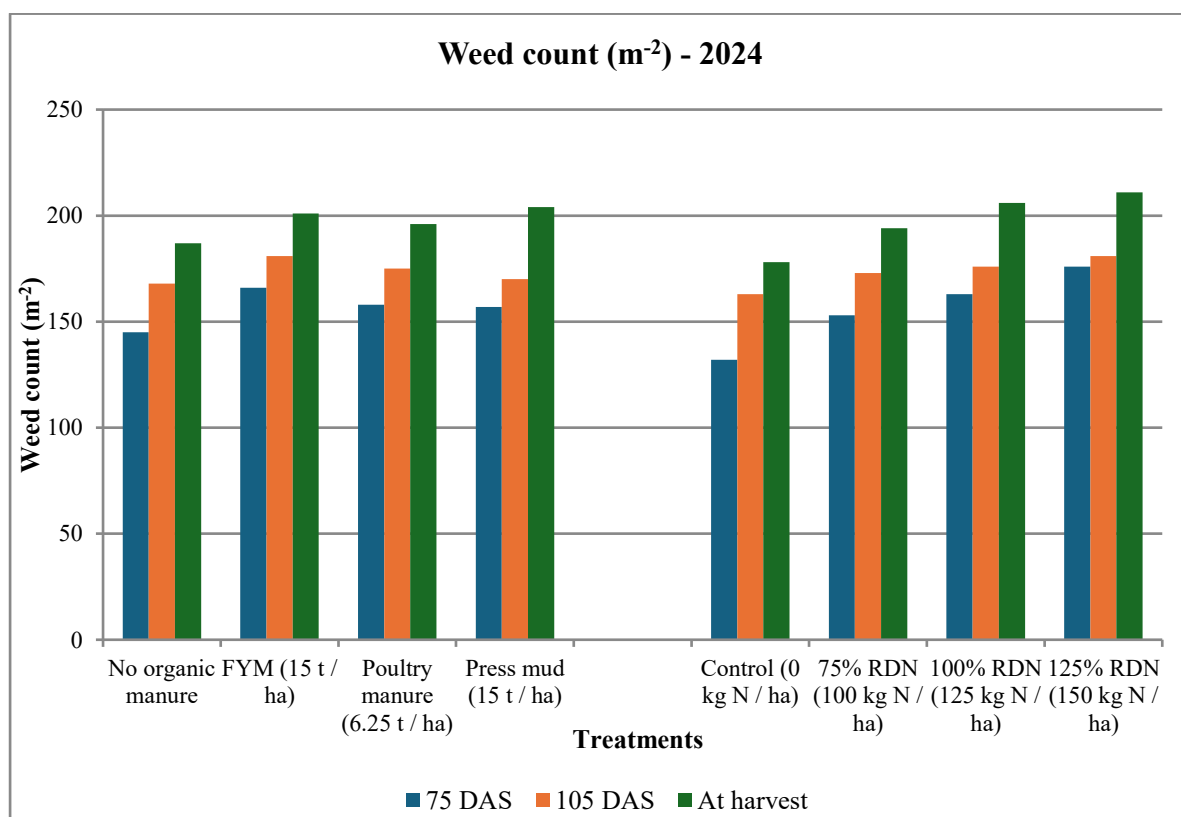
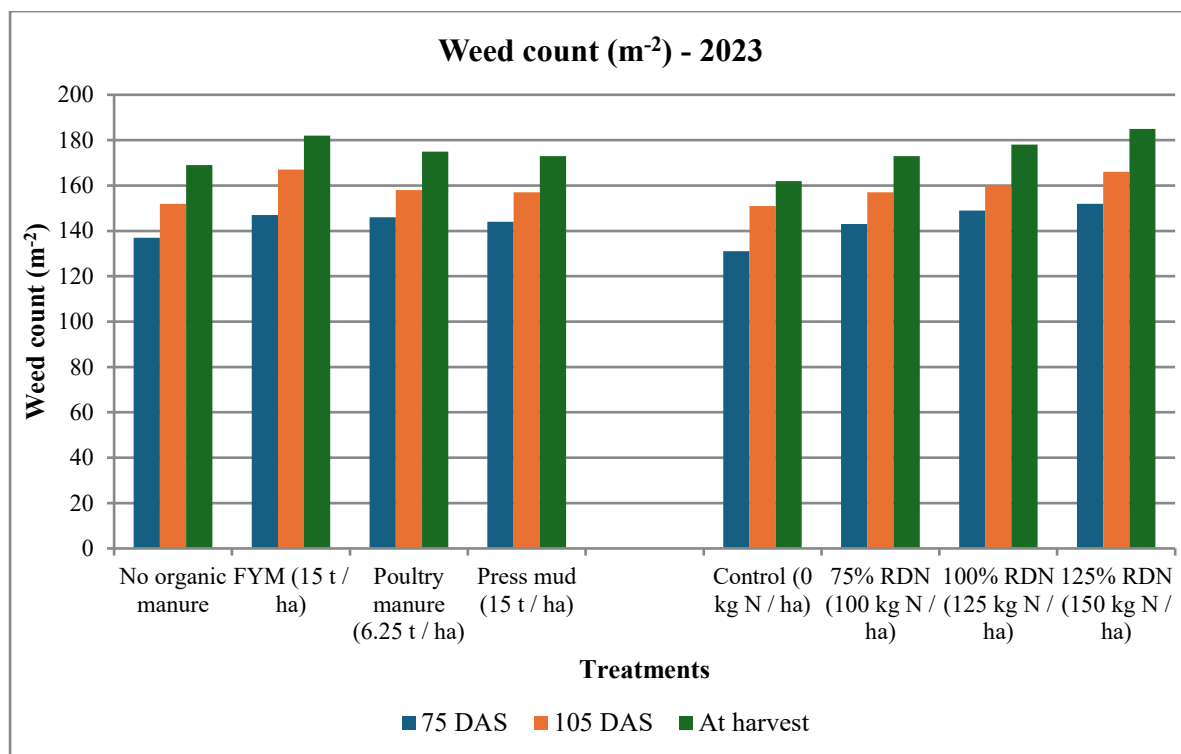


Figure 4.1.1 Effect of organic manures and nitrogen levels on weed count (m⁻²) during 2023 and 2024

4.1.2 Weed dry weight (q ha^{-1})

Weed dry matter is the most appropriate indices of crop yield losses due to weeds, as higher dry matter accumulation means more nutrient and water uptake by weeds and ultimately lowering crop yield. The data on weed dry weight recorded at 75, 105 DAS and at harvest has been mentioned in Table 4.1.2 and depicted on Figure 4.1.2.

The differences for weed dry weight recorded at 75 DAS, among the organic manure treatments was found to be non-significant during 2023 (Table 4.1.2). Among the nitrogen levels, weed dry weight in 125% RDN and 100% RDN was statistically at par with each other during 2023. Significantly less weed dry weight was recorded in 75% RDN as compared to 100% RDN and 125% RDN. Also, significantly lower weed dry weight was recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, weed dry weight remained non-significant among the various organic manure treatments (Table 4.1.2). Among the nitrogen levels, significantly more weed dry weight was recorded in 125% RDN as compared to other nitrogen levels. Significantly less weed dry weight was recorded in 100% RDN as compared to 125% RDN whereas the weed dry weight in 75% RDN was significantly more than 0% RDN. Significantly lower weed dry weight was recorded in 0% RDN as compared to other applied nitrogen levels.

At 105 DAS, weed dry weight remained non-significant among the various organic manures (Table 4.1.2) during 2023. Among the nitrogen levels, the weed dry weight recorded in 125% RDN was significantly higher as compared to other nitrogen levels. Weed dry weight in 75% RDN was significantly less as compared to 100% RDN and 125% RDN. Significantly lower weed dry weight was recorded in 0% RDN (control) as compared to all other nitrogen levels during 2023. The findings hold good for 2024 also. There was progressive significant increase in dry matter accumulation by weeds with each increment in dose of nitrogen from 0 kg N ha^{-1} to 125 kg N ha^{-1} during both years.

At harvest, weed dry weight during 2023 among various organic manures treatments was non-significant (Table 4.1.2). Among the nitrogen levels, weed dry weight in 125% RDN was significantly more than 100% RDN. Weed dry weight recorded in

75% RDN was significantly less than 125% RDN and 100% RDN. Significantly lower weed dry weight was recorded in 0% RDN as compared to all other nitrogen levels. During 2024, the differences in weed dry matter was non-significant among various organic manure treatments (Table 4.1.2). Among the nitrogen levels, weed dry weight in 125% RDN was significantly higher as compared to other nitrogen levels. Significantly less weed dry weight was recorded in 100% RDN as compared to 125% RDN. The weed dry weight recorded in 75% RDN was significantly less as compared to 125% RDN and 100% RDN. Significantly lower weed dry weight was recorded in 0% RDN as compared to all other nitrogen levels. There was progressive significant increase in dry matter accumulation by weeds with each increment in dose of nitrogen from 0 kg N ha⁻¹ to 125 kg N ha⁻¹ during both years.

The differences in dry matter accumulation among organic matter treatments was non-significant during both years indicating thereby that all type of organic manures used showed no effect on weed growth which may be due to blanket application of atrazine and pendimethalin as pre-emergence. The application of 100% RDN and 125% RDN produced more weed dry biomass at all the growth stages of the crop. The availability of nitrogen in abundance in higher dose may have resulted in higher dry matter accumulation (Raniro *et al.*, 2023 and Lindquist *et al.*, 2010).

The interactive effect of organic manures and nitrogen levels on weed dry weight was non-significant at all growth stages during 2023 and 2024 (Table 4.1.2).

Table 4.1.2. Effect of organic manures and nitrogen levels on weed dry weight (q ha⁻¹) at 75, 105 DAS and at harvest

	Weed dry weight (q ha ⁻¹)					
	75 DAS		105 DAS		At harvest	
	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)						
No organic manure	1.7 (2.1)	1.8 (2.3)	2.3 (4.4)	2.4 (4.9)	2.4 (4.7)	2.5 (5.1)
FYM (15 t ha ⁻¹)	1.8 (2.4)	1.9 (2.6)	2.4 (5.0)	2.6 (5.6)	2.5 (5.2)	2.7 (6.0)
Poultry manure (6.25 t ha ⁻¹)	1.8 (2.3)	1.8 (2.4)	2.4 (5.0)	2.4 (5.0)	2.5 (5.0)	2.5 (5.3)
Press mud (15 t ha ⁻¹)	1.8 (2.2)	1.9 (2.4)	2.4 (4.8)	2.5 (5.2)	2.5 (5.1)	2.5 (5.4)
SE(m) ±	0.03	0.02	0.02	0.03	0.03	0.03
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (N levels)						
Control (0 kg N ha ⁻¹)	1.6 (1.6)	1.7 (1.8)	2.2 (3.7)	2.2 (4.0)	2.2 (3.8)	2.3 (4.2)
75% RDN (100 kg N ha ⁻¹)	1.8 (2.1)	1.8 (2.3)	2.3 (4.5)	2.4 (5.0)	2.4 (4.7)	2.5 (5.3)
100% RDN (125 kg N ha ⁻¹)	1.9 (2.7)	1.9 (2.7)	2.5 (5.4)	2.6 (5.7)	2.6 (5.7)	2.6 (5.9)
125% RDN (150 kg N ha ⁻¹)	1.9 (2.7)	2.0 (2.9)	2.6 (5.6)	2.7 (6.1)	2.6 (5.8)	2.7 (6.5)
SE(m) ±	0.02	0.02	0.02	0.03	0.02	0.03
C.D. (5%)	0.06	0.05	0.07	0.07	0.06	0.07
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS
Note: Values in parenthesis are original values and values without parenthesis are transformed values. Square root transformation ($\sqrt{x + 1}$) was used						

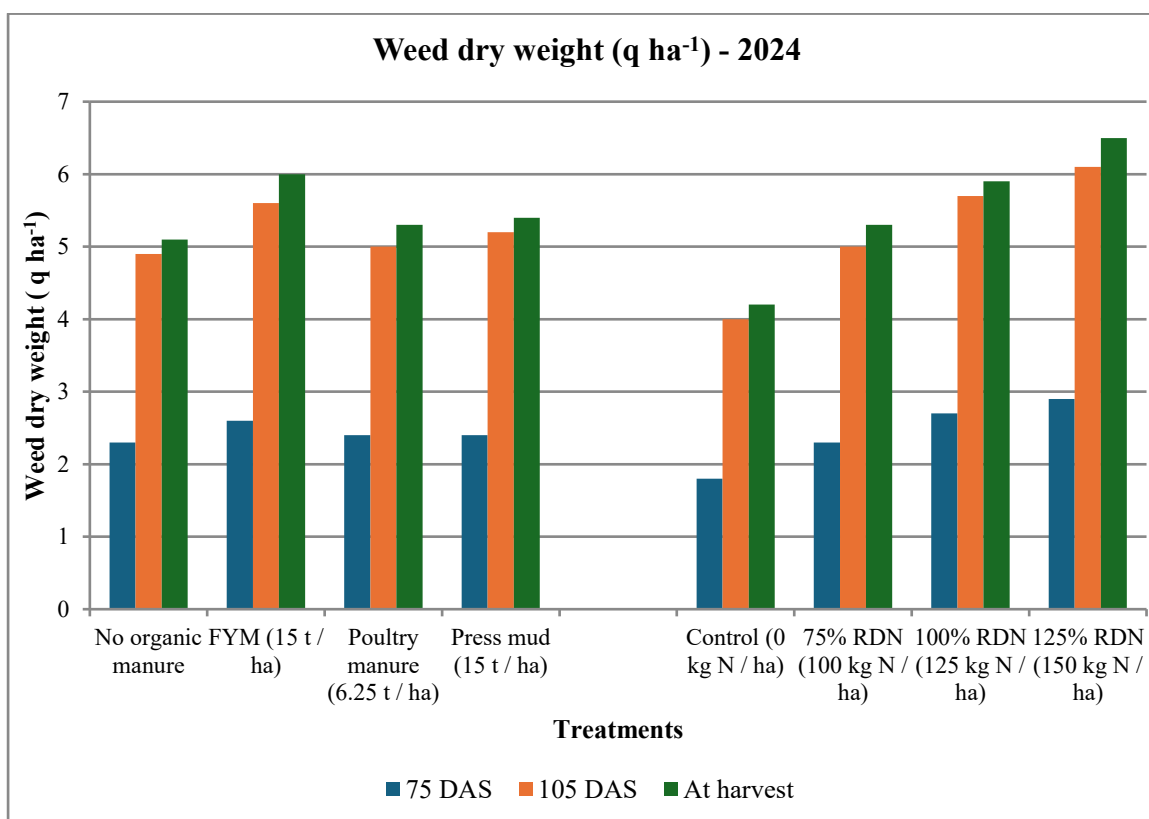
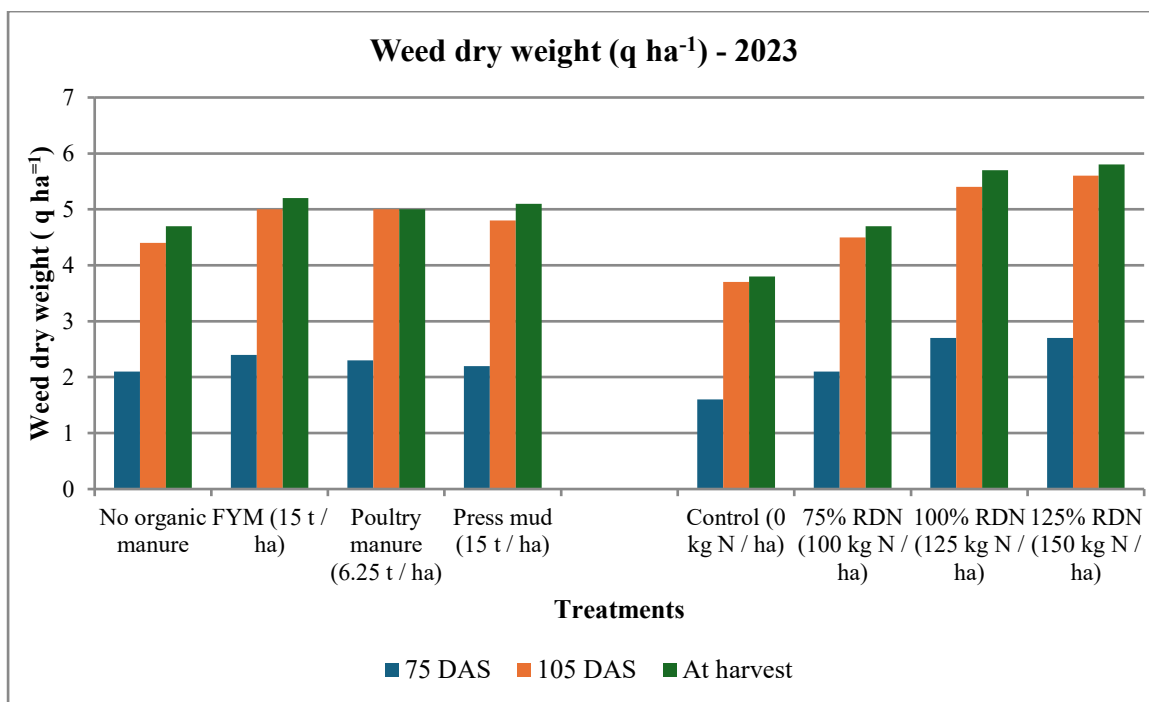


Figure 4.1.2 Effect of organic manures and nitrogen levels on weed dry weight (q ha⁻¹) during 2023 and 2024

4.2. Plant growth parameters

4.2.1 Plant height (cm)

The plant height is a critical element in assessing crop productivity. However, plant height is mainly governed by genetic potential and adoption of agronomic practices. The differences in plant height recorded at 45, 75, 105 DAS and harvest has been presented in Table 4.2.1 and depicted in Figure 4.2.1.

The differences in plant height (cm) due to organic manure treatments when recorded at 45 DAS was found to be non-significant (Table 4.2.1) during 2023. Among the N levels, the plant height in 100% RDN and 125% RDN was statistically at par with each other. Plant height was significantly more in 75% RDN as compared to control (0% RDN). Significantly lower plant height was recorded in control (0 kg N ha¹) as compared to all other nitrogen levels. These findings hold good for 2024 also.

At 75 DAS, the differences in plant height (cm) was found to be significant for organic manures and nitrogen level treatments (Table 4.2.1). Among organic manures, the plant height recorded during 2023 in poultry manure and FYM was statistically at par among themselves (Table 4.2.1) and both these treatments produced significantly more plant height than press mud. No organic manure treatment recorded significantly lower plant height as compared to other organic manure treatments. Among the nitrogen levels, the plant height during 2023 in 100% RDN and 125% RDN was statistically at par among themselves. Significantly less plant height was recorded in 75% RDN as compared to 100 % RDN and 125 % RDN. The control (0 % RDN) treatment recorded significantly lower plant height as compared to all other nitrogen levels. These findings hold good for 2024 also.

