Maize Journal (October 2023) 12(2): 106-112

RESEARCH PAPER

Response of planting methods and nitrogen levels on quality parameters of high-quality protein maize hybrids

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Abstract: A field experiment was conducted at Agronomy research farm, CCS Haryana Agricultural University, Hisar. The experiment consisted of four planting techniques *viz.* raised bed system (RBS), flat sowing with zero tillage (FSZT), flat sowing with minimum tillage (FSMT) and flat sowing with conventional tillage (FSCT) in main plots and two maize hybrids *viz.* HQPM-1 and HQPM-5 and three nitrogen levels *viz.* 120, 150 and 180 kg N ha^{-1} in sub plots with combination, were tested in split plot design with three replications. Results indicated that the planting of maize on FSZT resulted in significantly higher lysine content (more than 3.2%) as compared to FSCT and FSMT. Among the maize hybrids, significantly higher lysine content was recorded with HQPM-5 hybrids, during both the crop seasons. Application of nitrogen @ 180 kg ha^{-1} produced significantly higher lysine content (more than 2.6%) compared to 120 kg ha^{-1} and 150 kg ha^{-1}. FSZT with 180 kg N ha^{-1} recorded significantly higher tryptophan content (more than 0.85%) than FSMT and FSCT but did not differ with FSZT under 150 kg N ha^{-1} during both the crop seasons. FSZT planted maize with 180 kg N ha^{-1} had significantly highest total protein content (11.1%) over all other treatment combinations in 2014, but it was at par with FSZT planted maize with the application of 180 N kg ha^{-1} in 2013. Under all the planting methods, the total protein content was increased with increasing dose of nitrogenous fertilizer during both the years of study. Quality parameters *viz.*, lysine, tryptophan and protein during the two crop seasons were appreciably higher with FSZT under HQPM-5 hybrid and 180 kg N ha^{-1}. Stable starch, sugar, fat content and specific gravity of maize were not influenced significantly by different planting methods, maize hybrids and N levels during both the crop seasons.

Keywords: High quality protein maize (HQPM) · Raised bed system · Zero tillage · Nitrogen levels · Quality parameters

Introduction

Maize (*Zea mays* L.) is one of the important staple food crop of the world after wheat and rice. It contributes significantly in world's economy, grown over an area of 193.7 mha with a total production of 1147.7 million MT with average productivity of 5.75 t/ha (FAOSTAT, 2020). In India, it is an important cereal crop next only to rice and wheat with acreage of around 9.86 mha and production of 31.51 million tonnes during 2020-21 (DES, 2021). Maize was grown in an area of 4970 hectare with production of 15570 tonnes and productivity of 3133 kg per ha in Haryana during 2021-22 (GOI, 2022). One of the green revolution states, Haryana has come a long way in food production. The last few decades have seen some radical changes in the agriculture sector of the state and production and productivity have increased many folds. Earlier, the primary focus of agriculture in the State had been to increase food production and to improve livelihood of farmers, now agriculture sector is gradually becoming a technologically driven dynamic profession. However, this success has also given rise to the second-generation problems. The problems of soil degradation (soil compaction, soil salinity, sodicity, water

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Received: 16 August 2023/ Accepted: 23 September 2023

logging, and pesticide residue), multiple nutrient deficiency, low organic carbon content and decline in the total factor productivity have been observed under different production systems in the State. Haryana may have ample scope to increase acreage and productivity of maize as it has potential to substitute puddled transplanted rice. In addition, cultivation of maize is easy, faces less incidence of pest and diseases with high potential till there is lot of scope to increase the present maize yields.

