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Interactive effect of different levels of Nitrogen and FYM on growth, yield, and protein content of spring maize (*Zea mays* L.)

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Abstract
A field study entitled 'Interactive effect of different levels of nitrogen and FYM on growth, yield and protein content of spring maize (*Zea mays* L.)' was conducted during spring season in the year 2022 at LPU, Phagwara, Punjab. The experiment was conducted in split plot design with three levels of FYM (0, 15 and 22.5 t ha^{-1}) as main plot treatments and four levels of N (0, 62.5, 94 and 125 kg ha^{-1}) as sub plot treatments with three replications. Irrespective of FYM, increase in the level of N significantly increased the grain yield at every level of N applied. The higher grain yield under N_{125} was accompanied by a significant increase in growth and yield attributes. Irrespective of N, application of FYM_{15} significantly increased the grain over FYM_0 but further increase to $FYM_{22.5}$ failed to cause further significant affect over FYM_{15}. The higher grain yield under FYM_{15} was accompanied by the significant increase in the growth and yield attributes. The interaction between N and FYM was significant. The highest grain yield (7.67 t ha^{-1}) was recorded under the combination of FYM_{15} + N_{125}, which was at par with FYM22.5 + N125 (7.89 t ha^{-1}) but 12 % higher than $FYM_{22.5}$ + N_{94} (6.84 t ha^{-1}) and 15 % higher than FYM_{15} + N_{94}.

Keywords: Nitrogen, FYM, significance, grain yield, maize, growth, yield attributes, nutrient levels, treatments

1. Introduction
One of the most adaptable crops is maize (*Zea mays* L.), which can adjust to a wide range of agro-climatic conditions. Maize is renowned for being the "queen among cereals" due to its higher ability for productivity among all the cereals crops [1]. For millions of people around the world, maize is a staple diet. It is used to make a wide variety of food products including corn meal, corn flakes, corn syrup and popcorn. It is also used as animal feed for poultry, cattle, and other animals because it is an excellent source of carbohydrates, proteins, and other nutrients [2]. Industrial uses of maize include production of ethanol, which is used as a biofuel and manufacturing various products such as plastics, adhesives, and textiles. Maize is also used in the production of pharmaceutical products such as antibiotics and other medicines. Overall maize is a versatile crop with many important uses in various industries, and it continues to be an important crop for food security and economic development around the world [3].
The United States is the world's biggest maize producer, who contributes one third of the world's total maize output. According to the United States department of agriculture, The United States harvested maize on 33.7 million hectares in 2021, producing 360 million metric tons of the grain. In terms of maize production, India ranks 7th among the maize growing countries. During 2020-21 31.6 million metric tons of output were produced on 9.8 million hectares of area but the production has been increased to 34.6 million metric tons during 2022-2023 as of 2nd advance estimates in February 2023 [4].
In recent years, the country's spring maize region has also expanded quickly in the northwest, particularly in the states of Western Uttar Pradesh, Punjab, and Haryana. There are over 60,000 hectares of spring maize planted in these states. The greatest rate of growth among food crops since 2010, maize productivity in India is rising at the pace of 50 kg per ha per year. The two Indian states with the most land cultivated with maize are Madhya Pradesh and Karnataka (15%), followed by Uttar Pradesh (8%), Rajasthan (9%) and Maharashtra (10%). With 12 t ha-1, the state of Andhra Pradesh has the largest production [5].
Nutrient management is crucial for maize production because maize is a heavy feeder that requires adequate amount of nutrients to produce higher yields. Proper nutrient management helps to optimize the use of fertilizers and other soil amendments, prevent nutrient deficiencies

and toxicities, improves soil fertility, and decreased the act of nutrient leaching and runoff as they can harm the environment [6]. With a contribution of between 40 and 50 percent, nitrogen is essential for raising grain output. As nitrogen dosage is raised, so are yield and protein content in maize seed. Although plants absorb nitrogen during the whole growing season, they are most in need of nutrients during the tasseling, silking, and grain production phases [7]. During the vegetative growthy period, however, for the plant to grow at its fastest rate, it needs to have a reasonably high nutrient concentration. FYM is a degraded combination of animal waste, such as dung and urine, as well as litter and scraps from roughages or feeds given to cattle. It contributes to improving soil health by changing the biological, chemical, and physical features of the soil. Chemical fertilizers may be utilized more efficiently by maintaining enough soil aeration, improving the soil's capacity to hold water, and encouraging FYM. It aids in boosting the number of soil microorganisms, which improves the soil's ability to hold on to plant nutrients. It aids in enhancing the organic carbon condition of the soil [8]. Higher amounts of FYM application enhance soil characteristics. Furthermore, due to improved soil properties, applying FYM at higher rates significantly increases the amount of nutrients that maize plants can absorb [9].