The differences in plant height (cm) recorded at 105 DAS were found to be significant during 2023 and 2024 and data was presented in Table 4.2.1. During 2023, among the organic manures, the plant height in poultry manures and FYM was statistically at par. The plant height recorded in press mud was found to be statistically at par with FYM but significantly less than poultry manure. Significantly lower plant height was recorded in no organic manure as compared to all other organic manures. Among the

nitrogen levels, plant height recorded at 105 DAS was statistically at par among 100% RDN and 125% RDN. Significantly more plant height was recorded in 75% RDN as compared to 0% RDN (control). The plant height was significantly lower in control (0% RDN) as compared to all other nitrogen levels. These findings hold good for 2024 also.

At harvest during 2023, plant height (cm) was influenced significantly by organic manures and nitrogen level treatments (Table 4.2.1). Among the organic manure treatments, during 2023, the plant height in poultry manure was statistically at par with FYM. Significantly less plant height was recorded in press mud as compared to poultry manure and FYM. The plant height was significantly lower in no organic manure as compared to other organic manure treatments. Among the nitrogen levels, the plant height was statistically at par in 125% RDN and 100% RDN and it was significantly more than other nitrogen levels. The plant height in 75% RDN was significantly more than 0% RDN (control). The significantly less plant height was recorded in 0% RDN as compared to other nitrogen levels. During 2024, among the organic manures, plant height in poultry manure and FYM was found to be statistically at par with each other (Table 4.2.1). Press mud recorded significantly less plant height as compared to poultry manure and FYM. No organic manure recorded significantly lower plant height as compared to all organic manure treatments. Among the nitrogen levels, plant height in 125% RDN was statistically at par with 100% RDN. The application of 75% RDN recorded significantly less plant height as compared to 125% RDN and 100% RDN. The control (0% RDN) recorded significantly lower plant height as compared to all other nitrogen levels. Similar findings were reported by Dwivedi *et al.* (2022) and Mahat *et al.* (2023).

Overall, it can be concluded that plant height was more in organic manures especially poultry manure and FYM as compared to no organic manure that may be due to improved soil physical conditions with the application of these manures (Mbabah *et al.*, 2024). Plant height was more with application of 100% RDN and 125% RDN as compared to other lower nitrogen levels as sufficient amount of nitrogen was available for plant growth in former treatments. Plant height was less in control where no nitrogen was applied due to less crop growth (Zou *et al.*, 2024).

The interactive effect of organic manures and nitrogen levels on periodic plant height was found to be non-significant at all growth stages during 2023 and 2024 (Table 4.2.1).

Table 4.2.1 Plant height (cm) at 45, 75, 105 DAS and at harvest as influenced by organic manures and nitrogen levels

	Plant height (cm)							
	45 DAS		75 DAS		105 DAS		At harvest	
	2023	2024	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)								
No organic manure	54.3	55.5	155.4	139.8	168.5	166.0	175.6	169.0
FYM (15 t ha ⁻¹)	59.9	55.0	169.9	151.2	178.6	175.3	186.3	177.6
Poultry manure (6.25 t ha ⁻¹)	57.7	55.8	172.3	152.8	181.6	177.3	189.8	179.7
Press mud (15 t ha ⁻¹)	58.3	53.2	164.9	143.8	173.6	172.5	180.3	175.0
SE(m) ±	1.78	2.08	1.43	1.34	2.12	1.35	1.51	0.67
C.D. (5%)	NS	NS	4.65	4.34	6.86	4.39	4.88	2.19
Sub-plots (N levels)								
Control (0 kg N ha ⁻¹)	49.6	42.4	143.0	113.7	154.5	148.9	161.7	151.5
75% RDN (100 kg N ha ⁻¹)	56.1	58.5	165.5	153.7	175.7	173.8	184.9	177.0
100% RDN (125 kg N ha ⁻¹)	61.1	59.2	176.0	159.6	185.2	182.9	191.6	185.5
125% RDN (150 kg N ha ⁻¹)	63.3	59.5	178.0	160.6	186.9	185.6	193.9	187.3
SE(m) ±	1.06	1.09	0.84	1.16	0.92	1.12	0.96	0.95
C.D. (5%)	3.06	3.13	2.43	3.33	2.64	3.21	2.77	2.74
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS	NS	NS

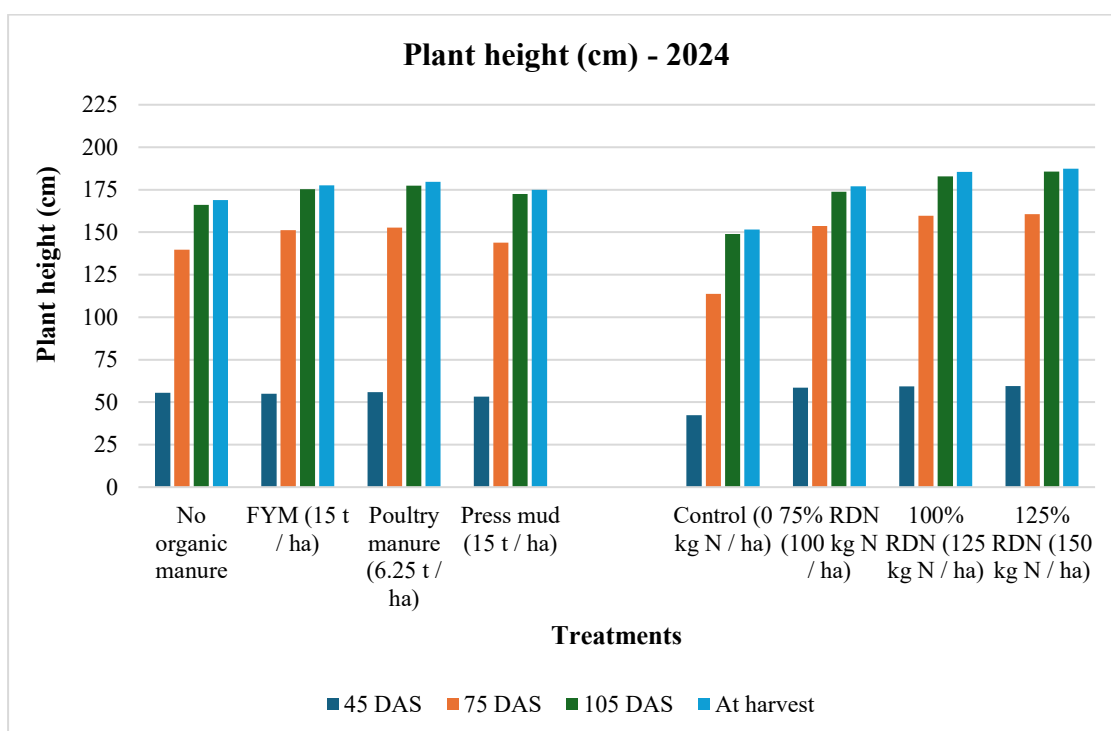
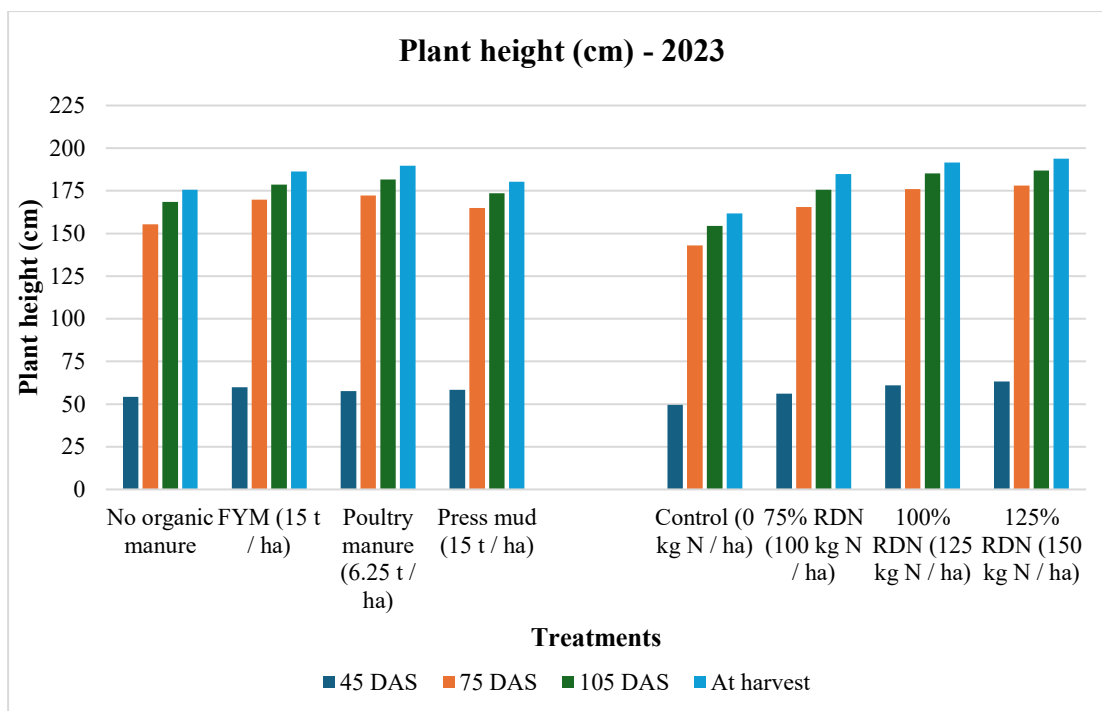


Figure 4.2.1 Effect of organic manures and nitrogen levels on plant height (cm) during 2023 and 2024

4.2.2 Plant dry weight (g plant⁻¹)

Plant dry weight indicates the dry matter accumulation by the crop. It gives reliable measure of actual biomass of crop that allows more accurate comparisons among different treatments. It also enables to assess crop growth and yield performance. The crop dry weight data recorded at 45, 75 and 105 DAS has been presented in Table 4.1.2 and depicted in Figure 4.2.2.

The differences in plant dry weight (g plant⁻¹) when recorded at 45 DAS were found to be significant for organic manures and nitrogen levels during 2023 (Table 4.2.2). Among the organic manures, plant dry weight was significantly higher in poultry manure as compared to all other organic manures. Plant dry weight in FYM was at par with press mud treatment but it was significantly less than poultry manure. Significantly lower plant dry weight was recorded in no organic manure as compared to other organic manure treatments. Among the nitrogen levels, the plant dry weight in 125% RDN and 100% RDN were found to be statistically at par with each other. The plant dry weight recorded in 75% RDN was significantly more than 0% RDN (control) and significantly less than 100% RDN and 125% RDN. The plant dry weight was significantly lower in 0% RDN (control) as compared to all other nitrogen levels. During 2024, among the organic manures, the plant dry weight was significantly higher in poultry manure as compared to all other organic treatments (Table 4.2.2). FYM and press mud recorded at par plant dry weight among themselves. Significantly less plant dry weight was recorded in no organic manure as compared to all other organic manures treatments. Among the nitrogen levels, the plant dry weight in 125% RDN and 100% RDN were statistically at par with each other. The application of 75% RDN recorded significantly less plant dry weight as compared to 100% RDN and 125% RDN. The plant dry weight recorded in 0% RDN was significantly lower as compared to all other nitrogen levels.

At 75 DAS, the plant dry weight (g plant⁻¹) was influenced significantly by organic manures and nitrogen levels during 2023 (Table 4.2.2). Among various organic manures, the plant dry weight recorded in poultry manure was found to be statistically at par with FYM and press mud treatment. Significantly lower plant dry weight was

recorded in no organic manure as compared to all other organic manure treatments. Among the nitrogen levels, the plant dry weight recorded in 125% RDN was statistically at par with 100% RDN. Significantly less plant dry weight was recorded in 75% RDN as compared to 100% and 125% RDN. Significantly lower plant dry weight was recorded in 0% RDN (control) as compared to all other nitrogen levels. Similar findings were obtained during second year also.

The differences in plant dry weight (g plant^{-1}) recorded at 105 DAS were found to be significant among various organic manures during 2023 (Table 4.2.2). Among the organic manures, plant dry weight recorded in poultry manure was found to be at par with FYM. Press mud recorded statistically at par plant dry weight with FYM but significantly less than poultry manure. Significantly lower plant dry weight was recorded in no organic manures as compared to all other organic manures. Among the nitrogen levels, plant dry weight in 100% RDN and 125% RDN were statistically at par among themselves. The plant dry weight recorded in 75% RDN was significantly less as compared to 100% and 125% RDN. Significantly lower plant dry weight was recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, among the organic manures, plant dry weight in poultry manure was found to be statistically at par with FYM (Table 4.2.2). Plant dry weight produced in press mud was found to be at par with FYM. No organic manure treatment recorded significantly lower plant dry weight as compared to all other organic manures. Among the nitrogen levels, plant dry weight recorded in 125% RDN was statistically at par with 100% RDN. Significantly less plant dry weight was recorded in 75% RDN as compared to 100% RDN and 125% RDN. The plant dry weight recorded in 0% RDN (control) was significantly lower than all other nitrogen levels.

Better nutrition with application of all organic manure treatments may be the reason for higher plant dry matter accumulation as compared to control (no organic manure) (Sigaye *et al.*, 2020). Application of 100% RDN and 125% RDN may have provided sufficient nitrogen for optimum photosynthesis resulting in improved plant dry matter accumulation in these treatments (Mahat *et al.*, 2023).

The interactive effect of organic manures and nitrogen levels on plant dry weight was non-significant at 45, 75 and 105 DAS during 2023 and 2024 (Table 4.2.2).

Table 4.2.2. Effect of organic manures and nitrogen levels on plant dry weight (g plant⁻¹) at 45, 75 and 105 DAS

	Plant dry weight (g plant ⁻¹)					
	45 DAS		75 DAS		105 DAS	
	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)						
No organic manure	52.3	47.1	162.0	170.1	221.4	228.0
FYM (15 t ha ⁻¹)	60.4	54.4	184.2	193.4	253.5	261.1
Poultry manure (6.25 t ha ⁻¹)	65.0	58.5	185.6	194.9	260.3	268.1
Press mud (15 t ha ⁻¹)	59.8	53.8	177.4	186.3	240.6	247.8
SE(m) ±	0.56	0.50	4.00	4.20	4.60	4.74
C.D. (5%)	1.82	1.64	12.94	13.59	14.91	15.36
Sub-plots (N levels)						
Control (0 kg N ha ⁻¹)	41.0	36.9	142.3	149.4	166.8	171.8
75% RDN (100 kg N ha ⁻¹)	56.1	50.5	168.5	176.9	242.9	250.2
100% RDN (125 kg N ha ⁻¹)	69.6	62.6	196.1	205.9	279.1	287.5
125% RDN (150 kg N ha ⁻¹)	71.0	63.9	202.4	212.5	287.1	295.7
SE(m) ±	0.51	0.46	2.48	2.60	5.55	5.72
C.D. (5%)	1.47	1.32	7.14	7.50	15.99	16.47
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

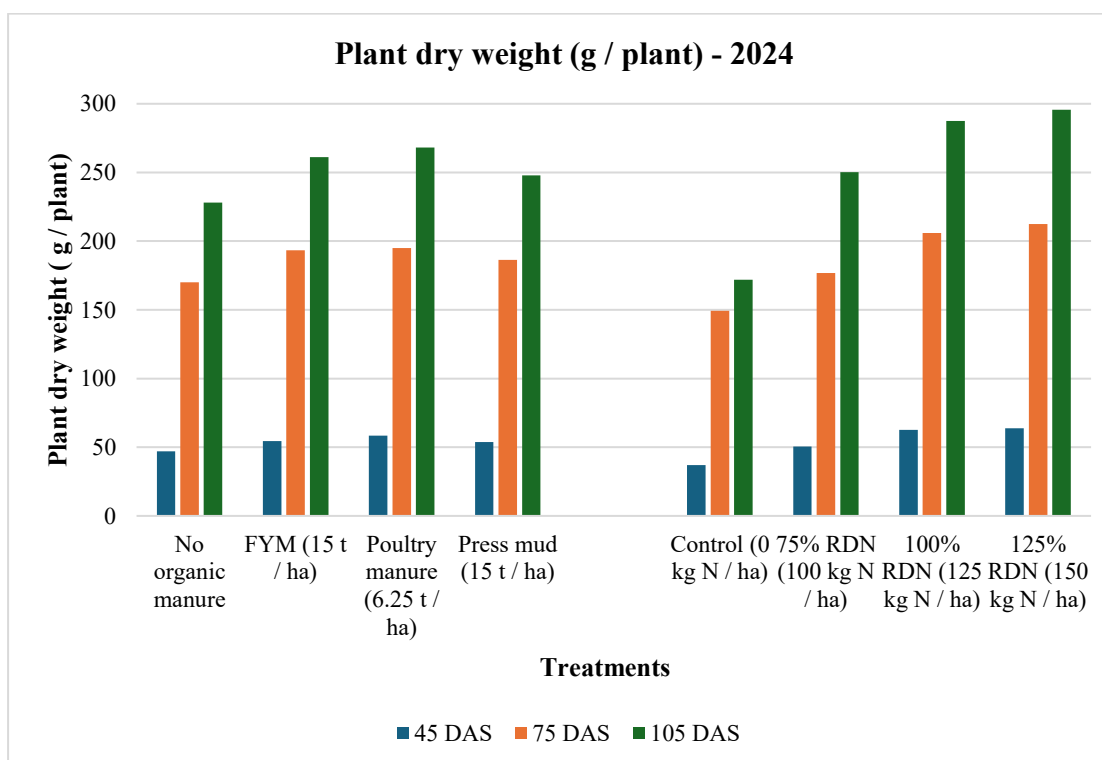
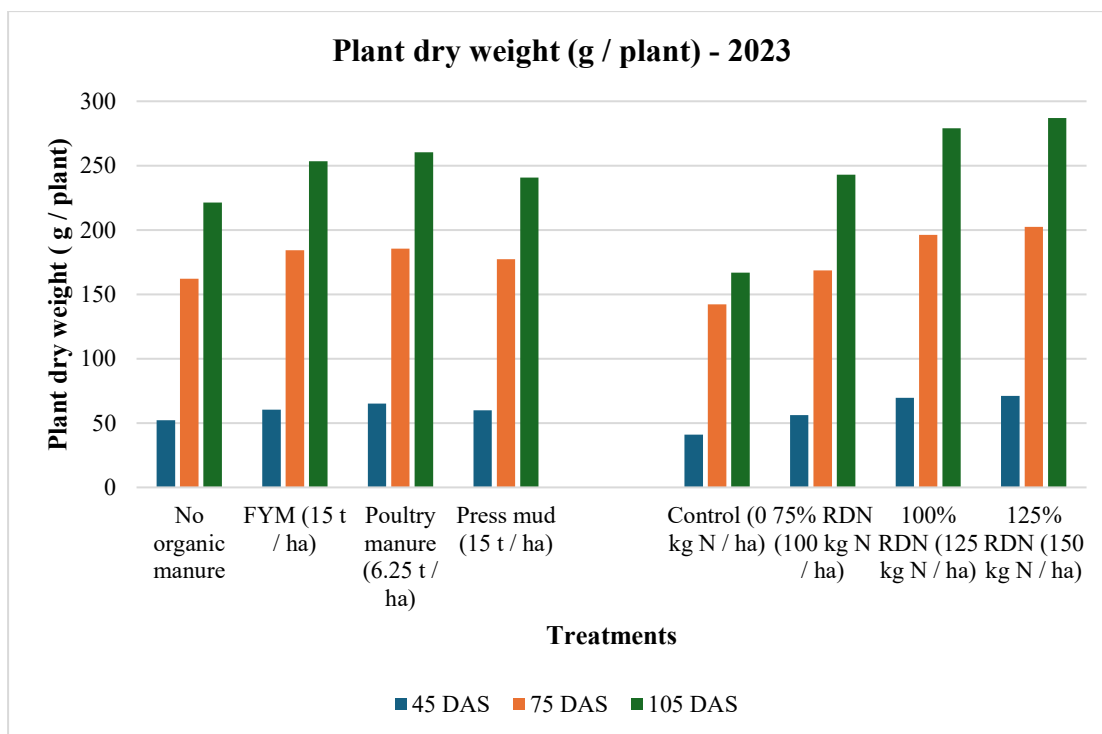


Figure 4.2.2 Effect of organic manures and nitrogen levels on plant dry weight (g plant⁻¹) during 2023 and 2024

4.2.3 Number of leaves per plant

The number of leaves per plant are also important as photosynthesis is performed by leaves which determines the food production potential of a crop. The data on the number of leaves per plant recorded at 45, 75, 105 DAS and at harvest has been presented in Table 4.2.3 and depicted in Figure 4.2.3.