Maize crop is cultivated throughout the year in the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn and pop corn in peri-urban areas. There are multiple benefits of resource conservation technology (RCT) adoption like enhanced productivity, resource use efficiency, profitability, reduced environmental foot prints and better soil health in Indo-Gangetic Plains of India (Jat *et al.,* 2019 and Parihar *et al.,* 2018). Nitrogen (N) management is an important aspect in CA, as it can synergizes the benefits from better soil health. The right placement of N in the vicinity of crop roots is important as it assures better N supply and can enhance the crop productivity. Traditionally any agronomic management is evaluated based on crop productivity and profitability. The mean grain yield of hybrid grown on FIRBS yielded 44% more than conventional practice and 12 per cent with no-till practices (Jat *et al*., 2007). Replacement of field maize by quality protein maize (HQPM) is the most effective and attractive measures to meet the dietary protein needs in human beings and animals. HQPM production in zero-tillage would help India become both “Food secure” and “Nutritional secure” (Jat 2007) and is also “environmental secure”. Selection of hybrid varieties of maize with different planting methods at optimum dose of nutrients particularly N is a serious problem in north India for quantitative and qualitative production of maize. Utilization and improvement of soil resources is of paramount importance for enhancing crop production (Shahane and Shivay, 2021; Guo, 2021). Proposed investigation was basically aimed to explore possibilities of crop diversification by including maize in the system as an alternate of rice and also to find out optimum dose of N besides suitable planting method. Saving in irrigation water, improvement in soil health and environmental protection will be possible broader outcome besides attaining higher productivity and profitability.

Materials and methods

A field experiment was conducted during the *kharif* seasons of 2013 and 2014 at the Agronomy Research Farm, of CCS Haryana Agricultural University, (situated at 29^o 10' North latitude and 75^o 46' East longitudes at an elevation of 215.2 m above mean sea level) Hisar, India. Composite samples, prepared by passing though 2 mm mesh sieve, were analysed for various soil properties. The details of physical and chemical properties of the experimental field along with the method followed are given in table 1. The rainfall received during the crop seasons of 2013 and 2014 was 661.7 and 212.1 mm, respectively (Figure 1 & 2). The mean weekly maximum temperature in *kharif* 2013 ranged between 31.3 to 39.6°C and minimum between 22.4 to 28.4°C, while, their corresponding values in *kharif* 2014 were 32.5 to 42.3°C and 21.5 to 28.6°C. The mean weekly morning and evening relative humidity ranged between 67 to 96 per cent and 33 to 81 per cent in *kharif* 2013 and between 60 to 94 per cent and 32 to 72 per cent in the year *kharif* 2014, respectively (Figure 1 & 2). The experiment consisted of four planting techniques *viz.* raised bed system (RBS), flat sowing with zero tillage (FSZT), flat sowing with minimum tillage (FSMT) and flat sowing with conventional tillage (FSCT) in main plots and two maize hybrids *viz.* HQPM-1 and HQPM-5 and three nitrogen levels *viz.* 120, 150 and 180 kg N ha^{-1} in sub plots with combination. The 24 treatment combinations were tested in split-split plot design with three replications, presented in Table 2.

Hybrid maize HQPM-1 and HQPM-5 were sown on 20.06.2013 during first year and on 22.06.2014 during second year by dibbling method at spacing of 70 cm from line to line and 22.5 cm from plant to plant at 5-6 cm depth. Nitrogen, phosphorus and potassium were applied trough urea, DAP and MOP as per the treatments. All the field operations such as hoeing, irrigation *etc.* were done as per agronomic procedures required. The crop was harvested on 23.10.2013 during first year and on 09.10.2014 during second year of study. The harvested grain and stover from each plot was weighted *in situ* on weighing balance in kg plot^{-1}. The plot sizes of each treatment were 24 m^2 (4 m × 6 m). A random sample of 500 g was taken from each plot at the time of harvesting of grains as well as stover. The samples were first dried in the electric hot air oven at the