Together, N and FYM raise the soil's nitrogen concentration. For striking a balance between crop demands and soil growth, combining organic and inorganic fertilizers seems to be a suitable alternative [10]. The use of chemical fertilizer sources aids in a temporary rise in agricultural output, but it also has the unintended side effect of depleting natural resources. Although multiple macro and micronutrients are provided to crops by organic sources of nutrition, Due to the limited nutritional value of organic manures, they alone cannot attain the highest level of maize output yield. Although the effectiveness of using diverse organic sources in combination with chemical fertilizers can enhance soil quality and increase crop yield over time, it is not as certain as using mineral fertilizers to satisfy the crop's nutritional needs. A high agricultural output that is sustainable and does not harm the land or only by using the proper blend of various organic manures and inorganic fertilizers would it be possible to utilize other natural resources [11].

2. Material and Methods

2.1 Location of the experimented site

The experiment was conducted in the farm of the Lovely Professional University's School of Agriculture in Phagwara, Punjab, which is situated at 31°24'N latitude and 75°70'E longitude, has an approximate elevation of 252 meters above the mean sea level in northwest India. Topographically, the farm had a medium slope with well irrigation facilities.

2.2 Soil properties

Soil samples were collected at random places in the experimental site with the help of a shovel at a depth of 15 cm and were air-dried, grounded, and sieved. Finally, the soil is analyzed in the soil laboratory. Details of the method used, and nutrient values obtained were furnished in Table 1.

Table 1: Physical, chemical and nutrient analysis of the soil.

S. No	Properties	Values	Method used
1.	Soil texture	Clay loam	Textural triangle method
2.	Chemical Properties		
	pH	8.6	Glass electric pH meter [12]
	EC (ds m^{-1} at 25^0 C)	0.28	Conductivity meter method [13]
	Organic carbon (%)	0.60	Walkley and Black method [14]
	Available P (kg/ ha)	33.5	Calorimeter method [15]
	Available K (kg/ ha)	247.5	Flame photometer method [16]

2.3 Weather data

The monthly mean weather data was recorded in the cropping season during February 2022 to June 2022 was presented in Table 2.

Table 2: Weather data of cropping season.

Month	Temperature (^{0}C)			Relative humidity (%)	Rainfall (mm)
	Min.	Max.	Avg.		
February	9.0	16.3	12.7	65.6	0.6
March	17.8	26.4	22.1	48.9	0.0
April	27.7	38.6	33.1	36.7	0.0
May	30.3	39.8	35.1	32.5	0.4
June	31.3	39.8	35.6	43.4	2.4

2.4 Experiment details

The experiment was conducted in *spring* season in the year of 2022 in the Split-plot design (SPD) containing three replications and twelve treatments with three different amounts of FYM *viz*., F_0 (control), F_{15} (15 t ha^{-1}), $F_{22.5}$ (22.5 t ha^{-1}) as a main plot treatments, and four nitrogen levels of nitrogen *viz*., N_0 (control), $N_{62.5}$ (62.5 kg ha^{-1}), N_{94} (94 kg ha^{-1}), N_{125} (125 kg ha^{-1}) as subplot treatments. The recommended dose of FYM and nitrogen was 15 ton per hectare and 125 kg per hectare. The sub plot size was 4.2 m * 4 m (16.8 m^2) and. The *spring* maize variety P1899 which was released in 2019 with the average duration of 120 days was used in the experiment and seeds was sown manually by using the method of dibbling with the plant spacing of 20 cm and row spacing of 60 cm at the depth of 3 cm to ensure the proper plant population. FYM was applied at required rate according to treatments in the respective plots 10 days before the experiment to ensure proper mixing into the soil and 1/3rd portion of the N was applied in the respective plots before sowing and remaining doses were applied at knee height stage and pre tasseling stage as per doses needed. Experimental field has sufficient moisture so the first irrigation was given after the germination in all the plots after 10 DAS. Different growth parameters like height of the plant, chlorophyll index, area of the leaf, basal stem girth and basal stem area were noted at 30, 60, 90 DAS and at the harvest time. After the harvest of the crop, grain yield, straw yield, total biological yield, and various yield contributors like length of the cob, grain rows cob^{-1}, grains cob^{-1}, grains row^{-1}, test weight and index for harvest were noted. The quality parameter, content of protein in grain was estimated from each plot in the laboratory by using percent N content in grains multiplied with the conversion factor *viz*., 6.25 to get protein content in grains.

2.5 Statistical analysis

The experiment's data were processed, placed into an inventory sheet in MS Excel, and then put through statistical analysis that use web-based OPSTAT software in the Split-plot (SPD) experimental design. The ANOVA was built to perform further inference. The appropriate LSD at the 0.05 level of probability were obtained for each case to the comparison the treatment means.

Table 3: Influence of different levels of N and FYM on plant height (cm) at harvest, leaves plant^{-1}, chlorophyll index, basal stem girth (cm), basal stem area (cm^2) and leaf area at 90 DAS of spring maize.