At 45 DAS during 2023, the differences in the number of leaves per plant were non-significant among organic manures (Table 4.2.3). Among the nitrogen levels, the number of leaves per plant in 125% RDN and 100% RDN were statistically at par. Significantly less number of leaves per plant were recorded in 75% RDN as compared to 100% RDN and 125% RDN. The number of leaves per plant were significantly less in 0% RDN (control) as compared to all other nitrogen levels. During 2024, the number of leaves per plant were non-significant among organic manures. Among nitrogen levels, the number of leaves per plant in 125% RDN, 100% RDN and 75% RDN were statistically at par with each other. The number of leaves were significantly lower in 0% RDN as compared to 100% RDN and 125% RDN.

At 75 DAS, the number of leaves per plant during 2023 differed significantly among various organic manures (Table 4.2.3). The number of leaves in poultry manure, FYM and press mud were statistically at par with each other. Significantly less number of leaves were recorded in no organic manure as compared to poultry manure and farmyard manure treatments. However, number of leaves per plant in press mud and no organic manure treatments were found at par. Among the nitrogen levels, the number of leaves per plant in 125% RDN were statistically at par with 100% RDN. Significantly less number of leaves per plant were recorded in 75% RDN as compared to 100% and 125% RDN. Significantly lower number of leaves per plant were recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, among the organic manures, number of leaves per plant in poultry manure and FYM were statistically at par (Table 4.2.3). Press mud recorded statistically at par number of leaves per plant with FYM. Significantly lower number of leaves per plant were recorded in no organic manure as compared to poultry manure and FYM. Among the nitrogen levels, 100% RDN recorded statistically at par number of leaves per plant

with 125% RDN. The number of leaves per plant recorded in 75% RDN were significantly less as compared to 100% and 125% RDN. Also, significantly lower number of leaves per plant were recorded in 0% RDN (control) as compared to all other nitrogen levels.

At 105 DAS, the differences in number of leaves were non-significant among the various organic manure treatments (Table 4.2.3) during 2023. Among the nitrogen levels, the number of leaves per plant in 125% RDN were statistically at par with 100% RDN. Significantly less number of leaves were recorded in 75% RDN as compared to 100% RDN and 125% RDN. Application of 0% RDN (control) recorded significantly less number of leaves per plant as compared to all other nitrogen levels. The findings hold good for second year also.

At harvest, the differences in number of leaves per plant were non-significant among various organic manures during 2023 (Table 4.2.3). Among the nitrogen levels, number of leaves per plant in 125% RDN and 100 % RDN were found to be statistically at par. Number of leaves recorded in 75%RDN were statistically at par with 100% RDN. Significantly lower number of leaves per plant were recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, among the organic manures, the number of leaves per plant remained non-significant at harvest (Table 4.2.3). Among nitrogen levels, the number of leaves per plant in 125% RDN were statistically at par with 100% RDN. Significantly less number of leaves per plant were recorded in 75% RDN than 100% RDN and 125% RDN. Also, significantly lower number of leaves per plant were recorded in 0% RDN as compared to all other nitrogen levels.

More number of leaves in FYM and poultry manure may be due to more availability of nutrients as compared to press mud treatment and no organic manure treatment (Ali *et al.*, 2017). Higher number of leaves under 100 % RDN and 125% RDN can be attributed to sufficient nitrogen available for photosynthesis leading to better growth of crop plant (Tofa *et al.*, 2022).

The interactive effect of organic manures and nitrogen levels on the number of leaves per plant was non-significant at all growth stages during 2023 and 2024 (Table 4.2.3).

Table 4.2.3. Effect of organic manures and nitrogen levels on number of leaves per plant at 45, 75, 105 DAS and at harvest

	Number of leaves per plant							
	45 DAS		75 DAS		105 DAS		At harvest	
	2023	2024	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)								
No organic manure	7.6	7.8	12.4	10.8	12.9	12.2	2.6	3.8
FYM (15 t ha ⁻¹)	8.4	8.5	12.9	11.5	13.9	13.0	2.8	4.2
Poultry manure (6.25 t ha ⁻¹)	8.5	8.6	13.1	11.8	13.7	13.0	2.8	4.1
Press mud (15 t ha ⁻¹)	8.2	8.1	12.7	11.1	13.4	12.6	2.7	4.0
SE(m) ±	0.24	0.12	0.14	0.16	0.22	0.20	0.10	0.10
C.D. (5%)	NS	NS	0.44	0.50	NS	NS	NS	NS
Sub-plots (N levels)								
Control (0 kg N ha ⁻¹)	7.5	8.0	10.9	9.9	11.8	10.5	2.5	3.3
75% RDN (100 kg N ha ⁻¹)	8.1	8.2	12.8	11.4	13.4	12.7	2.7	4.0
100% RDN (125 kg N ha ⁻¹)	8.5	8.4	13.6	11.9	14.2	13.7	2.8	4.3
125% RDN (150 kg N ha ⁻¹)	8.5	8.4	13.9	12.0	14.5	13.9	2.9	4.4
SE(m) ±	0.11	0.09	0.13	0.13	0.14	0.13	0.01	0.10
C.D. (5%)	0.33	0.26	0.37	0.36	0.39	0.38	0.10	0.27
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS	NS	NS

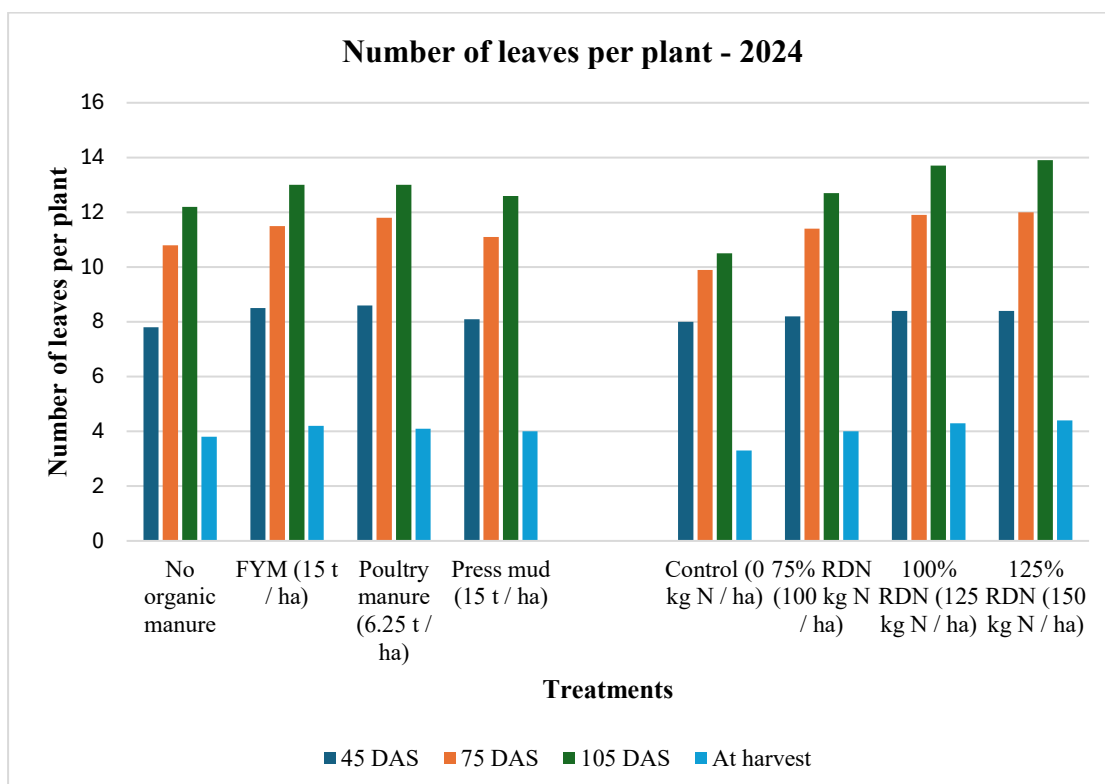
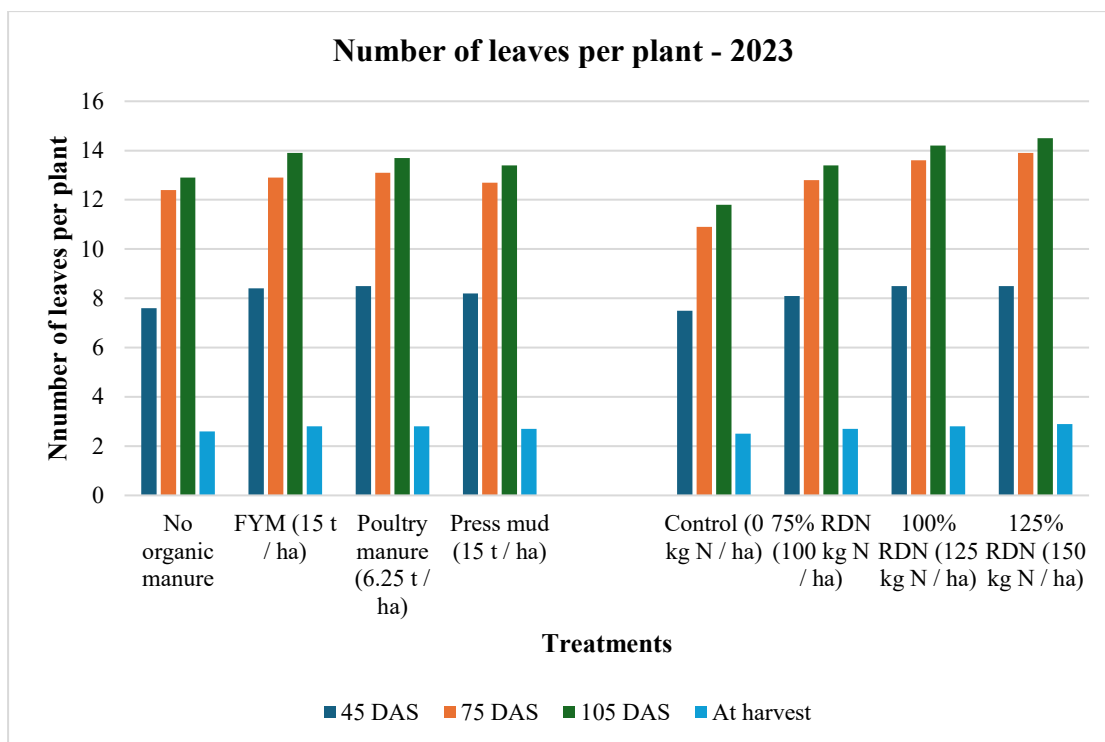


Figure 4.2.3 Effect of organic manures and nitrogen levels on number of leaves per plant during 2023 and 2024

4.2.4 Number of nodes per plant

A plant node is structure that connects petiole to the stem. The plant leaves in maize originate from nodes itself. It becomes an important parameter to record number of nodes per plant. The data on the number of nodes per plant recorded at 45, 75 DAS and at harvest has been presented in Table 4.2.4.

At 45 DAS, the differences in number of nodes per plant during 2023 were found to be significant (Table 4.2.4). Among organic manures, the number of nodes per plant in poultry manure and FYM were statistically at par with press mud treatment. Number of nodes per plant in press mud treatment were found to be at par with no organic manure treatment. No organic manure treatment recorded significantly lower number of nodes per plant as compared to poultry manure and FYM. Among the nitrogen levels, the number of nodes per plant in 125% RDN and 100% RDN were statistically at par. The number of nodes per plant were significantly lower in 0% RDN (control) as compared to 125% RDN and 100% RDN. During 2024, the number of leaves per plant in poultry manure and FYM were statistically at par (Table 4.2.4). Press mud recorded significantly less number of nodes per plant as compared to poultry manure. Significantly lower number of nodes per plant were recorded in no organic manure as compared to all organic manures except press mud treatment. Among nitrogen levels, the number of nodes per plant in 125% RDN, 100% RDN and 75% RDN were statistically at par with each other. The application of 75% RDN recorded significantly less number of nodes per plant as compared to 100% RDN and 125% RDN. The number of nodes were significantly lower in 0% RDN as compared to 125% RDN and 100% RDN.

At 75 DAS, the number of nodes per plant differed significantly among various organic manures during 2023 (Table 4.2.4). The number of nodes in poultry manure and FYM were statistically at par with each other. The number of nodes per plant recorded in press mud were statistically at par with each other. Significantly lower number of leaves were recorded in no organic manure as compared to all other organic manure treatments. Among the nitrogen levels, the number of nodes per plant in 125% RDN were significantly higher than other nitrogen levels. Significantly less

number of nodes per plant were recorded in 75% RDN as compared to 100% and 125% RDN. Also, significantly lower number of nodes per plant were recorded in 0% RDN (control) as compared to all other nitrogen levels. These findings hold good for 2024 also.

At harvest, among the organic manures, number of nodes per plant in poultry manure, FYM and press mud were statistically at par with each other during 2023 (Table 4.2.4). Significantly lower number of nodes per plant were recorded in no organic manure as compared to poultry manure and FYM. The number of nodes per plant in press mud were found at par with no organic manure treatment. Among the nitrogen levels, the number of nodes per plant in 100% RDN and 125% RDN were statistically at par among themselves. The number of nodes per plant recorded in 75% RDN were significantly less as compared to 100% and 125% RDN. Significantly lower number of nodes per plant were recorded in 0% RDN (control) as compared to all other nitrogen levels during 2023. The results obtained also hold good for second year.

Higher number of nodes per plant at all periodic intervals in poultry manure and FYM treatments as compared to press mud treatment may be due to more concentration of nutrients in the former organic manures (Maurya *et al.*, 2021). More number of nodes per plant with application of 100% RDN and 125% RDN may be due to better crop growth under these treatments (Singh *et al.*, 2012).

The interactive effect of organic manures and nitrogen levels on the number of nodes per plant was non-significant at all growth stages during 2023 and 2024 (Table 4.2.4).

Table 4.2.4. Effect of organic manures and nitrogen levels on the number of nodes per plant at 45, 75 DAS and at harvest

	Number of nodes per plant					
	45 DAS		75 DAS		At harvest	
	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)						
No organic manure	7.7	7.9	12.5	10.9	13.0	12.3
FYM (15 t ha ⁻¹)	8.5	8.6	13.0	11.6	14.0	13.1
Poultry manure (6.25 t ha ⁻¹)	8.6	8.7	13.2	11.8	13.9	13.0
Press mud (15 t ha ⁻¹)	8.3	8.2	12.9	11.2	13.5	12.6
SE(m) ±	0.19	0.11	0.09	0.13	0.20	0.18
C.D. (5%)	0.62	0.36	0.28	0.43	0.64	0.57
Sub-plots (N levels)						
Control (0 kg N ha ⁻¹)	7.6	8.1	11.0	9.9	12.0	10.6
75% RDN (100 kg N ha ⁻¹)	8.2	8.3	12.9	11.5	13.5	12.8
100% RDN (125 kg N ha ⁻¹)	8.6	8.5	13.7	12.0	14.3	13.7
125% RDN (150 kg N ha ⁻¹)	8.7	8.5	14.0	12.1	14.6	14.0
SE(m) ±	0.10	0.07	0.10	0.11	0.13	0.12
C.D. (5%)	0.28	0.21	0.29	0.33	0.38	0.36
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

4.2.5 Stem girth (mm)

The good performance of maize crop lies on the diameter of the stem and it can also be indicative of the plant health and strength which resist to lodging. The data on periodic stem girth recorded 75, 105 DAS and at harvest has been presented in Table 4.2.5.

The differences in stem girth (mm) when recorded at 75 DAS were found to be non-significant among the organic manure treatments during 2023 (Table 4.2.5). Among the nitrogen levels, the stem girth (mm) in 125% RDN and 100% RDN were found to be statistically at par and significantly better than 75% RDN. The stem girth was significantly lower in 0% RDN (control) as compared to all other nitrogen levels. During 2024, the stem girth among various organic manures was found to be non-significant (Table 4.2.5). Among the nitrogen levels, the stem girth in 125% RDN and 100% RDN were statistically at par with each other. The treatment of 75% RDN recorded significantly less stem girth as compared to 100% RDN and 125% RDN. The stem girth recorded in 0% RDN was significantly less as compared to all other nitrogen levels.