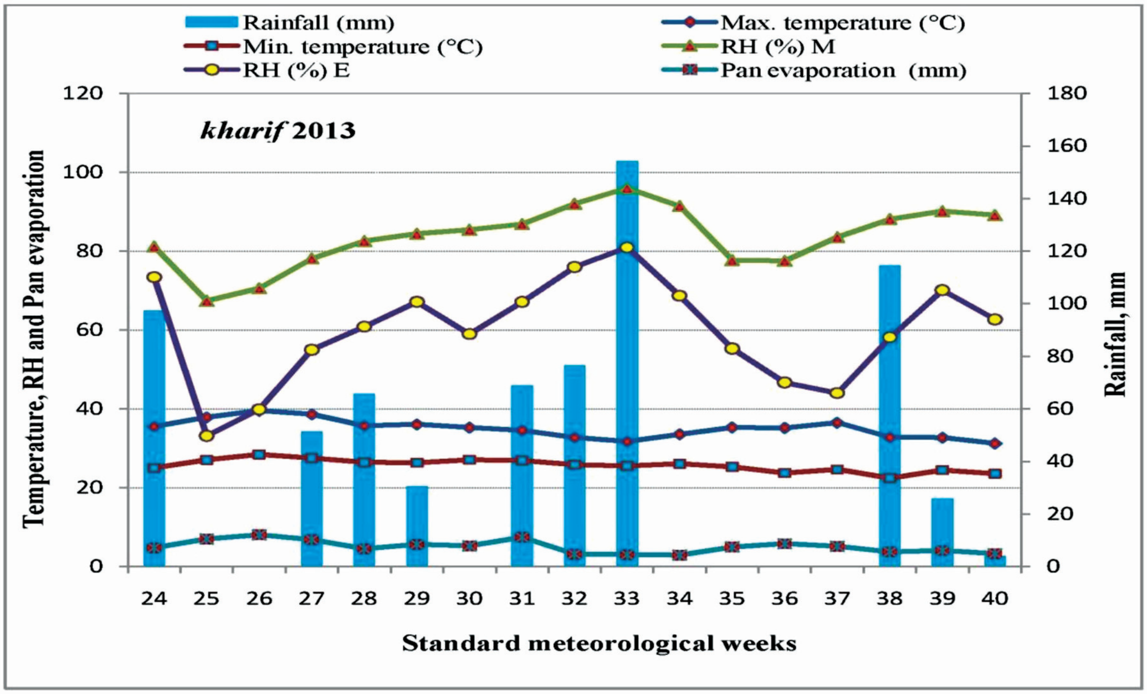

Figure 1. Weekly meteorological observatory data during experimental year of 2013

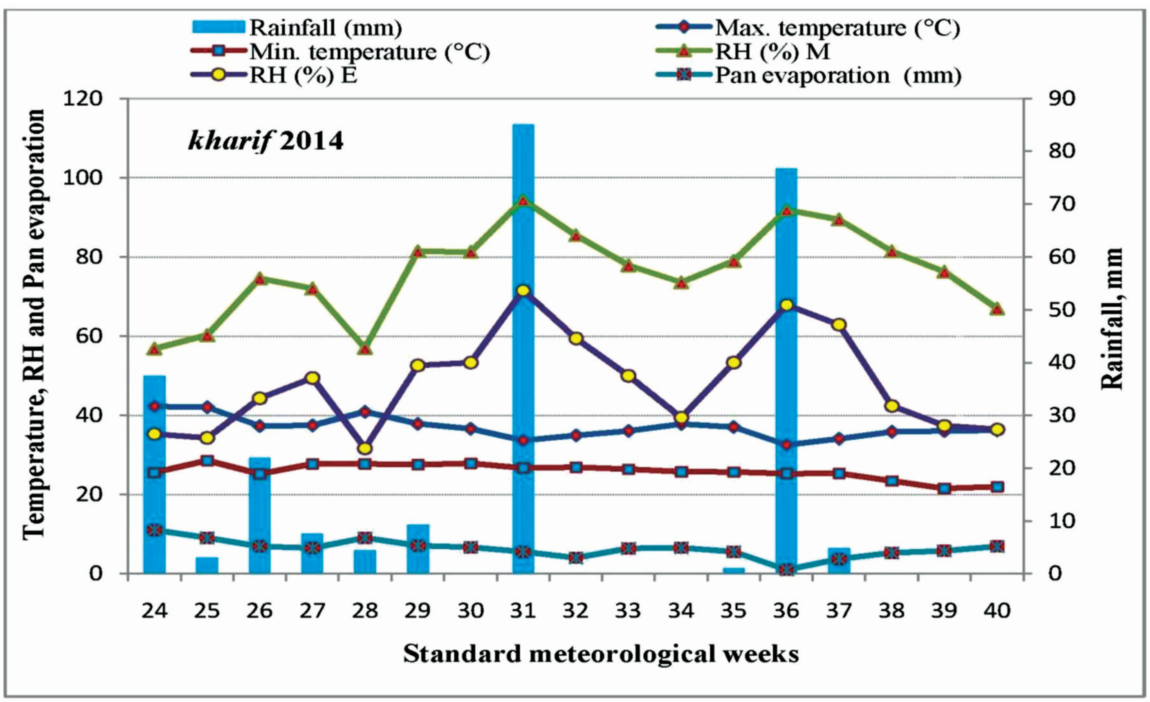

Figure 2. Weekly meteorological observatory data during experimental year of 2014