Nitrogen (kg/ ha)	FYM levels (t/ ha)			Mean
	FYM_0	FYM_{15}	$FYM_{22.5}$	
Plant height (cm)				
N_0	155	173	179	169
$N_{62.5}$	183	188	192	188
N_{94}	195	198	203	199
N_{125}	205	204	206	205
Mean	184	191	195	
Leaves plant^{-1}				
N_0	8.20	8.80	9.27	8.76
$N_{62.5}$	9.27	9.63	9.67	9.52
N_{94}	9.60	10.2	10.5	10.1
N_{125}	10.4	11.4	11.8	11.2
Mean	9.38	10.0	10.3	
Chlorophyll index				
N_0	33.4	34.5	35.2	34.4
$N_{62.5}$	34.8	35.0	36.4	35.4
N_{94}	35.2	37.5	42.8	38.5
N_{125}	38.0	43.2	42.7	41.3
Mean	35.4	37.5	39.3	
Basal stem girth (cm)				
N_0	7.00	7.21	7.66	7.29
$N_{62.5}$	7.37	7.75	8.00	7.70
N_{94}	7.72	8.13	8.65	8.16
N_{125}	8.06	8.50	9.14	8.57
Mean	7.54	7.90	8.36	
Basal stem area (cm^2)				
N_0	3.91	4.15	4.68	4.24
$N_{62.5}$	4.32	4.80	5.16	4.76
N_{94}	4.76	5.29	6.01	5.35
N_{125}	5.23	5.77	6.66	5.88
Mean	4.55	5.00	5.63	
Leaf area (cm^2)				
N_0	629	640	656	642
$N_{62.5}$	668	735	740	714
N_{94}	712	757	772	747
N_{125}	730	769	831	777
Mean	685	725	750	

		FYM	N	FYM × N
LSD (0.05)	Plant height	2.9	3.3	5.8
	Leaves plant^{-1}	0.300	0.347	0.604
	Chlorophyll index	1.61	1.86	3.23
	Basal stem girth	0.503	0.581	NS
	Basal stem area	0.653	0.754	NS
	Leaf area	10.4	12.0	20.8

3. Results and discussion

Plant height is the most important index for the rate of growth and the productivity of the crop. The data regarding the influence of various rates of N and FYM on the plant height at harvest of the maize were furnished in Table 3. The application of N and FYM, both alone and in combination, had a significant effect on the plant height of the maize at harvest. At harvest, irrespective of FYM, plant height was increased significantly at every level of N applied. Irrespective of N, increase in the level of FYM increased the plant height significantly at every level of FYM. The interaction between N and FYM was significant. At FYM_0 and FYM_{15}, the increase in the level of N resulted in a significant increase in plant height at every level of N. But at $FYM_{22.5}$, the increase in the plant height was significant up to N_{94} but further increase to N_{125} failed to increase the plant height significantly. The results further revealed that, at N_0, increase in the level of FYM to FYM_{15} increased the plant height significantly over FYM_0 further increase to $FYM_{22.5}$ caused further significant increase. At $N_{62.5}$ and N_{94}, increase in the levels of FYM to FYM_{15} failed to increase the plant height significantly but further increase to $FYM_{22.5}$ over FYM_0 but it was at par with FYM_{15}. At N_{125}, increase in the level of FYM failed to increase the plant height significantly. Various authors have reported that the plant height was increased significantly with the increase in the level of N (Khan *et al.* 2011 [17]; Parija 2013 [18]). Kafle and Sharma (2015) [19] concluded that increase in the level of FYM to 15 t ha^{-1} increased the plant height significantly in *Kharif* maize but further increase to 20 t ha^{-1} failed to cause further significant effect. Singh *et al.* (2013) [20] concluded that application of FYM along with the N levels increased the plant significantly over the alone application of N levels.

The number of leaves plant^{-1} is an important growth parameter and has a significant impact on plant growth, yield, and overall crop quality. The data regarding the influence of different levels of N and FYM on leaves plant^{-1} at 90 DAS of the maize are presented in Table 3. The application of N and FYM alone and in combination significantly affected the leaves plant^{-1}. At 90 DAS, irrespective of FYM, increase in the level of N significantly increased the leaves plant^{-1} at every level of N applied. Irrespective of N, increase in the level of FYM to FYM_{15} increased the leaves plant^{-1} significantly over FYM_0 but further increase to $FYM_{22.5}$ failed to increase significantly. The interaction between N and FYM was significant. At FYM_0, increase in the level of N to $N_{62.5}$ increased the leaves plant^{-1} significantly over N_0 further increase to N_{94} significantly increased the leaves plant^{-1} over N_0 but it was at par with $N_{62.5}$ but further increase to N_{125} increased the leaves plant^{-1} significantly. At FYM_{15}, the increase in the level of N to $N_{62.5}$ significantly increased the leaves plant^{-1} over N_0 further increase to N_{94} significantly increased leaves plant^{-1} over N_0 but it was at par with $N_{62.5}$ but further increase to N_{125} significantly increased the leaves plant^{-1}. At $FYM_{22.5}$, increase in the level of N to $N_{62.5}$ failed to increase the leaves plant^{-1} significantly over N_0 but further increase to N_{94} and N_{125} increased the leaves plant^{-1} significantly at their respective levels over N_0 and $N_{62.5}$. At N_0 and N_{125} application of FYM_{15} significantly increased the leaves plant^{-1} over FYM_0 further increase to $FYM_{22.5}$ failed to increase the leaves plant^{-1} significantly. At $N_{62.5}$ and N_{94}, application of FYM_{15} failed to increase the leaves plant^{-1} significantly over FYM_0 but further increase to $FYM_{22.5}$ significantly increased the leaves plant^{-1} over FYM_0 but it was at par with FYM_{15}. Various authors have reported the different results on effect of N and FYM on leaves plant^{-1}. Karkia *et al.* (2020) [21] concluded that the application of 60 kg N ha^{-1} increased the number of leaves plant^{-1} significantly over control. Kuntoji *et al.* (2021) [22] revealed that application of 150 kg N ha^{-1} significantly increased the number of leaves plant^{-1} significantly. Kafle and Sharma (2015) [19] concluded that application of 15 t ha^{-1} significantly increased the leaves plant^{-1}.