At 105 DAS, the stem girth (mm) during 2023 was found to be non-significant among various organic manures (Table 4.2.5). Among the nitrogen levels, stem girth recorded in 125% RDN was statistically at par with 100% RDN. Significantly less stem girth was recorded in 75% RDN as compared to 100% and 125% RDN. Significantly lower stem girth was recorded in 0% RDN (control) as compared to all other nitrogen levels during 2023. These findings hold good for second year also.

The differences in stem girth (mm) recorded at harvest during 2023 was found to be non-significant among various organic manures (Table 4.2.5). Among the nitrogen levels, stem girth in 100% RDN and 125% RDN were statistically at par among themselves. The stem girth recorded in 75% RDN were significantly less as compared to 100% and 125% RDN. Significantly lower stem girth was recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, stem girth at harvest was non-significant among the various organic manure treatments (Table 4.2.5). Among the nitrogen levels, stem girth recorded in 125% RDN was statistically at par

with 100% RDN. Significantly less stem girth was recorded in 75% RDN as compared to 100% RDN and 125% RDN. Stem girth was significantly less in 0% RDN as compared to all other nitrogen levels.

It can be concluded that stem girth (mm) was higher with application of 100% RDN and 125% RDN which may have provided sufficient nitrogen for proper growth and development of the crop (Sravankumar *et al.*, 2023 and Matusso *et al.*, 2016).

The interactive effect of organic manures and nitrogen levels on stem girth was non-significant at all growth stages during 2023 and 2024 (Table 4.2.5).

Table 4.2.5. Effect of organic manures and nitrogen levels on stem girth (mm) at 75, 105 DAS and at harvest

	Stem girth (mm)					
	75 DAS		105 DAS		At harvest	
	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)						
No organic manure	16.0	14.2	18.0	17.6	17.0	16.2
FYM (15 t ha ⁻¹)	17.0	14.7	19.5	18.4	18.1	17.0
Poultry manure (6.25 t ha ⁻¹)	16.7	14.5	18.5	18.3	17.0	16.8
Press mud (15 t ha ⁻¹)	16.3	14.3	18.6	18.1	17.1	16.9
SE(m) ±	0.39	0.18	0.49	0.38	0.53	0.25
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (N levels)						
Control (0 kg N ha ⁻¹)	14.3	11.8	16.2	15.1	15.0	13.9
75% RDN (100 kg N ha ⁻¹)	16.8	14.8	18.1	18.4	16.7	16.8
100% RDN (125 kg N ha ⁻¹)	17.4	15.5	19.9	19.5	18.4	18.1
125% RDN (150 kg N ha ⁻¹)	17.6	15.5	20.4	19.5	18.9	18.1
SE(m) ±	0.28	0.18	0.37	0.31	0.34	0.25
C.D. (5%)	0.82	0.51	1.05	0.89	0.97	0.71
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

4.2.6 Internodal length (cm)

Internodal length is related with the plant height, as increase in internode length can lead to more plant height. It also determines the distance among the leaves. The data on periodic internode length recorded at 75, 105 DAS and at harvest has been presented in Table 4.2.6.

The differences in internodal length (cm) when recorded at 75 DAS were found to be non-significant among the organic manure treatments during 2023 (Table 4.2.6). Among the nitrogen levels, the internodal length recorded in 125% RDN and 100% RDN was found to be statistically at par with each other. Internodal length recorded in 75% RDN was significantly less in comparison to 100% RDN and 125% RDN. The internodal length was significantly lower in 0% RDN (control) as compared to all other nitrogen levels. Similar findings were observed during second year also.

At 105 DAS, the internodal length (cm) recorded during 2023 was found to be non-significant among various organic manure treatments (Table 4.2.6) during 2023. Among the nitrogen levels, internode length recorded in 125% RDN was statistically at par with 100% RDN. Significantly less internodal length was recorded in 75% RDN as compared to 100% and 125% RDN. Significantly less internode length was recorded in 0% RDN (control) as compared to all other nitrogen levels during 2023. These findings hold good for 2024 also.

The differences in internodal length (cm) recorded at harvest were found to be non-significant among various organic manure treatments during 2023 (Table 4.2.6). Among the nitrogen levels, internodal length in 100% RDN and 125% RDN was found to be statistically at par among themselves. The internodal length recorded in 75% RDN were significantly less as compared to 100% and 125% RDN. Significantly lower internodal length was recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, the internodal length at harvest was non-significant among the various organic manure treatments. Among the nitrogen levels, internodal length recorded in 125% RDN was statistically at par with 100% RDN. Significantly less internodal length was recorded in 75% RDN as compared to 100% RDN and

125% RDN. Internodal length was significantly lower in 0% RDN as compared to all other nitrogen levels.

More internodal length (cm) at all periodic intervals was recorded in 125% RDN and 100% RDN treatments as crop received optimum dose of nitrogen for its proper growth and development (Gheith *et al.*, 2022 and Maurya *et al.*, 2021).

The interactive effect of organic manures and nitrogen levels on internodal length was non-significant at all growth stages during 2023 and 2024 (Table 4.2.6).

Table 4.2.6. Internodal length (cm) at 75, 105 DAS and at harvest as influenced by organic manures and nitrogen levels

	Internodal length (cm)					
	75 DAS		105 DAS		At harvest	
	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)						
No organic manure	10.07	12.89	11.55	12.91	12.90	13.02
FYM (15 t ha ⁻¹)	10.52	13.09	12.16	13.13	13.65	13.28
Poultry manure (6.25 t ha ⁻¹)	10.53	13.44	12.17	13.57	13.70	13.71
Press mud (15 t ha ⁻¹)	10.34	13.18	11.94	13.25	13.43	13.41
SE(m) ±	0.44	0.16	0.51	0.15	0.50	0.15
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (N levels)						
Control (0 kg N ha ⁻¹)	8.55	11.74	9.85	11.82	11.03	12.07
75% RDN (100 kg N ha ⁻¹)	10.41	13.27	12.02	13.35	13.49	13.46
100% RDN (125 kg N ha ⁻¹)	11.13	13.78	12.84	13.84	14.41	13.94
125% RDN (150 kg N ha ⁻¹)	11.37	13.80	13.11	13.86	14.75	13.94
SE(m) ±	0.15	0.11	0.17	0.09	0.20	0.09
C.D. (5%)	0.43	0.32	0.49	0.26	0.58	0.27
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

4.2.7 Chlorophyll index (SPAD value)

Chlorophyll index gives the indication about the health of the plant as it provides the estimate of nitrogen sufficiency or deficiency in the crop plant which impacts the growth and yield of the crop. The data on chlorophyll index recorded at 45, 75 and 105 DAS has been presented in Table 4.2.7.

The differences in chlorophyll index when recorded at 45 DAS were found to be non-significant among the organic manure treatments during 2023 (Table 4.2.7). Among the nitrogen levels, the chlorophyll index recorded in 125% RDN and 100% RDN was found to be statistically at par with each other. The chlorophyll index recorded in 75% RDN was significantly less as compared to 100% RDN and 125% RDN. The chlorophyll index was significantly less in 0% RDN (control) in comparison to all other nitrogen levels. During 2024, the chlorophyll index among various organic manure treatments was found to be non-significant (Table 4.2.7). Among the nitrogen levels, the chlorophyll index was significantly higher in 125% RDN as compared to all other nitrogen levels. The chlorophyll index recorded in 75% RDN was significantly less as compared to 100% RDN and 125% RDN. The chlorophyll index recorded in 0% RDN was significantly lower compared to all other nitrogen levels.

At 75 DAS, the chlorophyll index was found to be non-significant among various organic manure treatments (Table 4.2.7). Among the nitrogen levels, the chlorophyll index recorded in 125% RDN was statistically at par with 100% RDN. Significantly less chlorophyll index was recorded in 75% RDN as compared to 100% and 125% RDN. Significantly lower chlorophyll index was recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, the chlorophyll index among the various organic manures was non-significant when recorded at 75 DAS (Table 4.2.7). Among the nitrogen levels, the chlorophyll index recorded in 125% RDN and 100% RDN was found to be statistically at par among each other. Chlorophyll index in 100% RDN was found at par with 75% RDN. The significantly less chlorophyll index was recorded in 0% RDN as compared to all other nitrogen levels.

The differences in chlorophyll index recorded at 105 DAS were found to be non-significant among various organic manure treatments during 2023 (Table 4.2.7).

Among the nitrogen levels, the chlorophyll index recorded in 100% RDN and 125% RDN was found to be statistically at par with 75% RDN. Significantly less chlorophyll index was recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, the chlorophyll index recorded at 105 DAS was non-significant among the various organic manures (Table 4.2.7). Among the nitrogen levels, the chlorophyll index recorded in 125% RDN was statistically at par with 100% RDN and 75% RDN. The chlorophyll index was significantly less in 0% RDN as compared to all other nitrogen levels during 2024.

The chlorophyll index was higher in the 100% RDN and 125% RDN treatments as it is influenced directly by the nitrogen availability to the crop (Hokmalipour *et al.*, 2011).

The interactive effect of organic manures and nitrogen levels on chlorophyll index was non-significant at all growth stages during 2023 and 2024 (Table 4.2.7).

Table 4.2.7. Effect of organic manures and nitrogen levels on chlorophyll index at 45, 75 and 105 DAS

	Chlorophyll index (SPAD value)					
	45 DAS		75 DAS		105 DAS	
	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)						
No organic manure	47.7	48.1	50.1	49.9	43.1	49.0
FYM (15 t ha ⁻¹)	50.8	49.7	51.5	49.0	48.2	49.0
Poultry manure (6.25 t ha ⁻¹)	51.5	49.9	51.3	50.2	48.6	50.2
Press mud (15 t ha ⁻¹)	50.5	48.8	49.6	48.4	45.6	49.3
SE(m) ±	0.97	0.44	0.93	1.32	1.53	0.94
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (N levels)						
Control (0 kg N ha ⁻¹)	43.0	41.8	39.1	38.2	35.1	38.0
75% RDN (100 kg N ha ⁻¹)	50.6	50.2	52.0	51.9	48.2	53.0
100% RDN (125 kg N ha ⁻¹)	53.2	51.5	54.9	52.7	50.7	53.3
125% RDN (150 kg N ha ⁻¹)	53.8	52.9	56.5	54.7	51.6	53.3
SE(m) ±	0.75	0.44	0.81	0.96	1.32	0.92
C.D. (5%)	2.17	1.26	2.33	2.76	3.80	2.64
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

4.3 Yield and yield attributes

4.3.1 Number of cobs per plant, cob length (cm) and cob girth (mm)

Number of cobs per plant adds to the grain yield. Number of seeds per row depends on the length of the cob and number of rows per cob depends on cob girth. The data on number of cobs per plant, cob length (cm) and cob girth (mm) has been presented in Table 4.3.1 and Figure 4.3.1.

The differences in number of cobs per plant were found to be significant and presented in Table 4.3.1. During 2023, among the organic manures, highest number of cobs per plant recorded in FYM which were statistically at par with poultry manure. Press mud recorded statistically at par number of cobs per plant with poultry manure. Significantly lower number of cobs per plant were recorded in no organic manure as compared to FYM and poultry manure treatment. Among the nitrogen levels, the number of cobs per plant in 125% RDN and 100% RDN were found to be statistically at par with each other. The number of cobs per plant were significantly lower in 75% RDN and 0% RDN as compared to other nitrogen levels. During 2024, the number of cobs per plant recorded in FYM were statistically at par with poultry manure (Table 4.3.1). The number of cobs per plant in press mud treatment were statistically at par with poultry manure. Significantly lower number of cobs per plant were recorded in no organic manure as compared to FYM and poultry manure. Among the nitrogen levels, the number of cobs per plant were statistically at par among 100% RDN and 125% RDN. Significantly lower number of cobs per plant were recorded in 0% RDN and 75% RDN as compared to other nitrogen levels.

The differences in cob length (cm) due to organic manure treatments was significant and data presented in Table 4.3.1. Among the organic manures, cob length recorded in poultry manure and FYM was statistically at par with press mud. Significantly lower cob length was recorded in no organic manure as compared to all other organic manure treatments. Among the nitrogen levels, the cob length recorded in 125% RDN was statistically at par with 100% RDN. Significantly less cob length was recorded in 75% RDN as compared to 100% and 125% RDN. Significantly lower cob length was recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024,

the cob length recorded in FYM and poultry manure was found to be statistically at par with press mud treatments (Table 4.3.1). Significantly less cob length was recorded in no organic manure as compared to FYM and poultry manure. Among the nitrogen levels, the cob length recorded in 125% RDN and 100% RDN was found to be statistically at par with each other. Cob length in 75% RDN was statistically at par with 100% RDN. Significantly lower cob length was recorded in 0% RDN as compared to all other nitrogen levels during 2024.

During 2023, the differences in cob girth (mm) was found to be significant and data presented in Table 4.3.1. Among various organic manures, cob girth in poultry manure and FYM was statistically at par with each other. Press mud recorded significantly less cob girth as compared to poultry manure and FYM. Significantly lower cob girth was recorded in no organic manure as compared to all other organic manure treatments. Among the nitrogen levels, the cob girth in 100% RDN and 125% RDN was found to be statistically at par among themselves. The cob girth recorded in 75% RDN was significantly less than 100% RDN and 125% RDN. Significantly less cob girth was recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, cob girth (mm) in FYM and poultry manure was found to be statistically at par with each other (Table 4.3.1). Significantly less cob girth was recorded in press mud as compared to poultry manure and FYM. Significantly less cob girth was recorded in no organic manure as compared to poultry manure and FYM. Among the nitrogen levels, the cob girth recorded in 125% RDN was statistically at par with 100% RDN. Significantly less cob girth was recorded in 75% RDN as compared to 100% RDN and 125% RDN. The cob girth was significantly less in 0% RDN as compared to all other nitrogen levels.

It can be concluded that application of organic manures and increased nitrogen levels improved the number of cobs per plant, cob length and cob girth which may be due to the prolonged availability of nutrients from the organic manures at later stages and sufficient nitrogen availability during the peak nutrient demand of the crop (Srivankumar *et al.*, 2023 and Dwivedi *et al.*, 2022).

The interactive effect of organic manures and nitrogen levels on cob girth was found to be non-significant during 2023. The interactive effect of organic manures and nitrogen levels on cob girth was found to be significant during 2024 and data has been presented in Table 4.3.2. During 2024, application of FYM or poultry manure supplied with less nitrogen *i.e.* 75% RDN produced at par cob girth (mm) with application of 125% RDN under no organic manure treatment indicating that maize crop responds more to the application of organic manures such as FYM and poultry manures. It can also be concluded that application of either FYM or poultry manure to maize crop without any application of inorganic nutrient can produce maize cob girth at par with application of 75% RDN alone.

The interactive effect of organic manures and nitrogen levels on number of cobs per plant and cob length was non-significant during 2023 and 2024 (Table 4.3.1).

Table 4.3.1. Effect of organic manures and nitrogen levels on number of cobs per plant, cob length (cm) and cob girth (mm)

	Number of cobs per plant		Cob length (cm)		Cob girth (mm)	
	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)						
No organic manure	1.01	1.00	15.3	15.5	41.2	41.6
FYM (15 t ha ⁻¹)	1.06	1.05	16.0	16.1	43.2	43.6
Poultry manure (6.25 t ha ⁻¹)	1.05	1.04	16.1	16.3	43.1	43.7
Press mud (15 t ha ⁻¹)	1.02	1.02	15.9	15.9	42.1	42.4
SE(m) ±	0.01	0.01	0.17	0.15	0.22	0.28
C.D. (5%)	0.04	0.03	0.56	0.49	0.72	0.91
Sub-plots (N levels)						
Control (0 kg N ha ⁻¹)	1.01	1.00	14.9	14.6	40.0	40.5
75% RDN (100 kg N ha ⁻¹)	1.01	1.01	15.4	16.0	41.4	41.8
100% RDN (125 kg N ha ⁻¹)	1.05	1.05	16.4	16.5	44.0	44.5
125% RDN (150 kg N ha ⁻¹)	1.06	1.05	16.8	16.8	44.2	44.6
SE(m) ±	0.01	0.01	0.17	0.18	0.23	0.21
C.D. (5%)	0.03	0.02	0.50	0.52	0.65	0.61
Interaction C.D. (5%)	NS	NS	NS	NS	NS	1.27

Table 4.3.2. Interactive effect of organic manures and nitrogen levels on cob girth (mm) during 2024

Cob girth (mm) - 2024

	Control (0 kg N ha ⁻¹)	75% RDN (100 kg N ha ⁻¹)	100% RDN (125 kg N ha ⁻¹)	125% RDN (150 kg N ha ⁻¹)	Mean A
No organic manure	39.9	41.3	42.3	42.9	41.6
FYM (15 t ha ⁻¹)	40.8	42.0	45.7	45.9	43.6
Poultry manure (6.25 t ha ⁻¹)	40.9	42.2	45.8	45.9	43.7
Press mud (15 t ha ⁻¹)	40.3	41.6	44.1	43.7	42.4
Mean B	40.5	41.8	44.5	44.6	
SE(m) ±	0.21				
C.D. (5%)	1.27				

