

Original Research Article

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Effect of Planting Methods, Maize Hybrids and Nitrogen Levels on Nutrient Uptake of High Quality Protein Maize (*Zea mays* L.)

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ABSTRACT

A field experiment entitled, “Performance of maize (*Zea mays* L.) hybrids under different planting methods and nitrogen levels” was conducted at Agronomy research farm, CCS Haryana Agricultural University, Hisar during *kharif* 2013 and 2014. 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 obtained from this experiment indicated that the highest nutrient uptake by maize was recorded with FSZT as compared to RBS, FSMT and FSCT. The highest nitrogen uptake by maize (91.50 kg ha⁻¹ by grain and 59.01 by stover during 2013 and 86.28 kg ha⁻¹ by grain and 53.28 kg ha⁻¹ by stover during 2014 crop seasons, respectively) was recorded with FSZT planted maize. Likewise, between the maize hybrids HQPM-5 recorded significantly higher nitrogen uptake over HQPM-1 hybrid during both the crop seasons. Among the nitrogen levels N uptake was found to enhance with successive levels of nitrogen from 120 kg N ha⁻¹ to 180 kg N ha⁻¹ during 2013 and 2014 crop seasons. Effects of different treatments on uptake of phosphorus and potassium by maize grain and stover were almost similar to nitrogen uptake. Application of nitrogen increased significantly NPK uptake.

Keywords

High quality protein maize (HQPM), RBS, FSZT, FSMT, FSCT, nitrogen levels, NPK uptake

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Introduction

Maize (*Zea mays* L.) is a one of the important staple food crops of the world and ranks next only to wheat and rice as the third most important crop in the world. Maize is the most important crop in world's economy, grown over an area of 177 m ha with a total production of 967 mt. India ranks fourth in area and sixth in production of maize. In India, it is an important cereal crop next only to rice

and wheat with acreage of around 9.4 million hectares and production of 23.0 million tonnes with the highest per day productivity (Anonymous, 2015a). Maize was grown in an area of 9,000 hectare with production of 27,000 tonnes and productivity of 3,000 kg per hectare in Haryana during 2014-2015 (Anonymous, 2015b). Haryana state has an ample scope to further increase acreage and productivity of maize as it can be strong candidate in the derive of crop diversification

to displace puddled transplanted rice. In the recent years, maize has replaced many traditional crops and its area is increasing very fast in Haryana due to severe incidence of pests and diseases and greater rainfall abnormality, the traditional crops became non profitable. In addition to many above good characters of maize, easiness in cultivation, free from pest and diseases, high yield, better market price, better soils and good rainfall with well distribution has become popular and more profitable. In these areas maize attained a commercial crop status. Still there is lot of scope to increase the present maize yields. Maize crop management involves decision making on several cultural/agronomic practices aimed to maximize grain yields like planting methods (CA based RCTs), improved varieties and proper nutrient management. Interventions in the form of new resource conservation technologies (RCTs) like zero-tillage and furrow irrigated raised bed system (FIRBS) coupled with crop diversification by including maize in place of rice may be a viable solution. The mean grain yield of hybrid genotypes grown on FIRBS yielded 44% more than conventional practice and 12% with no-till practices (Jat *et al.*, 2007). The total water use in maize under FIRBS (2030.3 m³ ha⁻¹) and no-tillage (2722.8 m³ ha⁻¹) were remarkably reduced by 84.3 and 62.8 %, respectively compared to conventional tillage (3231.0 m³ ha⁻¹) practice. Further, the water productivity (kg grain m³ water) was also considerably higher under FIRBS (3.05) and no-tillage (2.02) compared to conventional practice (1.33). Replacement of common maize by hybrid quality protein maize (HQPM) is the most effective and attractive measure to meet quality protein needs and to raise the nutritional status of human beings and animals. HQPM production in zero-tillage would help India become both "Food secure" and "Nutritional secure" (Jat *et al.*, 2007) and is also "environmental secure". Selection of hybrid varieties of maize and different