temperature of 70 ± 5°C till constant weight. The samples of grain and stover were analyzed by following standard procedures in the laboratory. The colorimetric method was followed extensively for screening the maize germplasm for lysine content because of its simplicity and rapidly. The lysine determination is performed only on those samples selected as having high tryptophan values, or when lysine value, in addition to tryptophan, is desired. Method used for tryptophan estimation as suggested by Hernandez and Bates was used. In protein determination first the nitrogen content was determined by Kjeldhal method and the percentage protein was calculated by using factor 6.25 for maize grain. The stable starch content was estimated by Anthron method.

The sugar content of maize grain was estimated by Somogyi's titrimetric method used with spectrophotometer, and employs copper and arsenomolybdate reagents. The fat content of maize was estimated by Soxlet method. The principle is based on the extraction of oil using non-polar solvents *viz.* ether, hexane, petroleum ether (40-60ºC) and chloroform: methanol (2:1). It involves repeated extraction of oil. The solvent is then distilled off completely. The oil is dried, weighed and the percentage of oil is calculated by following formula.

$$\text{Fat in the sample (\%)} = \frac{\text{Weight of fat (g)}}{\text{Weight of sample (g)}} \times 100$$

Data collected during the study were statistically analyzed by using the technique of analysis of variance (ANOVA) described by (Panse and Sukhatme, 1978).

Table 2. Details of treatments used in experiments.

Planting methods	Symbol used
Raised bed system (RBS)	P1
Flat sowing with zero tillage (FSZT)	P2
Flat sowing with minimum tillage (FSMT)	P3
Flat sowing with conventional tillage (FSCT)	P4
Maize hybrids	
HQPM-1	V1
HQPM-5	V2
Nitrogen levels (kg ha^{-1})	
120	N1
150	N2
180	N3

Results and discussion

Effect on lysine, tryptophan and total protein content (%) of maize

Different planting methods significantly influenced lysine, tryptophan and total protein content of maize (Table 3). Planting of maize on FSZT resulted in significantly higher lysine content (3.22% and 3.29%), tryptophan content (0.83% and 0.85%) and protein content (10.85% and 10.90%) during 2013 and 2014, respectively as compared to FSCT and FSMT but was at par with raised bed system (Table 3). Lysine, tryptophan and protein content are the important quality parameters of the crop which are to be considered while assessing the effect of different treatments and competitive ability of the crop with nutrients. Lysine, tryptophan and protein increased with the FSZT planting method. This might be due to the vigorous growth and bolder grain and higher uptake of nutrients by the maize crop Dey *et al.* (2016). Among the maize hybrids significantly higher lysine, tryptophan and total protein content were recorded with HQPM-5 hybrids, during both the crop seasons. There was a significant variation in lysine, tryptophan and protein content by maize crop under HQPM-5 maize hybrids because it has genetic character for higher quality proteins. Yadav *et al.* (2016) and Jat *et al.* (2009) also reported the similar results of quality parameters of maize.

Application of nitrogen @ 180 kg ha^{-1} (N3) produced significantly higher lysine content (2.63% and 2.71%), tryptophan content (0.77% and 0.81%) and protein content (9.03 and 4.38%) during 2013 and 2014, respectively, as compared to 150 kg ha^{-1} (N1) and 120 kg ha^{-1} (N2). Nitrogen is the most common element limiting growth and yield as well as quality of maize. Adequate supply of the nutrient to crop, helped in the synthesis of carbohydrates and protein in plants. The role of nitrogen in synthesizing zien protein, protoplasm and body building materials of plants are well documented. Increased nitrogen application resulted in increase in more lysine,