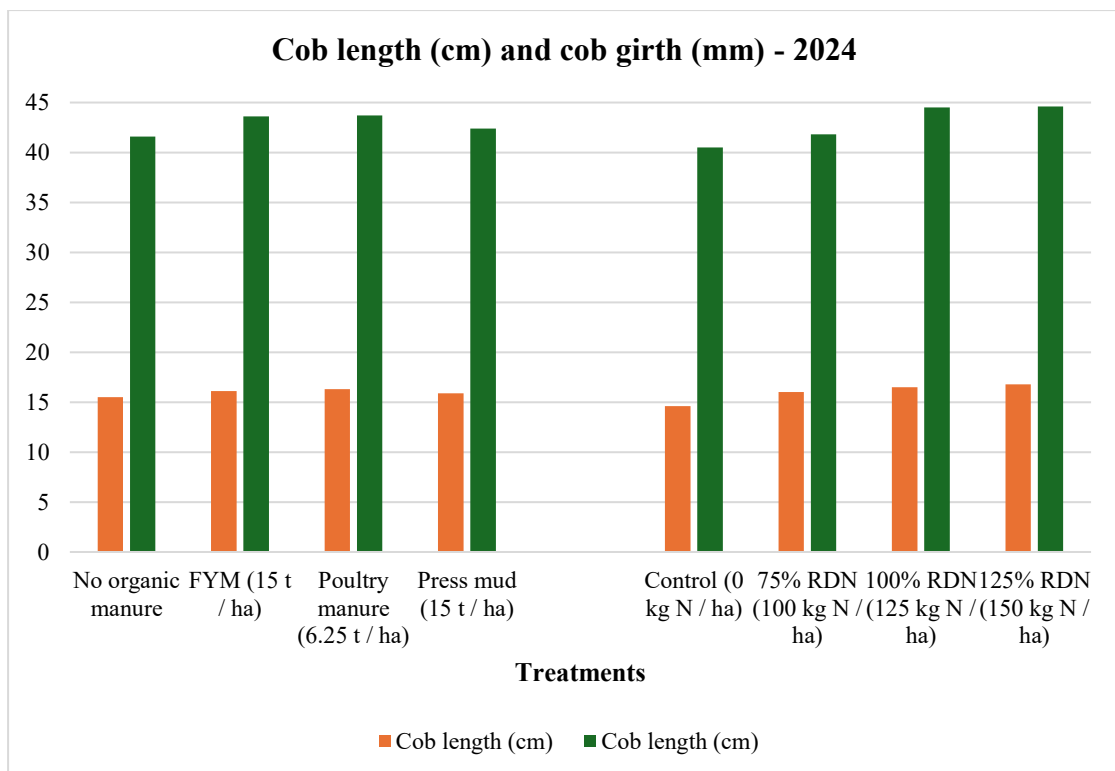
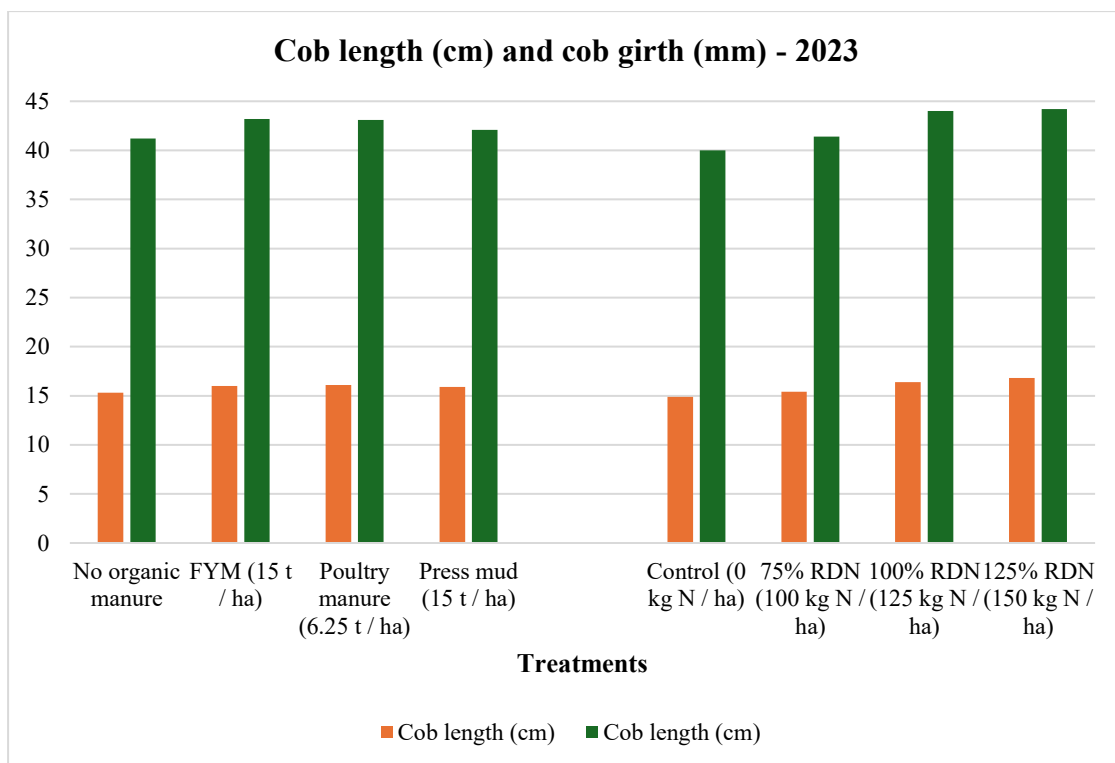


Figure 4.3.1 Effect of organic manures and nitrogen levels on cob length (cm) and cob girth (mm) during 2023 and 2024

4.3.2 Number of rows / cob, number of grains / cob and 1000 grain weight (g)

The yield characteristics, such as the number of rows per cob, the number of grains per cob, and the weight of 1000 grains, contribute to the overall grain yield of the crop. Test weight serves as an indicator of general grain quality. The data on effect of organic manure treatments and nitrogen level treatments on number of rows per cob, number of grains per cob and 1000 grain weight during 2023 and 2024 has been presented in Table 4.3.3 and Figure 4.3.2.

The differences in number of rows per cob were found to be significant and presented in Table 4.3.3. Among the organic manure treatments, number of rows per cob in poultry manure were found to be statistically at par with FYM and press mud. Significantly less number of rows per cob were recorded in no organic manure as compared to FYM and poultry manure treatments. Among the nitrogen levels, the number of rows per cob recorded in 125% RDN and 100% RDN were found to be statistically at par with each other. The number of rows per cob were significantly less in 75% RDN as compared to 100% RDN and 125% RDN. Significantly less number of rows per cob were recorded in 0% RDN as compared to other nitrogen levels. During 2024, the number of rows per cob recorded in poultry manure were statistically at par with FYM and press mud (Table 4.3.3). The number of rows per cob recorded in no organic manure were significantly less in comparison to other organic manures. Among the nitrogen levels, the number of rows per cob were significantly higher in 125% RDN as compared to other nitrogen levels. Significantly more number of rows per cob were recorded in 100% RDN as compared to 75% RDN. Significantly less number of rows per cob were recorded in 0% RDN as compared to other nitrogen levels.

The differences in the number of grains per cob were significant during 2023 and data presented in Table 4.3.3. Among the organic manures, number of grains per cob recorded in poultry manure and FYM were statistically at par with each other. Significantly less number of grains per cob were recorded in press mud as compared to poultry manure and FYM. Significantly less number of grains per cob were recorded in no organic manure as compared to all other organic manures. Among the

nitrogen levels, the number of grains per cob recorded in 125% RDN was statistically at par with 100% RDN. Significantly less number of grains per cob were recorded in 75% RDN as compared to 100% and 125% RDN. Significantly less number of grains per cob was recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, the number of grains per cob recorded in FYM and poultry manure were found to be statistically at par with each other (Table 4.3.3). Significantly less number of grains per cob were recorded in press mud as compared to poultry manure and FYM. Significantly less number of grains per cob were recorded in no organic manure as compared to other organic manures. Among the nitrogen levels, the number of grains per cob recorded in 125% RDN and 100% RDN were found to be statistically at par with each other. The significantly less number of grains per cob were obtained in 75% RDN as compared to 100% RDN and 125% RDN. Significantly less number of grains per cob were recorded in 0% RDN as compared to all other nitrogen levels.

The differences in 1000-grain weight during 2023 was found to be significant and presented in Table 4.3.3. Among various organic manures, 1000-grain weight in poultry manure and FYM was statistically at par with press mud. Significantly lower 1000-grain weight was recorded in no organic manure as compared to poultry manure and FYM during 2023. Among the nitrogen levels, the 1000-grain weight recorded in 100% RDN and 125% RDN was found to be statistically at par among themselves. The 1000 grain weight recorded in 75% RDN was significantly less as compared to 100% RDN and 125% RDN. Significantly less 1000-grain weight was recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, the 1000-grain weight in FYM and poultry manure was found to be statistically at par with press mud (4.3.3). Significantly less 1000-grain weight was recorded in no organic manure as compared to poultry manure and FYM. Among the nitrogen levels, the 1000-grain weight recorded in 125% RDN was statistically at par with 100% RDN. Significantly less 1000-grain weight was recorded in 75% RDN as compared to 100% RDN and 125% RDN. The 1000-grain weight was significantly lower in 0% RDN as compared to all other nitrogen levels.

Improved yield attributes under the application of organic manures and higher levels of nitrogen *i.e.* 100% RDN and 125% RDN may be attributed to better growth

characteristics of maize crop because of availability of more nutrition for better crop growth (Dwivedi *et al.*, 2022; Gheith *et al.*, 2022 and Sravankumar *et al.*, 2023).

The interactive effect of organic manures and nitrogen level treatments on number of grains per cob was non-significant during 2023 (Table 4.3.3). The interactive effect of organic manures and nitrogen levels for number of rows per cob and 1000-grain weight was found to be non-significant during 2023 and 2024 (Table 4.3.3). The interactive effect of organic manures and nitrogen levels on number of grains per cob was found to be significant during 2024 and data has been presented in Table 4.3.4. Application of FYM, poultry manure or press mud to maize supplied with less nitrogen *i.e.* 75% RDN produced at par number of grains per cob with application of 125% RDN under no organic manure treatment indicating the response of organic manures to maize crop. Also, maize crop supplied with either with FYM or poultry manure receiving recommended dose of nitrogen (100% RDN) produced number of grains per cob at par with application of press mud with 125% RDN *i.e.* 150 kg N ha⁻¹ during both years indicating thereby that press mud is less effective than FYM and poultry manure. Application of 75% RDN along with organic manures *i.e.* FYM, poultry manure or press mud produced at par number of grains per cob with application of 125% RDN under no organic manure treatment. These findings holds good for both years.

Table 4.3.3. Number of rows per cob, number of grains per cob and 1000 grain weight (g) as influenced by organic manures and nitrogen levels

	Number of rows per cob		Number of grains per cob		1000 grain weight (g)	
	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)						
No organic manure	14.6	14.5	472.9	473.7	278.4	277.0
FYM (15 t ha ⁻¹)	15.2	15.3	534.0	542.2	288.7	288.4
Poultry manure (6.25 t ha ⁻¹)	15.3	15.4	540.5	547.4	290.3	289.3
Press mud (15 t ha ⁻¹)	14.9	15.1	514.1	521.4	283.7	281.5
SE(m) ±	0.15	0.10	4.93	6.10	2.25	2.76
C.D. (5%)	0.49	0.31	16.00	19.79	7.29	8.95
Sub-plots (N levels)						
Control (0 kg N ha ⁻¹)	14.4	14.4	446.3	448.8	273.5	271.8
75% RDN (100 kg N ha ⁻¹)	14.8	14.9	481.8	491.6	281.6	280.2
100% RDN (125 kg N ha ⁻¹)	15.4	15.4	561.3	564.1	291.5	290.6
125% RDN (150 kg N ha ⁻¹)	15.5	15.7	572.0	580.3	294.5	293.5
SE(m) ±	0.13	0.08	6.90	4.41	2.38	2.37
C.D. (5%)	0.38	0.24	19.87	16.71	6.86	6.81
Interaction C.D. (5%)	NS	NS	NS	26.67	NS	NS

Table 4.3.4 Interactive effect of organic manures and nitrogen levels on number of grains per cob during 2024

Number of grains per cob - 2024

	Control (0 kg N ha ⁻¹)	75% RDN (100 kg N ha ⁻¹)	100% RDN (125 kg N ha ⁻¹)	125% RDN (150 kg N ha ⁻¹)	Mean A
No organic manure	420.5	462.2	496.1	516.2	473.7
FYM (15 t ha ⁻¹)	464.9	499.0	597.5	607.3	542.2
Poultry manure (6.25 t ha ⁻¹)	465.2	513.2	595.4	615.9	547.4
Press mud (15 t ha ⁻¹)	444.8	491.8	567.4	581.7	521.4
Mean B	448.8	491.6	564.1	580.3	
SE(m) ±	12.20				
C.D. (5%)	26.67				

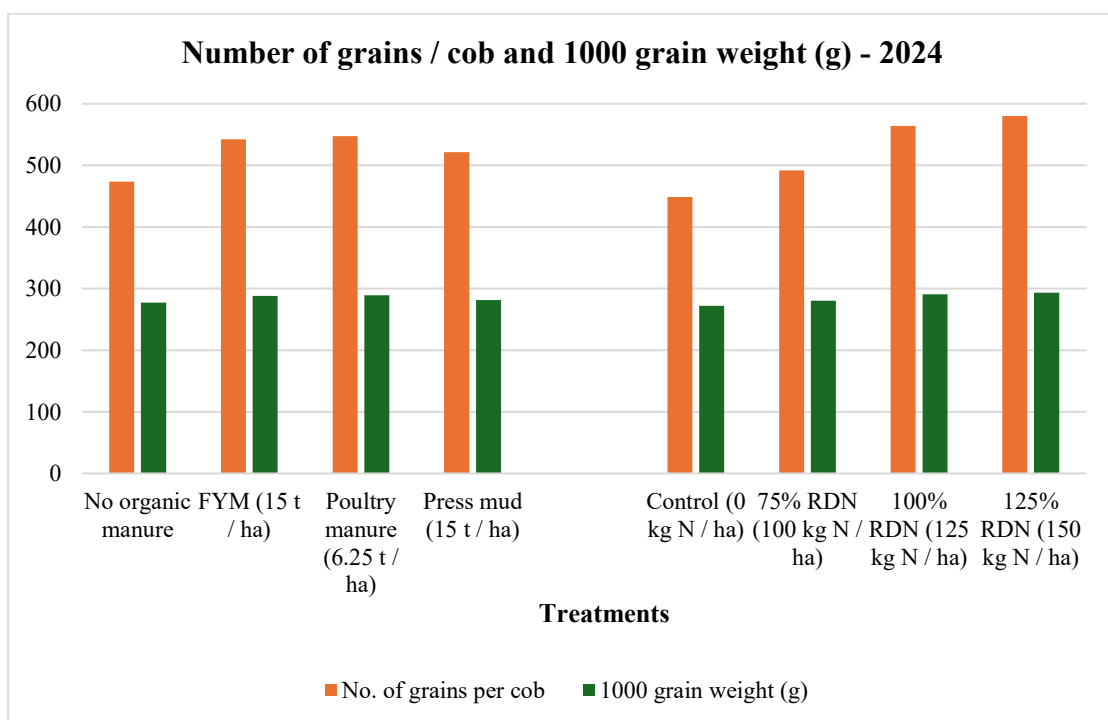
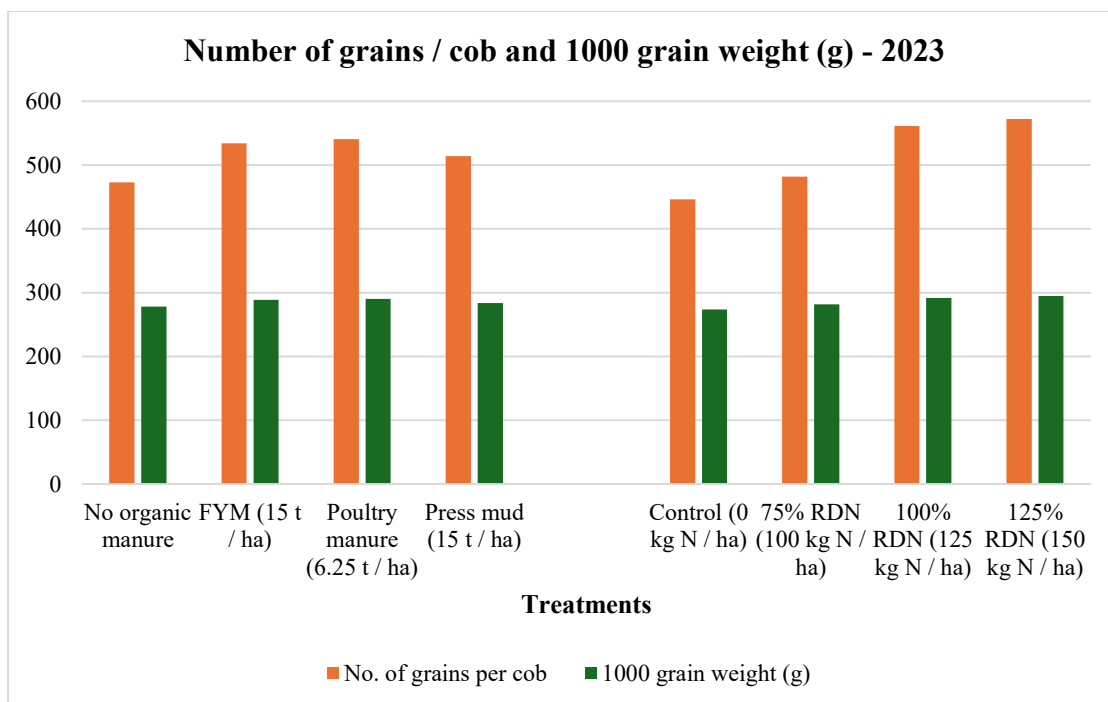


Figure 4.3.2 Effect of organic manures and nitrogen levels on number of grains per cob and 1000 seed weight (g) during 2023 and 2024

4.3.3 Grain yield and stover yield (q ha⁻¹)

The grain yield (q ha⁻¹) is the economic part of the crop which is ultimate product of crop growth factors and yield attributes. The differences in grain yield were found to be significant and data presented in Table 4.3.5 and Figure 4.3.3. During 2023, among the organic manure treatments, grain yield in poultry manure was statistically at par with FYM treatment. Significantly less grain yield was recorded in press mud as compared to poultry manure and FYM. No organic manure treatment recorded significantly less grain yield as compared to other organic manure treatments. Among the nitrogen levels, grain yield in 125% RDN and 100% RDN was found to be statistically at par with each other. Significantly less grain yield was recorded in 75% RDN as compared to 100% RDN and 125% RDN. Significantly less grain yield was recorded in 0% RDN (control) as compared to other nitrogen level treatments. During 2024, among the organic manures, grain yield (q ha⁻¹) in poultry manure and FYM was statistically at par with each other which was significantly more than press mud treatment (Table 4.3.5). Significantly less grain yield was recorded in no organic manure as compared to other organic manure treatments. Among the nitrogen levels, grain yield in 125% RDN was statistically at par with 100% RDN. Significantly less grain yield was recorded in 75% RDN as compared to 100% RDN and 125% RDN. Significantly lower grain yield was recorded in 0% RDN (control) as compared to all other nitrogen levels.

The pooled analysis of grain yield has been presented in Table 4.3.5. Among the organic manures, the grain yield in poultry manure and FYM was statistically at par with each other. Press mud recorded significantly less grain yield as compared to poultry manure and FYM. Significantly lower grain yield was recorded in no organic manure as compared to other organic manure treatments. Similar findings were reported by Essilfie *et al.* (2024) and Mahmood *et al.* (2017). Among the nitrogen levels, grain yield in 125% RDN was found to be statistically at par with 100% RDN. Significantly less grain yield was recorded in 75% RDN as compared to 100% RDN and 125% RDN. The treatment of 0% RDN (control) recorded significantly lower grain yield as compared to all other nitrogen levels. Similar findings were reported by Gheith *et al.* (2022) and Tofa *et al.* (2022).