planting methods at suitable 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. Adequate information is not available on the performance of maize hybrids under different planting methods and varying dose of nutrients particularly N. Proposed investigation is 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 site 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. The soil of the field is derived from Indo-Gangetic alluvium soil is sandy loam in texture. Four representative soil samples were drawn from different places in the experimental field from 0-15 cm depth before starts of the experiments. Composite samples, prepared by passing through 2 mm mesh sieve, were analysed. The details of physical and chemical properties of the experimental field along with the method followed are given in table 1 and 2. The rainfall received during the *kharif* crop seasons of 2013 and 2014 was 661.7 and 212.1 mm, respectively. 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. 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 plot design with three replications, presented in table 3.

Nitrogen, phosphorus and potassium were applied through urea, DAP and MOP as per the treatments. All the field operations such as hoeing, irrigation *etc.* Were done as and when required. The harvested grain and stover from each plot was weighted *in situ* on salter balance in kg plot⁻¹. 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 temperature of 70 ± 5°C till constant weight. The samples of grain and stover were analyzed by following standard procedures in the laboratory. Total N in grain and stover were analyzed by colorimetric (Nessler's reagent) method (Linder, 1944) and total P analyzed by Vanadomolybdo phosphoric yellow colour method (Koenig and Johnson, 1942). The total K in grain and stover were analyzed by flame photometer. Data collected during the study were statistically analyzed by using the technique of analysis of variance (ANOVA) described by (Panse and Sukhatme 1978). To judge the significant difference between means of two treatments, the critical difference (C.D.) was worked out using following formula, cited in Cochran and Cox (1959).

Results and Discussion

Nutrients uptake by high quality protein maize

The data pertaining to nitrogen uptake (kg ha⁻¹) by grain is given in Table 4. Among different planting techniques maximum nitrogen uptake by grain was recorded by zero tilled maize (FSZT), which was significantly better than FSMT and FSCT but was at par to raised bed system (RBS).

Between the maize hybrids, HQPM-5 hybrid was found to superior over HQPM-1 hybrid for the uptake of nitrogen during both the crop seasons. Nitrogen uptake by grain was found to increased with increasing fertility levels. Among different N levels maximum nitrogen uptake by grain was recorded with 180 kg N ha⁻¹ and lowest with 120 kg N ha⁻¹ during both the crop seasons.

The data on interaction effect of various planting methods with nitrogen levels on nitrogen uptake by grain (Table 5) revealed that FSZT planted maize with nitrogen at the rate of 180 kg ha⁻¹ (N3) had significantly highest N uptake by maize grain (101.45 kg ha⁻¹ and 95.52 kg ha⁻¹ in the respective two seasons) over the FSCT with N3, N2 and N1 combinations, but all other treatment combinations at par with FSZT planted maize with nitrogen at the rate of 180 kg ha⁻¹ (N3).

The data pertaining to nitrogen uptake (kg ha⁻¹) by stover is given in table 4. The nitrogen uptake by maize stover was significantly higher under FSZT as compared to FSMT and FSCT. However, FSZT was at par to raised bed system (RBS) in respect of nitrogen uptake by maize stover. Nitrogen uptake by grain was found to increase with increasing fertility levels. Nitrogen uptake by stover was found to increase with HQPM-5 maize hybrid over the HQPM-1 hybrid.

Table.1 Physico-hydrological properties of experimental soil

Component	Fraction, %	Method of Estimation
Sand	57.3	International pipette method (Piper 1966)
Silt	24.5	
Clay	18.2	
Textural class	Sandy loam	
Bulk density, g cm ⁻³	1.39	Core sampling (Piper 1966)
Infiltration rate, mm hr ⁻¹	4.27	Ring infiltrometers (Reddy 2012)
FC at -0.03 MPa	19.89	Pressure membrane apparatus (Richards 1954)
PWP at -1.5 MPa	5.93	
Available water, %	13.85	

