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RESEARCH PAPER

Economic returns, nutrients status and nitrogen uptake in maize (*Zea mays* L.) as influenced by planting methods and nitrogen levels

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Abstract : A field experiment was conducted during *Kharif* 2015 at Punjab Agricultural University, Ludhiana to study the effect of three planting methods (flat, ridge and bed) and five nitrogen levels (0, 90, 120, 150 and 180 kg ha^{-1}) on economic returns, nutrients status and nitrogen uptake in *Kharif* maize. Among various planting methods, bed planting produced significantly higher gross returns, net returns and benefit cost ratio as compared to flat sowing method but it was statistically at par with ridge sowing method. The gross returns, net returns and benefit cost ratio were increased with increase in each level of nitrogen upto 180 kg N ha^{-1}, however, the significant response was only observed upto 150 kg N ha^{-1}. Maximum nitrogen uptake of 115.3 kg ha^{-1}in grains and 40.4 kg ha^{-1} in stover was observed under bed planting which was at par with ridge sowing method but significantly higher than flat sowing method. Application of 150 kg N ha^{-1} recorded significantly higher nitrogen uptake in grains and stover over control, 90 kg N ha^{-1} and 120 kg N ha^{-1} but was at par with 180 kg N ha^{-1}. Available nitrogen status in soil after harvesting of maize was not significantly affected by different planting methods. Maximum available nitrogen status in soil (146.8 kg ha^{-1}) was recorded after the application of 180 kg N ha^{-1} to maize which was significantly higher than control (105.7), 90 kg N ha^{-1} (122.0 kg ha^{-1}) and 120 kg N ha^{-1} (135.3 kg ha^{-1}) but was at par with 150 kg N ha^{-1} (141.2 kg ha^{-1}) at depth of 0-15 cm. Different planting methods and nitrogen levels did not significantly influence the plant stand and available phosphorus and potassium status in soil after harvesting of maize. So, it may be concluded that for getting higher gross returns, net returns and benefit cost ratio, maize may be grown on beds with application of 150 kg N ha^{-1}.

Key Words : Maize, Planting methods, Nitrogen, Economic returns, Nitrogen uptake, Soil status

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INTRODUCTION

Maize (Z*ea mays* L.) in many Asian countries has resulted in increased interest among scientists to improve maize productivity. The continuous adoption of rice-wheat cropping system in Punjab has led to a number of problems such as severe depletion of underground water, deterioration of soil health, increased environment

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pollution and emergence of new insect-pests, diseases and resistant weeds. These factors led to the need for replacing high water requiring rice crop with comparatively low water demanding maize cultivation for adoption of crop diversification. Jalota and Arora (2002) suggested that maize-wheat cropping system have low water requirement and this can be an appropriate alternative to rice-wheat cropping system for maintaining soil health and balanced hydrology in the Punjab state. There is a scope to increase the maize productivity through various agronomic manipulations. Method of sowing is a major factor to mitigate the vagaries of climate which is also responsible for soil moisture storage, judicious use of water, good crop stand and better crop growth. Maize is mainly grown during the *Kharif* season in Punjab. The planting of maize during this season experiences high rainfall in monsoon season which often causes temporary flooding in flat method of sowing. Sayer (2003) reported that raised bed planting has traditionally been associated with water management as it reduces the impact of excess water in high production irrigated systems. Mehta *et al.* (2010) observed significant increase in total grain yield, harvest index and shelling percentage in bed planted crop supplied with higher nitrogen dose. The conventional flat planting is the common practice of raising crops in India but this practice caused the degradation and inefficient use of basic resources and various inputs. Planting of maize on raised beds and ridges provide a better option for managing water, nutrients and weeds as observed by Freeman *et al.* (2007). So, there is a need to investigate best planting method for reducing the problem of water stagnation and to enhance the productivity and profitability in maize. Sowing on ridges and bed planting can meet this purpose.

Maize is a very exhaustive crop and depletes soil nutrients in large quantities. Among all the nutrients, nitrogen is generally most limiting nutrient under Indian conditions. Nitrogen requirement of maize crop may vary with soil types, climatic conditions, genotypes and different agronomic management practices. Nitrogen is an essential macro-nutrient that plays a pivotal role in plant growth, development and yield. It is one of the most important limiting essential plant nutrients in Punjab soils owing to their low organic matter content. Nitrogen availability to the maize plant not only affects the grain yield but also affects the quality of grains to a great extent. At present, the nitrogen dose of 125 kg ha^{-1} is recommended for *Kharif* maize under flat sowing method in Punjab. The amount of maize grain produced per unit of fertilizer N applied depends upon the uptake from fertilizer and soil N and its utilization in producing grains. As such, nitrogen being the most limiting nutrient its supply along with other nutrients becomes a matter of paramount concern to maintain fertility of the soils for sustained high crop production. In Punjab, at present there are single cross maize hybrids which are more responsive to higher nitrogen application and their response may vary with different planting methods. Proper method of application and management of nitrogen dose reduced the losses due to leaching and denitrification and ultimately increased N use efficiency and grain yield (Scharf *et al.*, 2002). The amount of maize grain produced per unit of fertilizer N applied depends upon the uptake from fertilizer and soil N and its utilization in producing grains. Nitrogen fertilization plays a significant role in improving soil fertility and increasing crop productivity (Habtegebrial *et al.*, 2007). Application of nitrogen is known to increase root cation exchange capacity, which might have enhanced the absorption of nutrients and their uptake (Singh *et al.*, 2000 and Mishra *et al.*, 2001). Al-Kaisi and Yin (2003) conducted an experiment at Yuma on sandy loam soil and reported that maximum plant nitrogen uptake was recorded with the application of nitrogen at 360 kg ha^{-1} which was statistically at par with 250 and 140 kg N ha^{-1} and significantly higher than 30 kg N ha^{-1}. Fahong *et al.* (2004) conducted a field experiment in China and observed that raised bed method improved the nitrogen use efficiency by 10 per cent as compared to flat method. So keeping these points in view, the present study was undertaken with the objective to find out the influence of different planting methods and nitrogen levels on economic returns, nutrients status and nitrogen uptake in *Kharif* maize.