Higher grain yield in poultry manure and FYM may be due to better growth factors (Table 4.2.1 to 4.2.7) and yield attributes (Table 4.3.1 to 4.3.4) in these treatments as compared to press mud and no organic manure treatment. On the basis of pooled data, poultry manure, FYM and press mud increased the grain yield by 16.22, 15.09 and 9.87 percent than no organic manure treatment. Among the nitrogen levels, more grain yield in 125% RDN and 100% RDN treatments may be due to good crop growth (Table 4.2.1 to 4.2.7) and better yield attributes (Table 4.3.1 to 4.3.4) as compared to 75% RDN and 0% RDN (control) treatments. On an average of two years, 125% RDN, 100% RDN and 75% RDN increased the grain yield of maize crop by 42.51, 40.39 and 26.55 percent as compared to 0% RDN (control) treatment.

The interactive effect of organic manures and nitrogen levels on grain yield was found to be significant during 2023, 2024 and pooled and data has been presented in Table 4.3.6. During both years, application of FYM or poultry manure supplied with less nitrogen *i.e.* 75% RDN produced at par grain yield with application of 125% RDN under no organic manure treatment indicating that maize crop responds more to application of FYM and poultry manures. Also, maize crop supplied with poultry manure at 6.25 t ha⁻¹ receiving recommended dose of nitrogen (100% RDN) produced significantly higher grain yield compared to application of press mud with 125% RDN *i.e.* 150 kg N ha⁻¹ during both years indicating thereby that press mud is less effective than poultry manure. Application of 75% RDN along with organic manures produced at par grain yield with application of 125% RDN under no organic treatment. These findings hold good for both years as well as for pooled analysis.

Stover yield (q ha⁻¹) is important component of biological yield. Stover can be used as cattle feed or can be incorporated in the field which on decomposition may improve the organic matter, nutrients content of the soil and soil physical conditions. During 2023, the differences in stover yield were found to be significant and data presented in Table 4.3.5 and Figure 4.3.3. Among the organic manures, stover yield recorded in poultry manure was statistically at par with FYM. Significantly less stover yield was recorded in press mud as compared to poultry manure and FYM. No organic manure treatment recorded significantly lower stover yield as compared to other organic manure treatments. Among the nitrogen levels, stover yield recorded in 125% RDN

and 100% RDN was found to be statistically at par with each other. Significantly less stover yield was recorded in 75% RDN as compared to 100% RDN and 125% RDN. Significantly less stover yield (q/ha) was recorded in 0% RDN (control) as compared to other nitrogen levels. During 2024, among the organic manures, stover yield in poultry manure and FYM was statistically at par with press mud. Significantly lower stover yield was recorded in no organic manure as compared to all organic manure treatments. Among the nitrogen levels, stover yield in 125% RDN was statistically at par with 100% RDN. Significantly less stover yield was recorded in 75% RDN as compared to 100% RDN and 125% RDN. Significantly lower stover yield was recorded in 0% RDN (control) as compared to all other nitrogen levels.

The interactive effect of organic manures and nitrogen levels on stover yield was found to be significant during 2023 and data has been presented in Table 4.3.3. During 2023, application of FYM or poultry manure supplied with no nitrogen *i.e.* 0% RDN produced at par stover yield with application of 75% RDN under no organic manure and press mud treatment under 0 kg N ha⁻¹ indicating the response of FYM and poultry manures to maize crop. Also, maize crop supplied with either with FYM or poultry manure receiving recommended dose of nitrogen (100% RDN) produced significantly higher stover yield than application of press mud with 125% RDN *i.e.* 150 kg N ha⁻¹ during both years indicating thereby that press mud is less effective than FYM and poultry manure. Application of 100% RDN along with poultry manure produced significantly higher stover yield than application of 125% RDN in no organic manure plots. During 2024, the interactive effect of organic manures and nitrogen levels on stover yield was found to be non-significant (Table 4.3.5).

More stover yield was found under application of organic manures might be due to improved soil physical conditions, microbial activity and longer availability of nutrients to the crop plant. The application of 100% RDN and 125% RDN produced greater stover yield than lower doses of nitrogen which may be attributed to better growth characteristics of maize under former treatments (Langhari *et al.*, 2024; Abrol *et al.*, 2024 and Essilfie *et al.*, 2024).

Table 4.3.5. Grain yield and stover yield (q ha⁻¹) as influenced by organic manures and nitrogen levels

	Grain yield (q ha ⁻¹)			Stover yield (q ha ⁻¹)	
	2023	2024	Pooled	2023	2024
Main plots (Organic manures)					
No organic manure	69.4	72.4	70.9	101.1	103.1
FYM (15 t ha ⁻¹)	81.0	82.2	81.6	106.7	107.2
Poultry manure (6.25 t ha ⁻¹)	81.7	83.0	82.4	107.0	107.7
Press mud (15 t ha ⁻¹)	77.6	78.2	77.9	103.7	105.9
SE(m) ±	0.61	0.42	0.32	0.44	0.96
C.D. (5%)	1.99	1.35	1.04	1.41	3.11
Sub-plots (N levels)					
Control (0 kg N ha ⁻¹)	60.7	62.1	61.4	97.0	99.9
75% RDN (100 kg N ha ⁻¹)	76.9	78.5	77.7	101.5	102.5
100% RDN (125 kg N ha ⁻¹)	85.3	87.0	86.2	109.3	110.5
125% RDN (150 kg N ha ⁻¹)	86.8	88.3	87.5	110.8	111.0
SE(m) ±	0.60	0.62	0.47	0.55	0.83
C.D. (5%)	1.72	1.79	1.36	1.59	2.38
Interaction C.D. (5%)	3.55	3.64	2.76	3.25	NS

Table 4.3.6. Interactive effect of organic manures and nitrogen levels on grain yield (q ha⁻¹) during 2023, 2024 and pooled

Grain yield - 2023

	Control (0 kg N ha ⁻¹)	75% RDN (100 kg N ha ⁻¹)	100% RDN (125 kg N ha ⁻¹)	125% RDN (150 kg N ha ⁻¹)	Mean A
No organic manure	48.9	69.6	78.9	80.5	69.4
FYM (15 t ha ⁻¹)	65.5	80.0	88.6	90.1	81.0
Poultry manure (6.25 t ha ⁻¹)	66.3	80.3	89.1	91.2	81.7
Press mud (15 t ha ⁻¹)	62.4	77.7	84.8	85.5	77.6
Mean B	60.7	76.9	85.3	86.8	
SE(m) ±	1.23				
C.D. (5%)	3.55				

Grain yield -2024

	Control (0 kg N ha ⁻¹)	75% RDN (100 kg N ha ⁻¹)	100% RDN (125 kg N ha ⁻¹)	125% RDN (150 kg N ha ⁻¹)	Mean A
No organic manure	51.7	72.7	81.9	83.5	72.4
FYM (15 t ha ⁻¹)	65.5	81.4	90.2	91.6	82.2
Poultry manure (6.25 t ha ⁻¹)	67.6	81.8	90.5	92.3	83.0
Press mud (15 t ha ⁻¹)	63.5	78.2	85.3	85.7	78.2
Mean B	62.1	78.5	87.0	88.3	
SE(m) ±	0.83				
C.D. (5%)	3.64				

Grain yield (pooled)

	Control (0 kg N ha ⁻¹)	75% RDN (100 kg N ha ⁻¹)	100% RDN (125 kg N ha ⁻¹)	125% RDN (150 kg N ha ⁻¹)	Mean A
No organic manure	50.3	71.1	80.4	82.0	70.9
FYM (15 t ha ⁻¹)	65.5	80.7	89.4	90.8	81.6
Poultry manure (6.25 t ha ⁻¹)	66.9	81.0	89.8	91.7	82.4
Press mud (15 t ha ⁻¹)	62.9	77.9	85.1	85.6	77.9
Mean B	61.4	77.7	86.2	87.5	
SE(m) ±	0.64				
C.D. (5%)	2.76				

Table 4.3.7. Interactive effect of organic manures and nitrogen levels on stover yield (q ha⁻¹) during 2023

Stover yield - 2023

	Control (0 kg N ha ⁻¹)	75% RDN (100 kg N ha ⁻¹)	100% RDN (125 kg N ha ⁻¹)	125% RDN (150 kg N ha ⁻¹)	Mean A
No organic manure	87.8	100.9	106.8	108.9	101.1
FYM (15 t ha ⁻¹)	100.7	101.6	111.9	112.8	106.7
Poultry manure (6.25 t ha ⁻¹)	100.3	101.0	112.9	113.8	107.0
Press mud (15 t ha ⁻¹)	99.0	102.4	105.8	107.6	103.7
Mean B	97.0	101.5	109.3	110.8	
SE(m) ±	0.87				
C.D. (5%)	3.25				

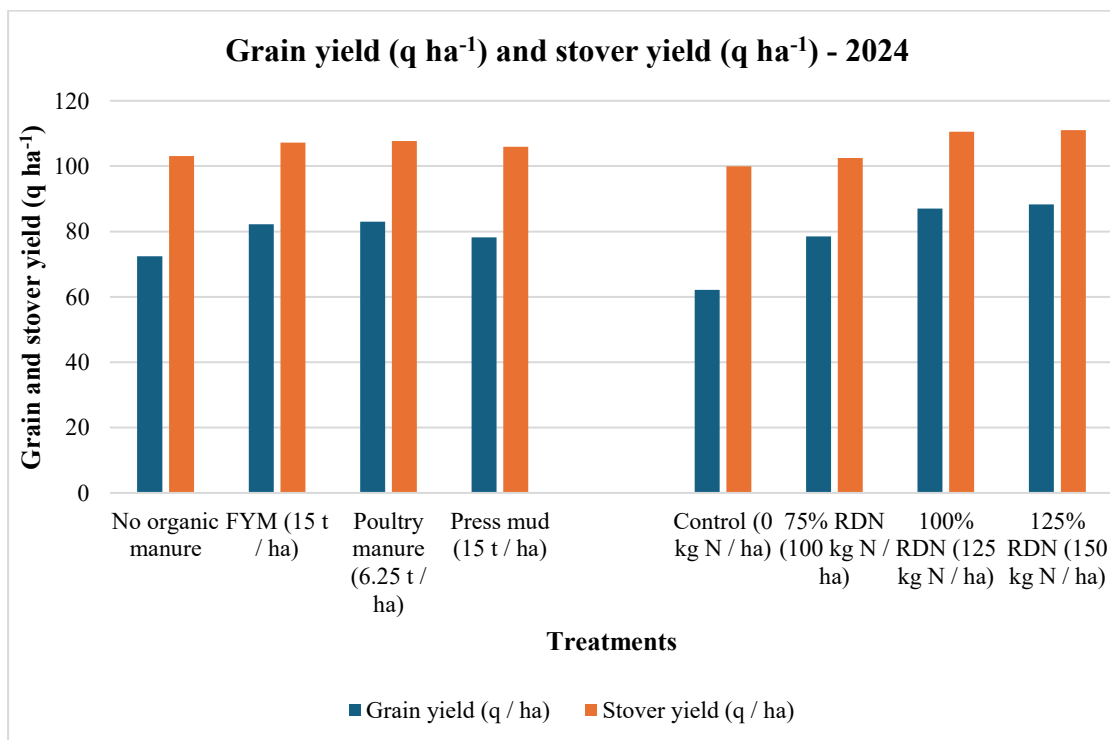
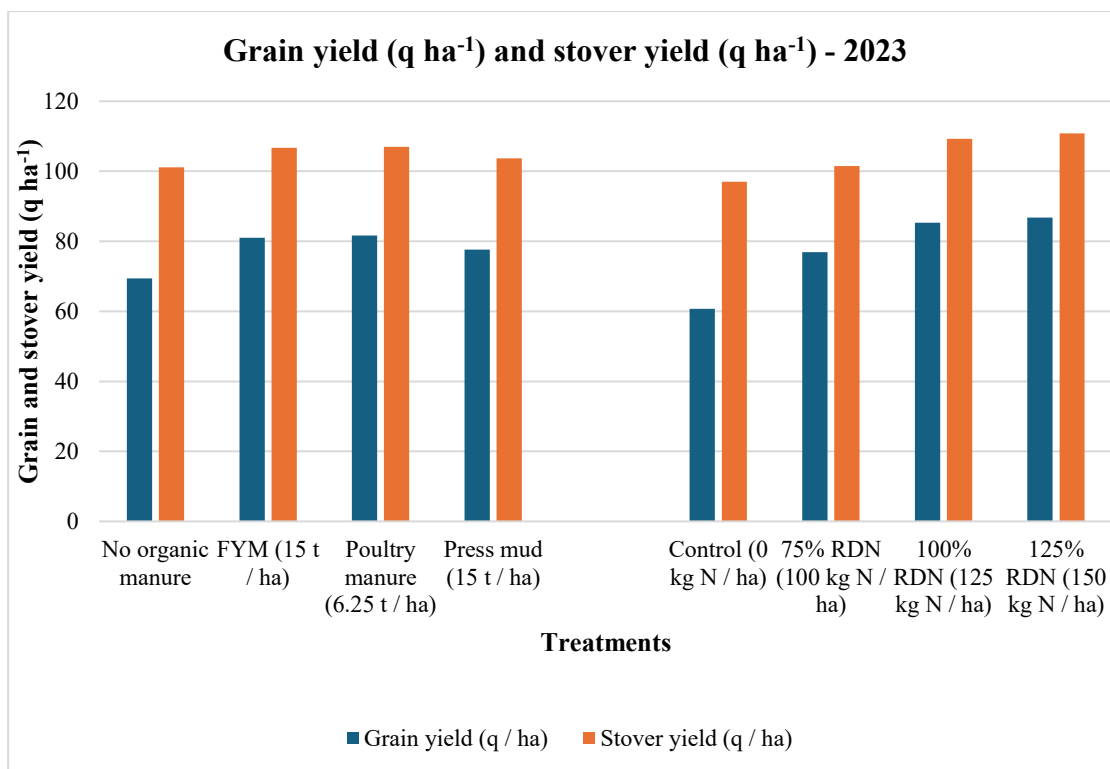


Figure 4.3.3 Effect of organic manures and nitrogen levels on grain yield (q ha⁻¹) and stover yield (q ha⁻¹) during 2023 and 2024

4.3.4 Biological yield (q ha^{-1}) and harvest index (%)

Biological yield (q ha^{-1}) is the indicative of biomass production by the crop whereas harvest index gives the percentage of economic part produced from the whole production or indicate the efficiency of partitioning of dry matter to the economic parts of the crop. The data on the effect of organic manures and nitrogen levels on biological yield and harvest index has been presented in Table 4.3.8.

The differences in biological yield (q ha^{-1}) was found to be significant and data presented in Table 4.3.8. During 2023, among the organic manures, biological yield recorded in poultry manure was statistically at par with FYM. Significantly less biological yield was recorded in press mud as compared to poultry manure and FYM. No organic manure treatment recorded significantly lower biological yield as compared to other organic manure treatments. Among the nitrogen levels, biological yield in 125% RDN and 100% RDN was found to be statistically at par with each other. Significantly less biological yield was recorded in 75% RDN as compared to 100% RDN and 125% RDN. Also, significantly lower biological yield was recorded in 0% RDN (control) as compared to other nitrogen levels. During 2024, among the organic manures, biological yield recorded in poultry manure and FYM was statistically at par with each other (Table 4.3.8). Press mud recorded significantly less biological yield as compared to poultry manure and FYM. Significantly less biological yield was recorded in no organic manure as compared to all tried organic manures. Among the nitrogen levels, biological yield in 125% RDN was statistically at par with 100% RDN. Significantly less biological yield was recorded in 75% RDN as compared to 100% RDN and 125% RDN. Significantly less biological yield was recorded in 0% RDN (control) as compared to all other nitrogen levels.

The differences in harvest index were found to be significant and presented in Table 4.3.8. During 2023, among the organic manures, harvest index recorded in poultry manure was statistically at par with FYM and press mud. No organic manure treatment recorded significantly lower harvest index as compared to other organic manure treatments. Among the nitrogen levels, harvest index recorded in 125% RDN and 100% RDN was found to be statistically at par with each other. Significantly less

harvest index was recorded in 75% RDN as compared to 100% RDN and 125% RDN. Significantly less the harvest index was recorded in 0% RDN (control) as compared to other nitrogen levels. Similar results were obtained during second year.

Application of organic manures like poultry manure and FYM improved the biological yield which may be because of sufficient nutrient availability to crop and enhanced soil physical properties due to addition of organic matter in the soil (Kandil *et al.*, 2020). The treatments of 100% RDN and 125% RDN produced significantly more biomass compared to other nitrogen levels which may be due to required nitrogen uptake by the crop and combined effect of better growth and yield attributes under these treatments (Mahat *et al.*, 2023).

The interactive effect of organic manures and nitrogen levels for biological yield and harvest index were non-significant during 2023 and 2024 (Table 4.3.8).

Table 4.3.8. Effect of organic manures and nitrogen levels on biological yield (q ha⁻¹) and harvest index (%)

	Biological yield (q ha ⁻¹)		Harvest index (%)	
	2023	2024	2023	2024
Main plots (Organic manures)				
No organic manure	170.5	175.5	40.4	40.9
FYM (15 t ha ⁻¹)	187.8	189.4	43.0	43.2
Poultry manure (6.25 t ha ⁻¹)	188.7	190.7	43.2	43.4
Press mud (15 t ha ⁻¹)	181.3	184.1	42.6	42.3
SE(m) ±	0.86	1.32	0.22	0.16
C.D. (5%)	2.78	4.27	0.70	0.52
Sub-plots (N levels)				
Control (0 kg N ha ⁻¹)	157.7	161.9	38.4	38.2
75% RDN (100 kg N ha ⁻¹)	178.4	181.0	43.1	43.3
100% RDN (125 kg N ha ⁻¹)	194.7	197.5	43.8	44.0
125% RDN (150 kg N ha ⁻¹)	197.5	199.3	43.9	44.3
SE(m) ±	0.99	0.38	0.20	0.18
C.D. (5%)	2.86	3.82	0.58	0.51
Interaction C.D. (5%)	NS	NS	NS	NS

4.4 Economics

Data on the economics of maize is presented in Table 4.4.1. On the basis of two year average, among organic manures, highest net returns were recorded in poultry manure followed by FYM application. Poultry manure recorded highest net returns (99993 ₹ ha⁻¹). However, benefit cost ratio was highest in FYM (1.70) followed by poultry manure (1.68). Among nitrogen levels, 100 % RDN and 125% RDN recorded better net returns as compared to other nitrogen levels. The highest net returns (108516 ₹ ha⁻¹) were observed in 125% RDN treatment with benefit cost ratio of 1.78 followed by 100% RDN treatment with benefit cost ratio of 1.76. The lowest benefit cost ratio (1.06) was found in control (0 N ha⁻¹). The net returns and benefit cost ratio showed increment with increasing doses of nitrogen as nitrogen has significant impact on grain yield of maize crop.