Chlorophyll index is a measure used to access the relative content of chlorophyll in plant leaves, it helps in quantifying and accessing the plant health, optimizing the crop management practicing and to predict the yields. The data regarding the influence of different levels of N and FYM on chlorophyll index at 90 DAS of the maize are presented in Table 3. At 90 DAS, irrespective of FYM, application of $N_{62.5}$ failed to increase the chlorophyll index significantly over N_0 but further increase to N_{94} and N_{125} significantly increased the chlorophyll index at their respective levels over N_0 and $N_{62.5}$. Irrespective of N, increase in the level of FYM significantly increased the chlorophyll index at every level FYM applied. The interaction between N and FYM was significant. At FYM_0 and FYM_{15}, increase in the level of N to $N_{62.5}$ and N_{94} failed to increase the chlorophyll index significantly but further increase to N_{125} increased the chlorophyll index significantly. At $FYM_{22.5}$, application of N_{94} significantly increased chlorophyll index over N_0 and $N_{62.5}$ but further increase to N_{125} failed to increase significantly. Adhikari *et al.* (2021) [23] concluded that application of 125 kg N ha^{-1} significantly increased the chlorophyll content at 60 DAS in *kharif* maize. Patel *et al.* (2006) [24] reported that application of 120 kg N ha^{-1} significantly increased the chlorophyll index. Inamullah *et al.* (2011) [25] concluded that application of 125 kg N ha^{-1} significantly increased the chlorophyll index.

Stem girth is an important growth parameter to be considered in maize cultivation, as it can impact maize stability, nutrient transport, and a thicker stem with a larger diameter can provide better support to the developing ears of maize. The data regarding the influence of different levels of N and FYM on stem girth at 90 DAS of the maize are presented in Table 3. At 90 DAS, irrespective of FYM, application of $N_{62.5}$ failed to increase the stem girth significantly over N_0 further increase to N_{94} significantly increased the stem girth compared to N_0, but it was at par with N_{94} further increase to N_{125} failed to increase significantly. Irrespective of N, application of FYM_{15} failed to increase the stem girth significantly over FYM_0 further increase to $FYM_{22.5}$ increased the stem girth significantly over FYM_0, but it was at par with FYM_{15}. However, the interaction between N and FYM was non-significant. Okumara *et al.* (2011) [26] reported that the increase in the level of N increased stem girth significantly.

The data regarding the influence of different levels of N and FYM on basal stem area of the maize are presented in Table 3. The application of N and FYM alone significantly affected the basal stem area. At 90 DAS, irrespective of FYM, increase in the level of N to $N_{62.5}$ failed to increase the basal stem area significantly over N_0 further increase to N_{94} increased the basal stem area over N_0, but it was at par with $N_{62.5}$ but further increase to N_{125} failed to increase the basal stem significantly. Irrespective of N, increase in the level of FYM to FYM_{15} failed to increase the basal stem area over FYM_0 further increase to $FYM_{22.5}$ significantly increased the basal stem area over FYM_0, but it was at par with FYM_{15}. However, the interaction between N and FYM was non-significant.

The leaf area is an important factor in determining the photosynthetic potential of a plant, it is also an important factor in plant growth and development, resource allocation and to withstand environmental stress. The data regarding the influence of different levels of N and FYM on leaf area at 90 DAS of the maize are presented in Table 3. The application of N and FYM alone and in combination significantly affected the leaf area. At 90 DAS, irrespective of FYM, increase in the level of N increased the leaf area significantly at every level of N. Irrespective of N, increase in the level of FYM significantly increased the leaf area at every level of FYM. The interaction between N and FYM was significant. At FYM_0 and FYM_{15}, increase in the level of N increased the leaf area significantly up to N_{94} further increase to N_{125} failed to increase the leaf area significantly. But at $FYM_{22.5}$, the increase in the level of N significantly increased the leaf area at every level of N. At N_0, application of FYM_{15} failed to increase the leaf area significantly over FYM_0 further increase to $FYM_{22.5}$ significantly increased the leaf area over FYM_0, but it was at par with FYM_{15}. At $N_{62.5}$ and N_{94}, application of FYM_{15} significantly increases the leaf area over FYM_0 further increase to $FYM_{22.5}$ failed to increase the leaf area significantly. At N_{125}, increase in the level of FYM significantly increased the leaf area at every level of FYM. Verma *et al.* (2012) [27]; Pokhrel *et al.* (2009) [28] conducted that the increase in the level of N increased the leaf area at every level of N at 90 DAS.

Table 4: Influence of different levels of N and FYM on days to 50 % tasseling, days to 50 % silking and Tassel length on spring maize.