MATERIAL AND METHODS

A field experiment was done during *Kharif* 2015 at Research Farm of Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana (30^o54' N latitude, 75^o48' E longitude) is situated at height of 247 metres above mean sea level and is placed in the central plain region of Punjab under Trans-Gangetic agro-climatic zone of India. The soil of experimental site was loamy sand with pH, electrical conductivity, organic carbon of 7.8, 0.21dSm^{-1}, 0.32 per cent with available N, P and K of 130.5, 18.6 and 181.5 kg ha^{-1}, respectively. The experiment was laid out in a split plot design with four replications. Three planting methods were kept in the main plots (flat, ridge and bed) and five nitrogen levels in the sub plots (0, 90, 120, 150 and 180 kg ha^{-1}). A primary tillage operation was done with tractor drawn disc harrows before applying pre-sowing irrigation. After that a heavy pre-sowing irrigation was applied to ensure adequate moisture in the soil profile at the time of planting.When the field attained proper soil moisture, a fine seedbed was prepared by giving two cultivations with tractor drawn cultivators each followed by planking. The maize hybrid PMH 1 was sown on June 22, 2015 on a well prepared seedbed by dibbling method using two seeds per hill. The row to row spacing of 60 cm and plant to plant spacing of 20 cm was kept for flat and ridge sowing methods and row to row spacing of 67.5 cm and plant to plant spacing of 18 cm was kept for bed planting method. Full dose of phosphorus (60 kg ha^{-1}) and potash (30 kg ha^{-1}) along with one third nitrogen was applied as per treatments at the time of sowing. Remaining two-third N was applied in two equal split doses at knee high and tasseling stages, respectively. Others compulsory need based practices *viz*., interculture, weed control and plant protection measures were applied. The crop was harvested manually on October 7, 2015. The gross returns were calculated on the basis of minimum support rice of maize and the prevailing market rate of maize stover. The net returns were calculated by subtracting the total cost of cultivation for raising maize crop from the gross returns. Benefit cost ratio was determined by dividing gross returns with the total cost of cultivation involved in different operations and for raising maize crop. Available soil nitrogen was determined by Alkaline Potassium Permanganate Method as described by Subbiah and Asija (1956). Available soil P was determined by the 0.5 M sodium bicarbonate method described by Olsen *et al.* (1954). Determination of available K was done by the method given by Merwin and Peech (1950). The index of K availability is the sum of exchangeable and water soluble potassium. For calculating the nitrogen uptake, the nitrogen content in grain and stover was determined by modified Micro-Kjeldhal's method (Subbiah and Asija, 1956). Statistical analysis of the data recorded on various aspects of investigation was done by Split Plot Design as per the procedure given by Cochran and Cox (1967).

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussion have been presented under the following heads:

Plant stand :

Plant stand was recorded after 30 days of sowing (DAS) and at harvest and is presented in Table 1. This observation was recorded to observe if the different planting methods and levels of nitrogen application do affect the plant stand which may ultimately influence the grain yield of the crop. The data showed that neither different planting methods nor different levels of nitrogen

Table 1: Effect of planting methods and nitrogen levels on plant stand at 30 DAS and at harvest of *Kharif* maize

Treatments	Plant stand (number/plot)	
	30 DAS	At harvest
Planting methods		
Flat sowing	172.3	165.0
Ridge sowing	173.0	167.4
Bed planting	172.5	167.1
C.D. (P=0.05)	NS	NS
Nitrogen levels (kg ha^{-1})		
0	172.3	164.9
90	172.8	165.2
120	173.0	167.1
150	173.8	167.7
180	172.6	167.5
C.D. (P=0.05)	NS	NS
Interaction	NS	NS

NS=Non-significant

significantly influenced the plant stand both at 30 DAS and at harvest. The interaction between planting methods and nitrogen levels was also not significant with respect to their influence on plant stand at 30 DAS and at harvest.