Table 4.4.1 Effect of organic manures and nitrogen levels on economics of spring maize (average of two years)

Treatments	Cost of cultivation (₹ ha ⁻¹)	Gross return (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	B:C ratio
Main plots (Organic manures)				
No organic manure	54997	136710	81713	1.49
FYM (15 t ha ⁻¹)	58447	158040	99593	1.70
Poultry manure (6.25 t ha ⁻¹)	59472	159465	99993	1.68
Press mud (15 t ha ⁻¹)	62997	151010	88013	1.40
Sub-plots (N levels)				
Control (0 kg N ha ⁻¹)	58194	119660	61466	1.06
75% RDN (100 kg N ha ⁻¹)	60095	150630	90535	1.51
100% RDN (125 kg N ha ⁻¹)	60462	166685	106223	1.76
125% RDN (150 kg N ha ⁻¹)	60829	169345	108516	1.78

4.5 Quality parameters

4.5.1 N content in grains (%), N content in stover (%) and protein content in grains (%)

N content in grains is one of the important quality parameter and protein content of grain depends upon N content in grains. The data on effect of organic manures and nitrogen levels on N content in grain, protein content in grains and N uptake by grains during 2023 and 2024 has been presented in Table 4.5.1.

The differences in N content in grains (%) were found to be significant and presented in Table 4.5.1. Among the organic manures, the N content in grains recorded during 2023 in poultry manure was found to be statistically at par with FYM and press mud. Significantly less N content in grains (%) were recorded in no organic manure as compared to all other organic manure treatments. Among the nitrogen levels, the N content in grains (%) recorded in 125% RDN was significantly higher than all other nitrogen levels. The N content in grains (%) was significantly less in 75% RDN as compared to 100% RDN and 125% RDN treatments. Significantly less N content in grains was recorded in 0% RDN as compared to all other nitrogen levels. During 2024, the N content in grains (%) recorded in poultry manure was statistically at par with FYM. Press mud recorded significantly less N content in grain as compared to poultry manure and FYM. The N content in grains (%) recorded in no organic manure was significantly lower as compared to all other organic manures treatments. Among the nitrogen levels, the N content in grains recorded in 125% RDN was significantly higher than all other nitrogen levels. Significantly less N content in grains was recorded in 75% RDN as compared to 100% RDN and 125% RDN treatments. Also, significantly lower N content in grains was recorded in 0% RDN (control) as compared to all other nitrogen levels.

The differences in N content in stover (%) among various organic manures and nitrogen levels treatments remained non-significant during 2023 (Table 4.5.1). During 2024, N content in stover (%) was statistically at par among poultry manure, FYM and press mud treatments. Significantly less N content in stover was recorded in no organic manure treatment as compared to all other organic manure treatments. Among

the nitrogen level treatments, N content in stover (%) recorded in 125% RDN was found to be statistically at par with 100% RDN treatment. The N content in stover (%) recorded in 75% RDN was found to be at par with 100% RDN treatment. Significantly less N content in stover was recorded in 0% RDN (control) as compared to all other nitrogen level treatments.

The differences in the protein content of grains (%) was found to be significant and presented in Table 4.5.1. Among the organic manures, the protein content of grains (%) recorded during 2023 in poultry manure and FYM was found to be statistically at par with press mud. Significantly lower protein content of grains (%) was recorded in no organic manure as compared to all other organic manure treatments. Among the nitrogen levels, the protein content of grains recorded in 125% RDN was significantly more than all other nitrogen levels. Significantly less protein content in grains was recorded in 75% RDN as compared to 100% and 125% RDN treatments. Significantly lower protein content in grains was recorded in 0% RDN (control) as compared to all other nitrogen levels. During 2024, the protein content in grains (%) recorded in FYM and poultry manure was found to be statistically at par with each other. Press mud recorded significantly less protein content in grains as compared to poultry manure and FYM. Significantly less protein content in grains (%) was recorded in no organic manure as compared to poultry manure and FYM. Among the nitrogen levels, the protein content in grains recorded in 125% RDN and 100% RDN was found to be statistically at par with each other. The application of 75% RDN treatment recorded significantly less protein content in grains as compared to 100% RDN and 125% RDN. Significantly less protein content in grains (%) was recorded in 0% RDN (control) as compared to all other nitrogen levels. There was progressive significant increase in protein content in grains with each increment in N dose during both years.

Improved grain quality with application of organic manures might be due to improved soil quality and nutrient availability to maize crop (Langhari *et al.*, 2024). Availability of adequate nitrogen produced better grain quality which may be due to enhanced soil properties and crop growth (Kandil *et al.*, 2020).

The interactive effect of organic manures and nitrogen levels for N content in grains, N content in stover and protein content in grains was non-significant during 2023 and 2024 (Table 4.5.1).

Table 4.5.1: Effect of organic manures and nitrogen levels on N content in grains (%), protein content in grains (%) and N content in stover (%)

	N content in grains (%)		N content in stover (%)		Protein content in grains (%)	
	2023	2024	2023	2024	2023	2024
Main factor (Organic manures)						
No organic manure	0.84	0.84	0.35	0.34	5.23	5.22
FYM (15 t ha ⁻¹)	0.88	0.90	0.35	0.36	5.53	5.61
Poultry manure (6.25 t ha ⁻¹)	0.90	0.89	0.35	0.36	5.65	5.54
Press mud (15 t ha ⁻¹)	0.90	0.86	0.34	0.35	5.63	5.35
SE(m) ±	0.01	0.01	0.01	0.01	0.05	0.05
C.D. (5%)	0.028	0.029	NS	0.012	0.164	0.178
Sub factor (N levels)						
Control (0 kg N ha ⁻¹)	0.79	0.78	0.32	0.33	4.97	4.90
75% RDN (100 kg N ha ⁻¹)	0.86	0.84	0.34	0.35	5.34	5.25
100% RDN (125 kg N ha ⁻¹)	0.92	0.90	0.35	0.36	5.76	5.65
125% RDN (150 kg N ha ⁻¹)	0.96	0.95	0.38	0.37	5.98	5.93
SE(m) ±	0.01	0.01	0.01	0.01	0.04	0.03
C.D. (5%)	0.017	0.015	0.018	0.015	0.106	0.093
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

4.5.2 N uptake by grains (kg ha⁻¹), N uptake by stover (kg ha⁻¹) and total N uptake by crop (kg ha⁻¹)

The differences in N uptake by grains (kg ha⁻¹) were significant among organic manures and nitrogen level treatments and data presented in Table 4.5.2. Among organic manures, N uptake by grains in poultry manure and FYM was statistically at par with each other during 2023. N uptake by grains in press mud treatment was statistically at par with FYM treatment. Significantly low N uptake by grains was recorded in no organic manure in comparison to all other organic manures treatments. Among nitrogen levels, N uptake by grains was significantly higher in 125% RDN in comparison to other nitrogen levels. Significantly more N uptake by grains was recorded in 100% RDN as compared to 75% RDN treatments. The N uptake by grains recorded in 0% RDN (control) was significantly lower than all other nitrogen levels. During 2024, the N uptake by grains in FYM and poultry manure was statistically at par with each other. N uptake by grains was significantly less in press mud as compared to poultry manure and FYM. Significantly less N uptake by grains was recorded in no organic manure as compared to all other organic manure treatments. Among the nitrogen levels, the N uptake by grains recorded in 125% RDN was significantly higher as compared to all other nitrogen levels. Significantly less N uptake by grains was recorded in 75% RDN as compared to 100% RDN and 125% RDN treatments. The N uptake by grains was significantly lower in 0% RDN as compared to all other nitrogen levels.

The differences in N uptake by stover (kg ha⁻¹) were non-significant among organic manures during 2023 (Table 4.5.2). Among nitrogen levels, N uptake by stover was significantly higher in 125% RDN as compared to other nitrogen levels. Significantly more N uptake by stover was recorded in 100% RDN as compared to 75% RDN treatments. The N uptake by stover recorded in 0% RDN (control) was significantly less than all other nitrogen levels. During 2024, the N uptake by stover in FYM and poultry manure was found to be statistically at par with press mud treatment. Significantly less N uptake by stover was recorded in no organic manure as compared to all other organic manure treatments. Among the nitrogen levels, N uptake by stover recorded in 125% RDN was statistically at par with 100% RDN treatment.

Significantly less N uptake by stover was recorded in 75% RDN as compared to 100% RDN and 125% RDN treatments. The N uptake by stover was significantly low in 0% RDN as compared to all other nitrogen levels.

The differences in total N uptake by crop (kg ha^{-1}) *i.e.* by grain and stover was significant among organic manures and nitrogen level treatments and data presented in Table 4.5.2. Among organic manures, N uptake by crop in poultry manure and FYM were statistically at par during 2023. Significantly less N uptake by crop was recorded in press mud treatment as compared to poultry manure and FYM treatments. Significantly low N uptake by crop was recorded in no organic manure as compared to all other organic manure treatments. Among the nitrogen levels, N uptake by crop was significantly more in 125% RDN as compared to all other nitrogen levels. Significantly more N uptake by crop was recorded in 100% RDN as compared to 75% RDN treatments. The N uptake by crop recorded in 0% RDN (control) was significantly less than all other nitrogen levels. During 2024, N uptake by crop in FYM and poultry manure was found to be statistically at par with each other. N uptake by crop was significantly less in press mud as compared to poultry manure and FYM treatments. Significantly less N uptake by crop (total) was recorded in no organic manure as compared to all other organic manure treatments. Among the nitrogen levels, the N uptake by crop recorded in 125% RDN was significantly higher as compared to all other nitrogen levels. Significantly less N uptake by crop was recorded in 75% RDN as compared to 100% RDN and 125% RDN treatments. The N uptake by crop was significantly less in 0% RDN than other nitrogen levels.

Improved uptake by crop under poultry manure and FYM treatments may be due to additional nutrients present in the organic manures and longer availability of nitrogen to crop at later stages of maize crop (He *et al.*, 2022). Higher nitrogen levels led to higher nitrogen uptake by crop which may be due to more nitrogen available to crop for utilization (Tiwari *et al.*, 2022).

The interactive effect of organic manures and nitrogen levels for N uptake by grains, N uptake by stover and total N uptake by crop was non-significant during 2023 and 2024 (Table 4.5.2).

Table 4.5.2 Effect of organic manures and nitrogen levels on N uptake by grains (kg ha⁻¹), N uptake by stover (kg ha⁻¹) and total N uptake by crop (kg ha⁻¹)

	N uptake by grains (kg ha ⁻¹)		N uptake by stover (kg ha ⁻¹)		N uptake by crop (kg ha ⁻¹)	
	2023	2024	2023	2024	2023	2024
Main factor (Organic manures)						
No organic manure	59.3	61.0	35.9	34.7	95.2	95.7
FYM (15 t ha ⁻¹)	72.5	74.6	37.2	37.9	109.8	112.5
Poultry manure (6.25 t ha ⁻¹)	74.2	74.2	37.4	39.0	111.6	113.1
Press mud (15 t ha ⁻¹)	70.6	67.3	35.6	37.2	106.2	104.5
SE(m) ±	1.03	0.94	0.53	0.73	0.90	1.51
C.D. (5%)	3.63	3.32	NS	2.57	3.18	5.32
Sub factor (N levels)						
Control (0 kg N ha ⁻¹)	48.6	48.9	30.2	32.8	78.8	81.8
75% RDN (100 kg N ha ⁻¹)	65.7	65.8	34.9	35.0	100.6	100.9
100% RDN (125 kg N ha ⁻¹)	79.0	78.9	38.7	39.9	117.6	118.8
125% RDN (150 kg N ha ⁻¹)	83.4	83.4	42.3	41.0	125.7	124.4
SE(m) ±	0.80	0.65	0.68	0.63	1.05	1.05
C.D. (5%)	2.35	1.92	1.99	1.84	3.09	3.10
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS

4.6 Soil properties

The important soil properties that influence crop growth and yield are soil pH, EC, OC (%), available N, available P and available K. The capacity of soil to provide nutrition to the crop is of prime importance.

4.6.1 Soil pH, EC and OC (%)

Soil pH describes the nature of the soil and it can be acidic, basic or neutral. Most of the crops prefer neutral soil pH for better growth and production. Soil EC is one of the key indicators of soil health which provides information on nutrient availability in the soil. Soil OC (%) is also an indicator of soil health. It acts as reservoir for carbon sequestration and supports microbial activity. The data on soil pH, EC and OC (%) after harvest has been presented in Table 4.6.1.

The differences in soil pH after harvest was found to be non-significant among the organic manure treatments (Table 4.6.1). Among nitrogen levels treatments, the soil pH was also non-significant during 2023 and 2024. The soil pH varied from 7.74 to 8.13.

The soil electrical conductivity (EC) after harvest was found to be non-significant during 2023 and 2024 among various organic manure treatments (Table 4.6.1). Among the nitrogen levels, soil EC did not differ significantly during both years. The soil EC of the experiment range from 0.18 to 0.21 dS m⁻¹.

The soil OC (%) after harvesting was found to be non-significant among various organic manure treatments during both years (Table 4.6.1). The nitrogen levels treatments also did not influence soil OC (%) significantly after harvest during 2023 and 2024. The soil organic carbon ranged from 0.40 to 0.42%.

The interactive effect of organic manures and nitrogen levels treatments on soil pH, EC and OC (%) were non-significant during 2023 and 2024 (Solanki *et al.*, 2024).

Table 4.6.1 Effect of organic manures and nitrogen levels on soil pH, EC and OC (%) after harvest

	pH		EC (dS m⁻¹)		OC (%)	
	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)						
No organic manure	7.88	8.13	0.20	0.19	0.40	0.40
FYM (15 t ha ⁻¹)	7.74	7.95	0.20	0.18	0.41	0.41
Poultry manure (6.25 t ha ⁻¹)	7.80	7.88	0.19	0.18	0.41	0.41
Press mud (15 t ha ⁻¹)	7.84	7.74	0.19	0.19	0.42	0.42
SE(m)±	0.06	0.09	0.01	0.01	0.01	0.01
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (N levels)						
Control (0 kg N ha ⁻¹)	7.88	7.80	0.18	0.19	0.40	0.40
75% RDN (100 kg N ha ⁻¹)	7.82	7.95	0.21	0.19	0.40	0.41
100% RDN (125 kg N ha ⁻¹)	7.76	7.99	0.20	0.19	0.41	0.40
125% RDN (150 kg N ha ⁻¹)	7.80	7.96	0.18	0.18	0.42	0.43
SE(m)±	0.11	0.10	0.02	0.01	0.02	0.01
C.D. (5%)	NS	NS	NS	NS	NS	NS
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS
Initial values	7.70	7.80	0.20	0.21	0.39	0.40

4.6.2. Soil available N, P and K (kg ha⁻¹)

NPK are essential primary nutrients for plants. The level of availability of these influences the productivity of the crop in certain soil. The data on available N, P and K (kg ha⁻¹) of soil after harvest has been presented in Table 4.6.2.

The differences in available soil nitrogen were non-significant among various organic manure treatments (Table 4.6.2). The available soil nitrogen was found to be non-significant among various nitrogen levels treatments. These findings hold good for both the years. The range of available nitrogen varies from 170.1 to 174.8 kg ha⁻¹.

The available soil phosphorus among the various organic manures differed non-significantly (Table 4.6.2). Among nitrogen levels treatments, the differences in available soil P were non-significant. The findings hold good for both the years. The range of available P varies from 24.8 to 26.3 kg ha⁻¹.

Among the organic manure treatments, available soil potassium was found to be non-significant each year. Available soil K differed non-significantly among various nitrogen levels treatments. The findings were similar during both the years. The range of available potassium varies from 178.2 to 185.9 kg ha⁻¹.

The interactive effect of organic manures and nitrogen levels treatments on available N, P and K were non-significant during 2023 and 2024. Similar findings were reported by Bashir *et al.* (2012).

**Table 4.6.2 Effect of organic manures and nitrogen levels on available N, P and K
(kg ha⁻¹) of soil after harvest**

	Available N (kg ha⁻¹)		Available P (kg ha⁻¹)		Available K (kg ha⁻¹)	
	2023	2024	2023	2024	2023	2024
Main plots (Organic manures)						
No organic manure	170.9	171.2	25.0	25.6	179.6	178.2
FYM (15 t ha ⁻¹)	173.8	171.3	25.6	26.3	181.7	180.4
Poultry manure (6.25 t ha ⁻¹)	174.8	173.0	26.3	25.4	184.6	182.5
Press mud (15 t ha ⁻¹)	174.0	170.4	25.4	25.6	181.8	181.5
SE(m)±	1.75	0.85	0.60	0.56	2.05	0.91
C.D. (5%)	NS	NS	NS	NS	NS	NS
Sub-plots (N levels)						
Control (0 kg N ha ⁻¹)	172.0	170.6	24.8	25.9	180.2	180.1
75% RDN (100 kg N ha ⁻¹)	173.0	170.1	25.8	25.7	179.3	180.2
100% RDN (125 kg N ha ⁻¹)	174.4	172.5	25.8	26.0	182.3	181.4
125% RDN (150 kg N ha ⁻¹)	174.1	172.7	25.9	25.3	185.9	180.9
SE(m)±	1.51	1.64	0.77	0.74	2.07	1.66
C.D. (5%)	NS	NS	NS	NS	NS	NS
Interaction C.D. (5%)	NS	NS	NS	NS	NS	NS
Initial values	172.3	171.8	25.7	25.1	186.8	182.5

The research trial entitled “**Maximizing yield of spring maize (*Zea mays* L.) with the manipulation of agronomic practices**” was conducted during spring season of 2023 and 2024 at the Research Farm of Department of Agronomy, Lovely Professional University, Phagwara. The two experiments were conducted in Split Plot Design with four replications each during 2023 and 2024. The salient achievements of research work are presented experiment wise in the following pages.