Nitrogen (kg ha^{-1})	Levels of FYM (t ha^{-1})			Mean
	FYM_0	FYM_{15}	$FYM_{22.5}$	
Days to 50 % tasseling				
N_0	82.3	78.6	76.3	79.1
$N_{62.5}$	79.3	77.6	75.3	77.4
N_{94}	77.3	75.6	73.3	75.4
N_{125}	76.3	75.0	72.3	74.5
Mean	78.8	76.7	74.3	
Days to 50 % silking				
N_0	81.6	79.6	78.3	79.8
$N_{62.5}$	81.0	79.0	77.6	79.2
N_{94}	78.3	77.0	76.3	77.2
N_{125}	77.0	75.0	74.6	75.5
Mean	79.5	77.6	76.7	
Tassel length (cm)				
N_0	18.6	21.3	22.9	20.9
$N_{62.5}$	22.7	23.7	23.6	23.3
N_{94}	23.6	27.8	28.6	26.7
N_{125}	26.7	30.4	32.5	29.8
Mean	22.9	25.8	26.9	

		FYM	N	FYM × N
LSD (0.05)	Days to 50% tasseling	1.96	2.27	NS
	Days to 50 % silking	1.70	1.93	NS
	Tassel length	1.02	1.18	2.05

The data regarding the influence of different levels of N and FYM on days to 50 % tasseling were presented in Table 4. The application of N and FYM alone significantly affected the days to 50 % tasseling. Irrespective of FYM, increase in the level of N to $N_{62.5}$ failed to decrease the days to 50 % tasseling significantly over N_0 but further increase to N_{94} significantly decreased the days to 50 % tasseling over N_0 but it was at par with $N_{62.5}$ but further increase to N_{125} failed to decrease the days to 50 % tasseling significantly. Irrespective of N, increase in the level of FYM significantly decreased the days to 50 % tasseling at every level of FYM applied. However, the interaction between N and FYM was non-significant. Ali (2021) [29] concluded that increase in the level of N significantly decreased the days to tasseling in *kharif* maize. Shrestha *et al.* (2018) [30] concluded that increase in the levels of N decreased the days to tasseling significantly at every level of N applied. Halecha *et al.* (2018) [31] revealed that increase in the level of FYM to 10 t ha^{-1} failed to cause any significant effect on days to tasseling.

The data regarding the influence of different levels of N and FYM on days to 50 % silking were presented in Table 4. The application of N and FYM alone significantly affected the days to 50 % silking. Irrespective of FYM, increase in the level of N to $N_{62.5}$ failed to decrease the days to 50 % silking over N_0 further increase to N_{94} significantly decreased the days to 50 % silking over N_0 and $N_{62.5}$ but further increase to N_{125} failed to decrease the days to 50 % silking. Irrespective of N, application of FYM_{15} significantly decreased the days to 50 % silking over FYM_0 but further increase to $FYM_{22.5}$ failed to decrease the days to 50 % silking significantly. However, the interaction between N and FYM was non-significant. Getnet *et al*. (2018) [32] concluded that application of 120 kg N ha^{-1} decreased the days to silking significantly at every level of N. Shrestha *et al*. (2018) [30] concluded that increase in the levels of N decreased the days to silking significantly at every level of N applied.

The tassel is the male reproductive part that forms at the top of the maize plant. It plays a vital role in the pollination process and is responsible for producing and dispersing pollen, which is necessary for fertilizing the female flowers and ensuring the development of maize kernels. The data regarding the influence of different levels of N and FYM on tassel length were presented in Table 4. The application of N and FYM alone and in combination significantly affected the tassel length. Irrespective of FYM, increase in the level of N significantly increased the tassel length at every level of N applied. Irrespective of N, increase in the level of FYM increased the tassel length significantly at every level of FYM. The interaction between N and FYM was significant. At FYM_0, increase in the level of N to $N_{62.5}$ increased the tassel length significantly over N_0 further increase to N_{94} increased the tassel length significantly over N_0, but it was at par with $N_{62.5}$ but further increased to N_{125} increased the tassel length significantly. At FYM_{15}, the increase in the level of N significantly increased the tassel length at every level of N. At $FYM_{22.5}$, the increase in the level of N to $N_{62.5}$ failed to increase the tassel length significantly over N_0 but further increase to N_{94} and N_{125} significantly increased the tassel length at their respective levels over N_0 and $N_{62.5}$. At N_0 and N_{94} application of FYM_{15} increased the tassel length significantly over FYM_0 but further increase to $FYM_{22.5}$ failed to increase the tassel length significantly. At $N_{62.5}$, increase in the level of FYM failed to increase the tassel length significantly. At N_{125}, increase in the level of FYM to FYM_{15} significantly increased the tassel length over FYM_0 but further increase to $FYM_{22.5}$ failed to increase the tassel length significantly.

Table 5: Influence of different levels of N and FYM on cob length, number of grain rows cob^{-1}, number of grains row^{-1} and total number of grain cob^{-1} of spring maize.