Table.2 Initial chemical properties of experimental soil

Soil parameter	Value	Status	Method of estimation
Soil pH (1:2 soil water suspension)	8.04	Alkaline	Glass electrode pH meter method (Jackson 1973)
EC (dSm ⁻¹ at 25°C) (1:2 soil water suspension)	0.20	-	Conductivity bridge method (Richards 1954)
Organic carbon (%)	0.45	Medium	Walkley and Black's wet Oxidation method (1934)
Available N (kg ha ⁻¹)	142.0	Low	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P ₂ O ₅ (kg ha ⁻¹)	22.7	High	Olsen's method (Olsen <i>et al.</i> , 1954)
Available K ₂ O (kg ha ⁻¹)	276.0	Medium	Flame photometer method (Richards 1954)

Table.3 Details of treatments used in experiments

A.	Planting methods	Symbol used
i.	Raised bed system (RBS)	P1
ii.	Flat sowing with zero tillage (FSZT)	P2
iii.	Flat sowing with minimum tillage (FSMT)	P3
iv.	Flat sowing with conventional tillage (FSMT)	P4
B.	Maize hybrids	Symbol used
i.	HQPM-1	V1
ii.	HQPM-5	V2
C.	Nitrogen levels (kg ha⁻¹)	Symbol used
i.	120	N1
ii.	150	N2
iii.	180	N3

Table.4 Nitrogen, phosphorus and potassium uptake by maize crop as influenced by various planting methods, maize hybrids and nitrogen levels

Treatments	Nitrogen uptake (kg ha ⁻¹)				Phosphorus uptake (kg ha ⁻¹)				Potassium uptake (kg ha ⁻¹)			
	2013		2014		2013		2014		2013		2014	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
Planting methods												
Raised bed system	81.91	51.20	77.09	46.50	20.12	11.60	19.15	11.97	18.02	105.98	18.17	95.05
FSZT	91.50	59.01	86.28	53.28	22.24	13.20	21.04	13.26	20.03	114.44	20.03	102.87
FSMT	80.83	49.48	76.11	44.65	19.19	10.32	18.28	11.19	17.12	106.04	17.36	94.47
FSCT	71.06	41.17	67.11	37.94	17.51	9.29	16.41	10.08	15.59	99.60	15.54	88.51
SEm±	0.50	0.07	0.53	0.29	0.12	0.05	0.16	0.12	0.09	0.23	0.09	0.43
CD at (5%)	1.75	0.24	1.85	1.00	0.43	0.17	0.57	0.43	0.33	0.80	0.32	0.149
Maize hybrids												
HQPM-1	78.04	48.46	73.88	44.12	18.86	10.56	17.93	11.21	16.89	104.17	17.04	92.99
HQPM-5	84.62	51.97	79.41	47.07	20.66	11.64	19.51	12.04	18.49	108.86	18.50	97.46
SEm±	0.36	0.08	0.41	0.13	0.09	0.03	0.11	0.08	0.9	0.19	0.12	0.28
CD at (5%)	1.03	0.25	1.18	0.39	0.26	0.08	0.33	0.25	0.27	0.55	0.36	0.79
Nitrogen levels (kg ha⁻¹)												
120	72.18	44.86	68.16	41.07	16.91	9.03	16.20	10.20	15.03	99.11	15.36	88.51
150	81.87	49.98	77.05	45.39	19.95	11.13	18.91	11.63	17.83	106.47	17.92	95.16
180	89.93	55.80	84.73	50.32	22.43	13.15	21.05	13.05	20.21	113.96	20.04	102.00
SEm±	0.44	0.10	0.50	0.16	0.11	0.03	0.14	0.10	0.11	0.23	0.14	0.34
CD at (5%)	1.26	0.29	1.45	0.48	0.32	0.10	0.41	0.31	0.33	0.68	0.41	0.79

Table.5 Interaction effect of planting methods and nitrogen levels on nitrogen, phosphorus and potassium uptake by maize crop