Table 1. Initial physic-chemical properties of experimental soil

Soil parameter/components	Value	Status	Method of estimation
Sand	57.3%	Sandy loam	International pipette method (Piper, 1966)
Silt	24.5%		
Clay	18.2%		
Soil pH (1:2 soil watersuspension)	8.04	Alkaline	Glass electrode pH meter method (Jackson, 1973)
Organic carbon (%)	0.45	Medium	Walkley & Black's wet Oxidation method (1934)
Available N (kg ha^{-1})	142.0	Low	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	22.7	High	Olsen's method (Olsen *et al*., 1954)
Available K_2O (kg ha^{-1})	276.0	Medium	Flame photometer method (Richards, 1954)

Table 3. Lysine, tryptophan and total protein content (%) of maize as influenced by various planting methods, hybrids and nitrogen levels

Treatments	Lysine content (%)		Tryptophan content (%)		Total protein content (%)	
	2013	2014	2013	2014	2013	2014
Planting methods						
RBS	2.37	2.82	0.74	0.78	10.23	10.34
FSZT	3.22	3.29	0.83	0.85	10.85	10.90
FSMT	2.29	2.40	0.72	0.76	9.77	10.07
FSCT	2.26	2.34	0.71	0.76	9.51	9.72
SEm±	0.046	0.051	0.006	0.007	0.003	0.007
CD at (5%)	0.128	0.159	0.019	0.021	0.011	0.021
Hybrids						
HQPM-1	2.38	2.70	0.73	0.75	9.97	10.08
HQPM-5	2.69	2.86	0.77	0.80	10.20	10.42
SEm±	0.011	0.013	0.002	0.003	0.001	0.006
CD at (5%)	0.031	0.039	0.005	0.009	0.002	0.018
Nitrogen levels (kg ha^{-1})						
120	2.43	2.52	0.73	0.75	9.71	9.92
150	2.54	2.65	0.75	0.80	10.20	10.43
180	2.63	2.71	0.77	0.81	10.35	11.03
SEm±	0.013	0.015	0.002	0.003	0.001	0.001
CD at (5%)	0.038	0.046	0.006	0.009	0.002	0.002

tryptophan and protein during both the crop seasons. Similar results were also reported by Sharma and Gautam (2006); Rao *et al.* (2009); Dawadi and Sah (2012); Kumar *et al.* (2018).

The data on interaction effect of various planting methods with nitrogen levels on lysine content (Table 4) revealed that FSZT planted maize with application of 180 kg N ha^{-1} (N3) had significantly higher lysine content (3.35% and 3.48% in the respective two seasons) over all other treatment combinations. Likewise, FSZT with 180 kg N ha^{-1} recorded significantly higher tryptophan content (0.85% in 2013 and 0.88% in 2014) but did not differ with FSZT under 150 kg N ha^{-1} during both the crop seasons (Table 4). Similarly, FSZT planted maize with nitrogen @ 180 kg ha^{-1} (N3) had significantly higher total protein content (11.13% and 11.15% in the respective two seasons) over all other treatment combinations, but it was at par with FSZT planted maize with the application of 180 N kg ha^{-1} (N3). Under all the planting methods, the lysine, tryptophan and total protein content were increased with increasing dose of nitrogenous fertilizer during both the years of study. With the successive increase in nitrogen application from 120 kg N ha^{-1} to 180 kg N ha^{-1}, there was significant increase in lysine, tryptophan and protein content of maize. The increased lysine, tryptophan and protein with enhancing level of nitrogen were also reported by Haokip *et al.* (2019); Awasthi (2014); Jat (2015).