Nitrogen (kg ha^{-1})	**Levels of FYM (t ha^{-1})**			**Mean**
	FYM_0	**FYM_{15}**	$FYM_{22.5}$	
Cob length (cm)				
N_0	16.2	16.4	16.5	16.4
$N_{62.5}$	17.5	18.2	18.8	18.2
N_{94}	19.5	20.5	21.0	20.3
N_{125}	20.6	23.6	24.0	22.7
Mean	18.5	19.6	20.1	
Number of grain rows cob^{-1}				
N_0	11.7	12.6	13.2	12.5
$N_{62.5}$	12.4	13.4	13.4	13.0
N_{94}	12.8	14.0	14.2	13.6
N_{125}	13.5	15.0	15.4	14.6
Mean	12.6	13.7	14.0	
Number of grains row^{-1}				
N_0	26.1	29.5	34.4	30.0
$N_{62.5}$	32.2	34.4	35.3	33.9
N_{94}	36.2	39.7	40.2	38.7
N_{125}	38.1	41.2	43.9	41.0
Mean	33.1	36.2	38.4	
Total number of grains cob^{-1}				
N_0	349	365	386	367
$N_{62.5}$	423	460	499	460
N_{94}	512	559	563	544
N_{125}	555	645	651	617
Mean	459	507	525	

		FYM	**N**	**FYM × N**
LSD (0.05)	Cob length	0.72	0.83	NS
	Number of grain rows cob^{-1}	0.95	1.09	NS
	Number of grains row^{-1}	2.20	2.54	NS
	Total number of grains cob^{-1}	23.3	26.9	NS

The data regarding the influence of different levels of N and FYM on cob length were presented in table 5. The application of N and FYM alone significantly affected the cob length. Irrespective of FYM, increase in the level of N significantly increased the cob length at every level of N. Irrespective of N, application of FYM15 significantly increased the cob length over FYM0 but further increase to FYM22.5 failed to cause further significant affect. However, the interaction between N and FYM was non-significant. Maqsood *et al*. (2012) [33] concluded that application 120 kg N ha^{-1} significantly increased the cob length. Halecha *et al.* (2018) [31] revealed that increase in the level of FYM to 10 t ha^{-1} failed to increase the cob length significantly over control. Khan *et al.* (2008) [34]

application of 20 t ha^{-1} significantly increased the cob length over no FYM.

The data regarding the influence of different levels of N and FYM on number of grain rows cob^{-1} were presented in table 5. The application of N and FYM alone significantly affected the number of grain rows cob^{-1}. Irrespective of FYM, increase in the level of N to $N_{62.5}$ failed to increase number of grain rows cob^{-1} significantly over N_0 further increase to N_{94} significantly increased the number of grain rows cob^{-1} over N_0, but it was at par with $N_{62.5}$ but further increase to N_{125} failed to increase the number of grain rows cob^{-1} significantly. Irrespective of N, increase in the level of FYM to FYM_{15} significantly increased the number of grain rows cob^{-1} over FYM_0 but further increase to $FYM_{22.5}$ failed to increase the number of grain rows cob^{-1} significantly. However, the interaction between N and FYM was non-significant. Rani *et al.* (2013) [35] application of 200 kg N ha^{-1} significantly increased the grain rows cob^{-1}. Imran *et al*. (2015) [36] reported that application of 120 kg N ha^{-1} significantly increased the grain rows cob^{-1}.

The data regarding the influence of different levels of N and FYM on number of grains row^{-1} were presented in table 5. The application of N and FYM alone significantly affected the number of grains row^{-1}. Irrespective of FYM, increase in the level of N to significantly increased the number of grains row^{-1} at every level up to N_{94} but further increase to N_{125} failed to increase the number of grains row^{-1} significantly. Irrespective of N, increase in the level of FYM to FYM_{15} significantly increased the number of grains row^{-1} but further increase to $FYM_{22.5}$ failed to cause further significant affect. However, the interaction between N and FYM was non-significant. Wang *et al*. (2017) [37] and Bakht *et al*. (2007) [38] concluded that increase in the level of N significantly increased the grains row^{-1}.

The data regarding the influence of different levels of N and FYM on total number of grains cob^{-1} were presented in Tables 5. The application of N and FYM alone significantly affected the total number of grains cob^{-1}. Irrespective of FYM, increase in the level of N significantly increased the total number of grains cob^{-1} at every level of N. Irrespective of N, increase in the level of FYM to FYM_{15} increased the total number of grains cob^{-1} significantly over FYM_0 but further increase to $FYM_{22.5}$ failed to cause further significant affect. However, the interaction between N and FYM was non-significant.

Table 6: Influence of different levels of N and FYM on total biological yield, stover yield, grain yield and harvest index of spring maize.