Experiment 1 - Impact of planting patterns and weed control treatments on growth and development of spring maize

5.1 Weed parameters

- Weed count (m^{-2}) was significantly less in ridge sowing as compared to single row flat sown crop and paired row sowing when recorded at all periodic intervals *i.e.* 45, 75, 105 DAS and at harvest during both years as weed seeds were buried deep in soil at the time of ridge preparation. Among sub-plots, weed population was significantly less in the intercropping treatments *i.e.* *Sesbania* or cowpea *fb* earthing up and straw mulching during both the years as compared to unweeded (control) at all periodic intervals.
- Weed dry weight (q ha^{-1}) was significantly more in paired row planting as compared to ridge sowing and flat sowing with single row when recorded at 45, 75, 105 DAS and at harvest which may be due to more weed population and availability of optimum space for weed growth may be the reason for higher weed dry weight in paired row sowing during both the years. The weed control treatments recorded significantly less weed dry weight than unweeded (control) at all growth stages during both the years.
- Weed control efficiency (%) was higher in ridge sowing followed by flat sown single row sowing during both the years. Among the weed control treatments, the highest weed control efficiency was recorded in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up and straw mulching which was followed by intercropping *Sesbania aculeata fb* earthing up and straw mulching during both the years.

5.2 Crop growth parameters

- Plant height (cm) when recorded at 45, 75, 105 DAS and at harvest was significantly higher in ridge sowing and flat sown single row crop as compared to paired row plant during both the years. Among the weed control treatments, the plant height during both years was significantly more in both intercropping treatments followed by pendimethalin + atrazine pre-emergence *fb* straw mulching during both years.
- Plant dry weight (g plant^{-1}) was significantly higher in ridge sowing and flat sown single row as compared to paired row planting method during both the years. The plant dry weight was significantly more in intercropping treatments as compared to unweeded (control) at all periodic intervals.
- Number of leaves per plant were not influenced by planting patterns. However, among the weed control treatments, significantly higher number of leaves per plant were recorded in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching as compared to unweeded (control) during both the years.
- Number of nodes per plant were not impacted significantly by various planting patterns during both the years. Among the weed control treatments, the number of nodes per plant were significantly higher in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching which was followed by pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments. The number of nodes per plant was significantly lower in unweeded (control) at all growth stages.
- Stem girth (mm) recorded at 75, 105 DAS and at harvest during both years was significantly higher in ridge sowing and flat sown single row as compared to paired row plant method. Among the weed control treatments, stem girth was significantly higher in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching as compared to pendimethalin + atrazine pre-

emergence *fb* straw mulching and two hand weeding treatment. Significantly lower stem girth at all periodic intervals was recorded in unweeded (control).

- Internodal length (cm) remained non-significant among various planting patterns during both the years. Internodal length was significantly higher in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching as compared to unweeded (control).
- Chlorophyll index (SPAD value) was found to be non-significant among various planting patterns during both years. Among the weed control treatments, significantly more chlorophyll index was recorded in intercropping treatments which was followed by pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatment. The chlorophyll index was significantly less in unweeded (control) as compared to all other weed control treatments.

5.3 Yield parameters

- Number of cobs per plant remained non-significant among various planting patterns during both years of experimentation. Among the weed control treatments, intercropping treatments recorded significantly more number of cobs per plant as compared to unweeded (control) during both the years.
- Cob length (cm) was significantly higher in ridge sowing and flat sown single row as compared to paired row planting during both years. Among the weed control treatments, the intercropping treatments recorded significantly higher cob length as compared to all other weed control treatments. The cob length recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatment was significantly more than unweeded (control).
- Cob girth (mm) in ridge sowing and flat sown single row crop was significantly more as compared to paired row planting method during both years. Significantly higher cob girth was recorded in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and

intercropping *Sesbania fb* earthing up & straw mulching as compared to unweeded (control).

- Number of rows per cob were significantly higher in ridge sowing and flat sown single row crop as compared to paired row planting during both years. The pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching recorded significantly higher number of rows per cob as compared to other weed control treatments.
- Number of grains per cob were significantly higher in ridge sowing and flat sown single row crop as compared to paired row planting during both years of experimentation. The pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching recorded significantly higher number of grains per cob as compared to other weed control treatments.
- 1000 grain weight (g) in ridge sowing and flat sown single row was statistically at par but significantly higher than paired row planting during both years of study. The pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching recorded significantly higher 1000 grain weight as compared to other weed control treatments.
- Grain yield (q ha^{-1}) in ridge sown and single row flat sown crop was 9.61 and 7.92 percent higher than paired row sown crop based on two-year averaged data. On an average of two years, intercropping *Sesbania fb* earthing up & straw mulching, pendimethalin pre-emergence with intercropping of cowpea *fb* earthing up & straw mulching, pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding increased the grain yield of maize crop by 44.48, 40.85, 31.39 and 26.34 percent, respectively as compared to unweeded (control) treatment.
- The stover yield (q ha^{-1}) recorded in ridge sowing and flat sown single row was statistically at par with each other but significantly higher than paired row planting method during both years. Significantly higher stover yield was recorded in pendimethalin pre-emergence, intercropping cowpea *fb* earthing

up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching as compared to other weed control treatments.

- Biological yield (q ha^{-1}) was significantly higher in ridge sowing and flat sown single row crop as compared to paired row planting during both years. Among the weed control treatments, intercropping treatments recorded significantly higher biological yield as compared to all other treatments. Significantly less biological yield was recorded in pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments as compared to intercropping treatments.
- Harvest index (%) remained non-significant among the various planting patterns during both years. Among the weed control treatments, the harvest index in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching, intercropping *Sesbania fb* earthing up & straw mulching, pendimethalin + atrazine pre-emergence *fb* straw mulching and two hand weeding treatments was significantly higher as compared to unweeded (control) treatment.

5.4 Quality parameters

- N content in grains (%) was significantly higher in flat sown single row and ridge sowing method as compared to paired row planting during both years. Among the weed control treatments, N content in grains in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was significantly higher as compared to all other weed control treatments.
- N content in stover (%) was significantly more in ridge sowing method as compared to all other planting patterns during both years. Among the weed control treatments, N content in stover in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was significantly more as compared to all other weed control treatments.

- Protein content in grains (%) was significantly more in flat sown single row and ridge sowing method as compared to paired row planting during both years. Among the weed control treatments, protein content in grains in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was significantly higher as compared to all other weed control treatments.
- N uptake by grains (kg ha^{-1}) was significantly more in flat sown single row and ridge sowing method as compared to paired row planting during both years. Among the weed control treatments, N uptake by grains in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was significantly more as compared to all other weed control treatments.
- N uptake by stover (kg ha^{-1}) was significantly more in ridge sowing method as compared to all other planting patterns during both years. Among the weed control treatments, N uptake by stover in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was significantly more as compared to all other weed control treatments.
- Total N uptake by crop (kg ha^{-1}) was significantly more in flat sown single row and ridge sowing method as compared to paired row planting during both years. Among the weed control treatments, total N uptake by crop in pendimethalin pre-emergence, intercropping cowpea *fb* earthing up & straw mulching and intercropping *Sesbania fb* earthing up & straw mulching was significantly more as compared to all other weed control treatments.
- N content in weeds (%) was significantly more in paired row planting as compared to all other planting patterns during both years. Among weed control treatments, N content in weeds in unweeded (control) was significantly more as compared to all other weed control treatments.
- N uptake by weeds (kg ha^{-1}) was significantly higher in paired row planting as compared to all other planting patterns during both years. Among weed control treatments, N uptake by weeds in unweeded (control) was significantly more as compared to all other weed control treatments.

5.5 Soil properties

- Soil pH remained non-significant among various planting patterns and weed control treatments during 2023 and 2024.
- Soil EC (dS m^{-1}) remained non-significant among various planting patterns and weed control treatments during 2023 and 2024.
- Soil OC (%) remained non-significant among various planting patterns and weed control treatments during 2023 and 2024.
- Available N (kg ha^{-1}) remained non-significant among various planting patterns and weed control treatments during 2023 and 2024.
- Available P (kg ha^{-1}) remained non-significant among various planting patterns and weed control treatments during 2023 and 2024.
- Available K (kg ha^{-1}) remained non-significant among various planting patterns and weed control treatments during 2023 and 2024.

Experiment 2 - Influence of organic and inorganic nutrition on growth and development of spring maize

5.6 Weed parameters

- Weed count (m^{-2}) remained non-significant at all growth stages among various organic manure treatments during both years. Among the nitrogen level treatments, weed count was significantly higher in 75% RDN, 100% RDN and 125% RDN as compared to 0% RDN (control) at all growth stages.
- Weed dry weight (q ha^{-1}) was not influenced significantly under various organic manures during both years. Among the nitrogen levels, weed dry weight was significantly higher in 125% RDN as compared to other nitrogen level treatments. The weed dry weight was significantly lower in 0% RDN (control) as compared to all other nitrogen levels.

5.7 Crop growth parameters

- Plant height (cm) was significantly higher in FYM and poultry manure as compared to no organic manure treatment when recorded at 75 DAS, 105 DAS and at harvest during both the years. Among the nitrogen levels, the plant height was significantly higher in 100% RDN and 125% RDN as compared to 75% RDN and 0% RDN treatments at all growth stages.
- Plant dry weight (g plant^{-1}) was significantly higher in FYM and poultry manure as compared to press mud and no organic manure treatment during both years. Plant height in 100% RDN and 125% RDN was significantly higher compared to other nitrogen levels at all growth stages.
- Number of leaves per plant were significantly higher in poultry manure, FYM and press mud as compared to no organic manure treatment when recorded at 75 DAS during both years. However, at other crop growth stages, the effect of organic manures on number of leaves per plant were non-significant. Among the nitrogen levels, number of leaves per plant were significantly higher in 100% RDN and 125% RDN as compared to all other nitrogen levels at all growth stages of crop.
- Number of nodes per plant were significantly higher in FYM and poultry manure treatments during both years as compared to no organic manure treatment at all periodic intervals. Among the nitrogen levels, significantly higher number of nodes per plant were recorded in 100% RDN and 125% RDN as compared to other lower levels of nitrogen.
- Stem girth (mm) remained non-significant among various organic manures during both years. Among the nitrogen levels, significantly higher stem girth was recorded in 100% RDN and 125% RDN as compared to 0% RDN (control) when recorded at 75 DAS, 105 DAS and at harvest.
- Internodal length (cm) was non-significant among various organic manure treatments during both years. Among the nitrogen level treatments, internodal length in 100% RDN and 125% RDN was significantly higher compared to all other nitrogen levels.

- Chlorophyll index (SPAD value) was non-significant among various organic manure treatments during both years. Among the nitrogen levels, significantly higher chlorophyll index was recorded in 100% RDN and 125% RDN as compared to 75% RDN and 0% RDN (control) when recorded at 75 DAS, 105 DAS and at harvest.

5.8 Yield parameters

- Number of cobs per plant were significantly higher in poultry manure and FYM as compared to no organic manure treatment during both years. Among the nitrogen levels, the number of cobs per plant were significantly higher in 125% RDN and 100% RDN as compared to lower nitrogen level treatments.
- Cob length (cm) was significantly higher in FYM, poultry manure and press mud as compared to no organic manure treatment. Among the nitrogen levels, cob length in 100% RDN and 125% RDN was significantly higher than 75% RDN and 0% RDN (control) during both years of experimentation.
- Cob girth (mm) recorded in FYM and poultry manure during 2023 and 2024 was significantly higher as compared to press mud and no organic manure treatment. The cob girth in 100% RDN and 125% RDN was also significantly higher as compared to 75% RDN and 0% RDN (control).
- Number of rows per cob were significantly higher in FYM, poultry manure and press mud treatments as compared to no organic manure. Among the nitrogen levels, number of rows per cob in 100% RDN and 125% RDN were significantly higher than all other nitrogen levels.
- Number of grains per cob were significantly higher in FYM and poultry manure as compared to press mud and no organic manure treatment during both years. Significantly more number of grains per cob were recorded in press mud as compared to no organic manure treatment. Among the nitrogen levels, 100% RDN and 125% RDN recorded significantly higher number of grains per cob as compared to 75% RDN and 0% RDN (control) during both years.

- 1000 grain weight (g) recorded in FYM and poultry manure was significantly higher than no organic manure(control) treatment. Among the nitrogen levels, 100% RDN and 125% RDN recorded significantly higher 1000 grain weight as compared to 75% RDN and 0% RDN (control) treatments.
- Grain yield (q ha^{-1}) in poultry manure, FYM and press mud was 16.22, 15.09 and 9.87 percent higher than no organic manure treatment. Among nitrogen levels, application of 125% RDN, 100% RDN and 75% RDN increased the grain yield of maize crop by 42.67, 40.39 and 26.55 percent, respectively as compared to 0% RDN (control) treatment on averaged data of two years.
- Stover yield (q ha^{-1}) was significantly higher in FYM, poultry manure and press mud as compared to no organic manure (control) treatment during both years. Among the nitrogen levels, the stover yield was significantly higher in 100% RDN and 125% RDN as compared to all other nitrogen levels.
- Biological yield (q ha^{-1}) was significantly higher in FYM and poultry manure as compared to press mud and no organic manure treatment during both years. Press mud recorded significantly more biological yield as compared to no organic manure (control) treatment. Among the nitrogen levels, the biological yield in 100% RDN and 125% RDN was significantly higher as compared to 75% RDN and 0% RDN (control) treatments. The biological yield in 75% RDN was significantly more than 0% RDN (control) treatment.
- The harvest index (%) was significantly higher in FYM, poultry manure and press mud treatment as compared to no organic manure (control) treatment during both years. Among the nitrogen levels, significantly higher harvest index was recorded in 100% RDN and 125% RDN as compared to all other nitrogen levels. The application of 75% RDN produced significantly better harvest index than 0% RDN (control) treatments.

5.9 Quality parameters

- N content in grains (%) was significantly higher in poultry manure, FYM and press mud as compared to no organic manure during both years. Among the

nitrogen levels, N content in grains was significantly higher in 125% RDN and 100% RDN as compared to 75% RDN and 0% RDN.

- N content in stover (%) was significantly higher in poultry manure, FYM and press mud as compared to no organic manure during 2023. Among the nitrogen levels, N content in stover was significantly higher in 125% RDN and 100% RDN as compared to 75% RDN and 0% RDN during both years.
- Protein content in grains (%) was significantly higher in poultry manure, FYM and press mud as compared to no organic manure during both years. Among the nitrogen levels, protein content in grains was significantly higher in 125% RDN and 100% RDN as compared to 75% RDN and 0% RDN.
- N uptake by grains (kg ha^{-1}) was significantly higher in poultry manure and FYM as compared to no organic manure during both years. Among the nitrogen levels, N uptake by in grains was significantly higher in 125% RDN and 100% RDN as compared to 75% RDN and 0% RDN.
- N uptake by stover (kg ha^{-1}) was significantly higher in poultry manure and FYM as compared to no organic manure during both years. Among the nitrogen levels, N uptake by stover was significantly higher in 125% RDN and 100% RDN as compared to 75% RDN and 0% RDN.
- Total N uptake by crop (kg ha^{-1}) was significantly higher in poultry manure and FYM as compared to no organic manure during both years. Among the nitrogen levels, total N uptake by crop was significantly higher in 125% RDN and 100% RDN as compared to 75% RDN and 0% RDN.

5.10 Soil properties

- Soil pH was non-significant among various organic manures and nitrogen level treatments during 2023 and 2024.
- Soil EC (dS m^{-1}) was non-significant among various organic manures and nitrogen level treatments during 2023 and 2024.
- Soil OC (%) was non-significant among various organic manures and nitrogen level treatments during 2023 and 2024.

- Available N (kg ha^{-1}) was non-significant among various organic manures and nitrogen level treatments during 2023 and 2024.
- Available P (kg ha^{-1}) was non-significant among various organic manures and nitrogen level treatments during 2023 and 2024.
- Available K (kg ha^{-1}) was non-significant among various organic manures and nitrogen level treatments during 2023 and 2024.

Conclusion:

In first experiment, the sowing of maize with ridge planting method along with intercropping of cowpea or *Sesbania fb* earthing up and straw mulching reduced the weed count & dry weight, improved the crop growth parameters like plant height (cm), plant dry weight (g plant^{-1}), stem girth (mm) etc., enhanced yield attributes like cob girth (mm), number of rows per cob, number of grains per cob & 1000 grain weight (g) and produced better grain yield (q ha^{-1}) as compared to all the other combination treatments. Higher net returns were obtained from flat sowing with single row and ridge sowing as compared to flat sowing with paired row. The net returns in both the intercropping treatments were higher than all other weed control treatments.

In second experiment, use of poultry manure or FYM along with 100% RDN improved the growth characteristics like plant height (cm), plant dry weight (g plant^{-1}), number of nodes per plant etc., recorded better yield attributes like number of cobs per plant, cob girth (mm), cob length (cm), number of grains per cob and 1000 grain weight (g) and enhanced grain yield (q/ha) along with improved protein content (%) in grains which was better than press mud and no organic manure. The differences in maize grain yield in 100% RDN and 125% RDN was found at par. FYM and poultry manure produced higher net returns as compared to press mud and no organic manure treatment. Among N levels, 100% RDN and 125% RDN produced higher net returns than 75% RDN and 0% RDN (control).

From the study, it can be concluded that the grain yield of spring maize can be improved with ridge sowing along with intercropping of cowpea or *Sesbania* and use of either poultry manure or FYM.

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LIST OF PUBLICATIONS

No.	Title	Type of paper	Journal name	Status
1	Influence of planting patterns and integrated weed management practices on weed biomass, growth and yield of Spring maize	Research	Plant Science Today	Published
2	Effect of planting patterns and weed control treatments on growth and yield of Spring maize	Research	Agricultural Science Digest	Published
3	Impact of planting patterns and weed control treatments on weed dynamics, growth and yield of transplanted rice under unpuddled and puddled conditions	Research	Plant Science Today	Published
4	Role of planting patterns and weed control methods on growth and development of Fennel (<i>Foeniculum vulgare</i> Mill.)	Research	Agricultural Science Digest	Published
5	Effects of integrated nutrient management and fertilizers on the yield of baby corn in Punjab's climatic context	Research	Plant Science Today	Published
6	Impact of various nutrient management technique on growth, yield and quality attributes of Sweet sorghum (<i>Sorghum bicolor</i> L.)	Research	Plant Science Today	Published

LIST OF CONFERENCES

No.	Name of conference	Organised at	Title of oral/poster presentation	Date
1	National Conference on Maize: A Crop for Food, Feed, Nutritional and Bioenergy Security with Environmental Sustainability 2024	Punjab Agricultural University	Influence of planting patterns and weed control treatments on growth and yield of spring maize	23-25 August, 2024
2	International conference on Recent trends in Smart and Sustainable Agriculture for Food and Nutritional Security	Lovely Professional University	Impact of planting patterns and integrated weed management on growth and yield of spring maize	27 – 28 September, 2024
3	National Conference on "Nurturing Agricultural Advancement and Sustainability 2024	Sampoorna IIASHT	Influence of organic manures and nitrogen levels on the growth and productivity of maize crop	10-11 February, 2024