Treatments	2013			2014		
	N1	N2	N3	N1	N2	N3
	Nitrogen uptake by grain (kg ha⁻¹)					
P1	71.06	83.32	91.38	66.29	78.30	86.69
P2	81.83	91.23	101.45	77.78	85.55	95.52
P3	72.15	82.86	87.48	68.18	77.93	82.23
P4	63.69	70.10	79.42	60.41	66.44	74.50
SEm±	0.88			1.01		
CD at (5%)	2.53			2.90		
	Nitrogen uptake by stover (kg ha⁻¹)					
P1	45.67	51.45	56.49	41.54	47.10	50.87
P2	53.18	58.39	65.47	48.42	52.79	58.65
P3	43.66	49.68	55.11	39.99	44.27	49.71
P4	36.93	40.44	46.14	34.36	37.41	42.05
SEm±	0.20			0.33		
CD at (5%)	0.59			0.95		
	Phosphorus uptake by grain (kg ha⁻¹)					
P1	16.30	20.72	23.34	15.78	19.55	22.13
P2	19.63	21.98	25.13	18.56	20.90	23.68
P3	16.59	19.80	21.19	16.18	19.01	19.68
P4	15.14	17.34	20.07	14.31	16.18	18.75
SEm±	0.22			0.28		
CD at (5%)	0.65			0.82		
	Phosphorus uptake by stover (kg ha⁻¹)					
P1	8.81	11.97	14.04	10.24	12.09	13.60
P2	11.50	12.80	15.31	11.87	13.10	14.81
P3	8.28	10.55	12.16	9.92	11.39	12.27
P4	7.56	9.21	11.12	8.79	9.95	11.52
SEm±	0.03			0.21		
CD at (5%)	0.10			NS		
	Potassium uptake by grain (kg ha⁻¹)					
P1	14.48	18.45	21.16	14.96	18.43	21.14
P2	17.58	19.78	22.74	17.62	19.89	22.58
P3	14.70	17.68	18.98	15.35	18.05	18.67
P4	13.38	15.45	17.97	13.53	15.31	17.80
SEm±	0.23			0.29		
CD at (5%)	0.66			0.83		
	Potassium uptake by stover (kg ha⁻¹)					
P1	97.80	107.05	113.10	87.80	95.97	101.39
P2	107.15	112.90	123.27	95.88	101.75	111.01
P3	98.34	106.63	113.16	88.09	94.83	100.51
P4	93.18	99.32	106.33	82.28	88.13	95.12
SEm±	0.47			0.68		
CD at (5%)	1.36			2.04		

Among different nitrogen levels maximum nitrogen uptake by stover was recorded with 180 kg N ha⁻¹ and lowest with 120 kg N ha⁻¹ during both the crop seasons. Interaction effect of planting methods with nitrogen levels on nitrogen uptake by stover of maize data (Table 5) revealed that it was significantly higher in FSZT planted maize under N3 (64.47 and 58.65 kg ha⁻¹, in the two crop seasons) but was at par with FSZT under N2 during 2013 and 2014 crop seasons.

The uptake pattern of phosphorus and potassium by grain and stover of maize with various planting methods, Maize hybrids and successive levels of nitrogen was found similar to the uptake pattern of nitrogen by grain and stover of maize. However, interaction effect between various treatments also found similar trend as nitrogen.

Nutrient uptake by grain and straw of maize was found to increase with FSZT, HQPM -5 hybrid maize hybrid and increasing fertility level from 120 kg N ha⁻¹ to 180 kg N ha⁻¹. This was due to increase in dry matter accumulation, grain, straw and biological yield. Among different N levels maximum nutrient uptake by grain and stover of maize was recorded with 180 kg N ha⁻¹ and lowest with 120 kg N ha⁻¹. The same trend was observed with phosphorus and potassium uptake during both the crop seasons. The increase in NPK uptake by fertilizer application has also been reported by Ahmed (1992); Bangarwa *et al.*, (1992); Varughese and Iruthayaraj, (1996); Selvaraju and Iruthayaraj (1994).

On the basis of experimental findings, it may concluded that planting of maize under FSZT with HQPM-5 and 180 kg N ha⁻¹ was found best with respect to grain and stover yield, nitrogen, phosphorus and potassium uptake by grains and stover over other treatment combination. The increased dose of

fertilization by nitrogen increases the growth, yields as well as it increased nutrient uptake.

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