Nitrogen (kg ha^{-1})	**Levels of FYM (t ha^{-1})**			**Mean**
	FYM_0	**FYM_{15}**	**$FYM_{22.5}$**	
Grain yield (t ha^{-1})				
N_0	3.44	4.47	4.81	4.24
$N_{62.5}$	4.56	5.57	5.82	5.32
N_{94}	5.60	6.64	6.84	6.36
N_{125}	6.62	7.67	7.89	7.40
Mean	5.06	6.09	6.34	
Stover yield (t ha^{-1})				
N_0	4.08	6.60	7.40	6.03
$N_{62.5}$	6.42	8.44	8.62	7.82
N_{94}	7.36	9.53	10.2	9.05
N_{125}	9.85	12.3	12.4	11.5
Mean	6.93	9.23	9.68	
Biological yield (t ha^{-1})				
N_0	7.53	11.0	13.3	10.6
$N_{62.5}$	10.9	14.0	14.4	13.1
N_{94}	13.0	16.1	17.0	15.4
N_{125}	16.4	20.0	20.3	18.9
Mean	12.0	15.3	16.3	
Harvest index (%)				
N_0	30.0	33.3	35.3	32.8
$N_{62.5}$	32.3	34.6	38.6	35.2
N_{94}	35.3	37.6	40.3	37.7
N_{125}	38.0	41.3	43.6	41.0
Mean	33.9	36.7	39.5	

		FYM	**N**	**FYM × N**
LSD (0.05)	Biological yield	0.456	0.571	0.902
	Stover yield	0.912	1.051	1.825
	Grain yield	0.92	1.06	1.84
	Harvest index	1.56	2.24	NS

Grain yield is the final total produced grain weight which is the result of the cumulative effect of the growth parameters like plant height, number of leaves plant^{-1}, leaf area, chlorophyll index and yield attributes like cob length, number of grain rows cob^{-1}, number of grains row^{-1}, total number of grains cob^{-1} and test weight. The data regarding the influence of different levels of N and FYM on grain yield were presented in Table 6. The application of N and FYM alone and in combination significantly affected the grain yield. Irrespective of FYM, increase in the level of N significantly increased the grin yield at every level of N. Irrespective of N, increase in the level of FYM to FYM_{15} increased the grain yield significantly over FYM_0 but further increase to $FYM_{22.5}$ failed to cause further significant affect. The interaction between N and FYM was significant. At all the levels of FYM, the increase in the level of N significantly increased the grain yield at every level of N.

At all the levels of N, application of FYM_{15} significantly increased the grain yield over FYM_0 but further increase to $FYM_{22.5}$ failed to increase significantly. Dawadi (2012) [39] revealed that application of 160 kg N ha^{-1} significantly increased the grain yield. Kuntoji *et al*. (2021) [22] concluded that application of 150 kg N ha^{-1} significantly increased the grain yield over control. Begum *et al*. (2018) [40] reported that application of 125 kg N ha^{-1} significantly increased the grain yield. Halecha *et al.* (2018) [31] concluded that application 10 t FYM ha^{-1} significantly increased the grain yield. Kadam *et al.* (2017) [41] revealed that increase in the level of FYM to 15 t ha^{-1} significantly increased the grain yield.

Stover yield was obtained after extracting the grains from the plants after harvest. The data regarding the influence of different levels of N and FYM on stover yield were presented in Table 6. The application of N and FYM alone and in combination significantly affected the stover yield. Irrespective of FYM, increase in the level of N increased the stover yield significantly at every level of N. Irrespective of N, application of FYM_{15} significantly increased the stover yield over FYM_0 but further increased to $FYM_{22.5}$ failed to increase significantly. The interaction between N and FYM was significant. At FYM_0 and FYM_{15}, increase in the level of N to $N_{62.5}$ increased the stover yield significantly over N_0 further increase to N_{94} increased the stover yield significantly over N_0, but it was at par with $N_{62.5}$ further increase to N_{125} significantly increased the stover yield. At $FYM_{22.5}$, the increase in the level of N to $N_{62.5}$ failed to increase the stover yield significantly over N_0 but further increase to N_{94} and N_{125} significantly increased the stover yield at their respective levels over N_0 and $N_{62.5}$. At all the levels of N, application of FYM_{15} significantly increased the stover yield over FYM_0 but further increase to $FYM_{22.5}$ failed to increase significantly. Jena *et al*. (2013) [42] concluded that increase in the level of N significantly increased the stover yield. Amanullah *et al*. (2015) [43] reported that application of 120 kg N ha^{-1} significantly increased the stover yield. Kadam *et al.* (2017) [41] concluded that increase in the level of FYM to 10 t ha^{-1} increased the stover yield significantly.

Biological yield is the total biomass resulted in whole life cycle of plants observed after the harvest of the crop. The data regarding the influence of different levels of N and FYM on biological yield were presented in Table 6. The application of N and FYM alone and in combination significantly affected the biological yield. Irrespective of FYM, increase in the level of N significantly increased the biological yield at every level of N. Irrespective of N, increase in the level of FYM significantly increased the biological yield at every level of FYM applied. The interaction between N and FYM was significant. At FYM_0 and FYM_{15}, increase in the level of N significantly increased the biological yield at every level of N. At $FYM_{22.5}$, increase in the level of N to $N_{62.5}$ failed to increase the biological yield over N_0, but further increase to N_{94} and N_{125} significantly increased the biological yield at their respective levels compared to N_0 and $N_{62.5}$. At N_0, increase in the level of FYM significantly increased the biological yield at every level. At $N_{62.5}$, N_{94} and N_{125}, application of FYM_{15} significantly increased the biological yield over FYM_0, but further increase to $FYM_{22.5}$ failed to increase significantly. Shahid *et al*. (2016) [44] concluded that application of 200 kg N ha^{-1} significantly increased the biological yield. Khan *et al* (2008) [34] reported that application of 20 t FYM ha^{-1} significantly increased the biological yield.