Effect on stable starch content, sugar content, fat content and specific gravity of maize

The stable starch content, sugar content, fat content and specific gravity of maize were not significantly influenced by different planting methods, maize hybrids and nitrogen levels (Table 5). Though, the highest values of above mentioned parameters were recorded in FSCT planted maize during both seasons of crop compared to other methods. Stable starch, sugar, fat content and specific gravity of maize were not influenced significantly by different planting methods, hybrid maize hybrid and nitrogen levels (Table 5). Maximum stable starch content was obtained in FSZT, and minimum with FSZT during both the crop seasons. This might be due to higher

Table 4. Interaction effects of planting methods and nitrogen levels on Lysine, tryptophan and total protein content of maize

Treatments	2013			2014		
	N1	N2	N3	N1	N2	N3
Lysine content (%)						
P1	2.18	2.41	2.52	2.41	2.59	2.70
P2	3.10	3.22	3.35	3.24	3.32	3.48
P3	2.23	2.28	2.36	2.42	2.54	2.59
P4	2.21	2.27	2.31	2.38	2.52	2.54
SEm±		0.02			0.04	
CD at (5%)		0.07			0.13	
Tryptophan content (%)						
P1	0.72	0.73	0.77	0.73	0.76	0.81
P2	0.82	0.84	0.86	0.85	0.87	0.88
P3	0.71	0.73	0.75	0.74	0.74	0.78
P4	0.70	0.72	0.73	0.73	0.74	0.77
SEm±		0.004			0.006	
CD at (5%)		0.012			0.019	
Total protein content (%)						
P1	9.72	10.41	10.57	9.83	10.55	10.89
P2	10.49	10.96	11.13	10.67	10.82	11.15
P3	9.43	9.85	10.04	9.58	9.89	10.43
P4	9.24	9.60	9.67	9.47	9.65	10.10
SEm±		0.09			0.07	
CD at (5%)		0.27			0.21	

Table 5. Stable starch content, sugar content, fat content and specific gravity of maize as influenced by various planting methods, hybrids and nitrogen levels

Treatments	Stable starch content (%)		Sugar content (%)		Fat content (%)		Specific gravity	
	2013	2014	2013	2014	2013	2014	2013	2014
Planting methods								
RBS	68.35	66.80	5.97	6.40	5.65	6.10	1.16	1.10
FSZT	67.78	65.21	6.08	6.90	5.74	6.41	1.20	1.17
FSMT	68.49	67.45	5.78	6.30	5.46	5.92	1.13	1.09
FSCT	69.01	67.95	5.29	6.21	4.97	5.64	1.09	1.06
SEm±	1.92	1.89	0.37	0.42	0.32	0.37	0.05	0.04
CD at (5%)	NS	NS	NS	NS	NS	NS	NS	NS
Hybrids								
HQPM-1	68.43	66.86	5.69	6.30	5.36	5.98	1.13	1.08
HQPM-5	68.39	66.12	5.88	5.63	5.56	6.09	1.16	1.13
SEm±	0.57	0.52	0.21	0.27	0.19	0.21	0.03	0.02
CD at (5%)	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen levels (kg ha^{-1})								
120	68.55	66.72	5.67	5.67	5.35	5.60	1.12	1.06
150	68.34	66.40	5.80	5.80	5.47	5.96	1.14	1.10
180	68.35	67.18	5.87	5.87	5.55	6.12	1.17	1.13
SEm±	1.43	1.34	0.24	0.24	0.26	0.29	0.042	0.039
CD at (5%)	NS	NS	NS	NS	NS	NS	NS	NS

accumulation of lysine, tryptophan and protein content. In case of sugar content, fat content and specific gravity of maize, these were recorded maximum with FSZT and lowest with FSCT treatments because of vigorous growth, bolder grains and higher uptake of nutrients. Among the maize hybrids, HQPM-5 recorded high stable starch, sugar, fat content and specific gravity due to genetic character for higher quality. Application of higher dose of nitrogen reduced stable starch content while increased sugar, fat content and specific gravity compared to low dose of nitrogen. This might be due to higher accumulation of lysine, tryptophan, protein, sugar, fat content and specific gravity. Similar results were also suggested by Awasthi (2014); Jayprakash *et al.* (2004); Ram *et al.* (2010); Jat *et al.* (2007).

Conclusion

Various aspects of the present investigation and observation generated showed that all the quality attributing traits *viz.,* lysine, tryptophan and protein content of maize were discernibly influenced by manipulation in planting methods, maize hybrid and N level. Results clearly suggested that, lysine, tryptophan and protein content of maize can be appreciably higher under flat sowing with zero tillage (FSZT) with HQPM-5 maize hybrid supplied with 180 kg N ha^{-1}.

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