The harvest index is an important parameter that measures the proportion of grain yield and total biomass produced, which is generally expressed as ratio or percentage, it is the direct measure of crop efficiency and yield prediction. The data regarding the influence of different levels of N and FYM on harvest index were presented in Table 6. The application of N and FYM alone significantly affected the harvest index. Irrespective of FYM, increase in the level of N increased the harvest index significantly at every level of N applied. Irrespective of N, increase in the level of FYM significantly increased the harvest index at every level of FYM applied. However, the interaction between N and FYM was non-significant. Rani *et al.* (2013) [35] concluded that application of 100 kg N ha^{-1} significantly increased the harvest index. Mahmood *et al*. (2001) [45] reported that the increase in the level of N significantly increased the harvest index.

Table 7: Influence of different levels of N and FYM on test weight and protein content of spring maize.

Nitrogen (kg ha^{-1})	Levels of FYM (t ha^{-1})			Mean
	FYM_0	FYM_{15}	$FYM_{22.5}$	
Test weight (g)				
N_0	280	288	293	287
$N_{62.5}$	286	306	305	299
N_{94}	311	320	331	321
N_{125}	321	328	333	327
Mean	300	310	315	
Protein content (%)				
N_0	4.56	5.52	6.65	5.58
$N_{62.5}$	5.55	6.70	7.46	6.57
N_{94}	6.65	7.65	8.94	7.74
N_{125}	7.99	9.22	9.98	9.06
Mean	6.19	7.27	8.26	

		FYM	N	FYM × N
LSD (0.05)	Test weight	4.7	5.4	NS
	Protein content	0.424	0.490	0.840

Test weight is the weight of 1000 grains, which is the essential parameter for grain quality estimation and yield estimation. The data regarding the influence of different levels of N and FYM on test weight were presented in Table 7. The application of N and FYM alone significantly affected the test weight. Irrespective of FYM, increase in the level of N significantly increased the test weight at every level of N. Irrespective of N, increase in the level of FYM to FYM_{15} significantly increased the test weight over FYM_0 but further increase to $FYM_{22.5}$ failed to increase significantly. However, the interaction between N and FYM was non-significant. Begum *et al*. (2018) [40] reported that increase in the level of N failed to increase the test weight significantly. Sharma *et al.* (2019) [46] concluded that application of 120 kg N ha^{-1} significantly increased the test weight.

Protein content in a grain is a qualitative analysis and the data regarding the influence of different levels of N and FYM on protein content were presented in Table 7. The application of N and FYM alone and in combination significantly affected the protein content. Irrespective of FYM, increase in the level of N significantly increased the protein content at every level of N. Irrespective of N, increase in the level of FYM increased the protein content significantly at every level of FYM applied. The interaction between N and FYM was significant. At FYM_0 and FYM_{15}, increase in the level of N significantly increased the protein content at every level of N. At $FYM_{22.5}$, increase in the level of N to $N_{62.5}$ failed to increase the protein content but further increase to N_{94} and N_{125} significantly increased the protein content at their respective levels over N_0 and $N_{62.5}$. At N_0 and N_{94}, increase in the level of FYM significantly increased the protein content at every level of FYM but at $N_{62.5}$ and N_{125}, application of FYM_{15} significantly increased the protein content over FYM_0 further increase to $FYM_{22.5}$ failed to increase significantly. Kuntoji *et al*. (2021) [22] reported that increase in the level of N significantly increased the protein content. Halecha *et al.* (2018) [31] concluded that application of 10 t FYM ha^{-1} significantly increased the protein content.

Conclusion

The results of the experimental study revealed that, irrespective of FYM, application of N_{125} produced significantly higher grain yield which was accompanied by significant increase in growth attributes *viz*., plant height, leaves $plant^{-1}$, chlorophyll index, basal stem girth, basal stem area and leaf area and yield attributes *viz*., cob length, number of grain rows cob^{-1}, number of grains row^{-1}, total number of grains cob^{-1}, test weight, stover yield and biological yield. Irrespective of N, application of $FYM_{22.5}$ significantly increased the growth attributes but in case of yield attributes FYM_{15} resulted in the significant increase. The interaction between N and FYM was significant, where the application of FYM_{15} along with the N_{125} produced significantly higher grain yield which was accompanied by the growth attributes *viz*., plant height, leaves $plant^{-1}$, chlorophyll index, basal stem girth, basal stem area and leaf area and yield attributes *viz*., cob length, number of grain rows cob^{-1}, number of grains row^{-1}, total number of grains cob^{-1}, test weight, stover yield and biological yield. The application of FYM along with the inorganic N improves nutrient balance, adds organic matter to the soil, improves soil health, slow release of nutrients which improves nutrient use efficiency and reduce harmful impacts on environment. By the application of proper ratio of inorganic N and FYM significantly increased the productivity levels and thus maximizes the crop yields compared to alone application of Inorganic N.

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