Total number of cobs per hectare:

The number of cobs has a direct effect on the grain yield because it contributes to more number of grains to increase the yield and ultimately more economic returns. The data given in Table 2 indicated that number of cobs per hectare was significantly higher under bed and ridge planting methods as compared to flat sowing methods. However, both bed and ridge planting method were statistically at par with each other. This may be due to good growth of plants which encouraged the large sink size and total number of cobs per hectare under bed and ridge sowing than flat sowing.

Application of different nitrogen levels significantly increased the number of cobs per hectare as compared to control. Among the different nitrogen levels, application of 180 kg N ha^{-1} produced significantly higher number of cobs per hectare as compared to all other nitrogen levels but was at par with 150 kg N ha^{-1}. More number of cobs per hectare at higher nitrogen levels (150 and 180 kg N ha^{-1}) might be due to better vegetative growth of the plants and hence developed large source size for sink development and ultimately higher number of cobs per hectare were achieved. Similar findings were also reported by Kumar (2009). However, interaction between planting methods and nitrogen levels was not significant.

Gross returns:

The planting methods significantly influenced the gross returns in maize (Table 2 and Fig. 1). Maximum gross returns (Rs. 89,938 ha^{-1}) were obtained in bed planting method which was at par with ridge sowing (Rs. 88,233 ha^{-1}) and significantly better in comparison to flat (Rs. 81,121 ha^{-1}) sowing method. The results are in close agreement with the findings of Kaur (2013). Nitrogen application significantly influenced the gross returns. Application of 180 kg N ha^{-1} produced maximum gross returns (Rs. 1,01,024 ha^{-1}) which was significantly higher than control (Rs. 55,388 ha^{-1}), 90 kg N ha^{-1} (Rs. 83,921 ha^{-1}) and 120 kg N ha^{-1} (Rs. 92,437 ha^{-1}) but was at par with 150 kg N ha^{-1} (Rs. 99,383 ha^{-1}). However, Kaur (2013) observed that the gross returns increased significantly with increase in nitrogen levels upto 125 kg ha^{-1}. The interaction between planting methods and nitrogen levels was not significant.

Net returns:

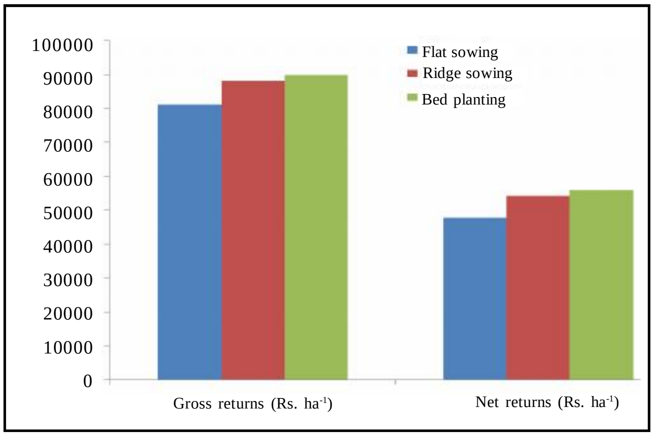
The data given in Table 2 and Fig. 1 indicated that net returns were significantly influenced by planting methods. Bed planting method recorded maximum net returns (Rs.55,898 ha^{-1}) and it was at par with ridge sowing (Rs.54,194 ha^{-1}) but significantly superior in comparison to flat sowing (Rs. 47,757 ha^{-1}). Similar findings were reported by Kaur (2013). The net returns were increased with increase in each level of nitrogen, however, the significant response was only observed upto 150 kg N ha^{-1}. Application of 180 kg N ha^{-1} produced maximum net returns (Rs. 66,417 ha^{-1}) which was at

Table 2 : Effect of planting methods and nitrogen levels on gross returns, net returns and benefit cost ratio of *Kharif* maize

Treatments	Total number of cobs ha^{-1}	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit cost ratio
Planting methods				
Flat sowing	73425	81121	47757	2.43
Ridge sowing	75254	88233	54194	2.58
Bed planting	75138	89938	55898	2.63
C.D. (P=0.05)	1405	6088	5565	NS
Nitrogen levels (kg ha^{-1})				
0	66975	55388	22630	1.68
90	73919	83921	50373	2.50
120	76273	92437	58535	2.73
150	77314	99383	65127	2.90
180	78549	101024	66417	2.92
C.D. (P=0.05)	1856	6943	6543	0.16
Interaction	NS	NS	NS	NS

NS= Non-significant

par with 150 kg N ha^{-1} (Rs. 65,127 ha^{-1}) but significantly better than control (Rs. 22,630 ha^{-1}), 90 kg N ha^{-1} (Rs. 50,373 ha^{-1}) and 120 kg N ha^{-1} Rs. 58,535 ha^{-1}). The results are in close agreement with the findings of Kaur (2013) who reported significant increased in the net returns with increase in nitrogen levels upto 125 kg ha^{-1}. The interaction effect between planting methods and nitrogen levels was not significant with respect to net returns in maize.



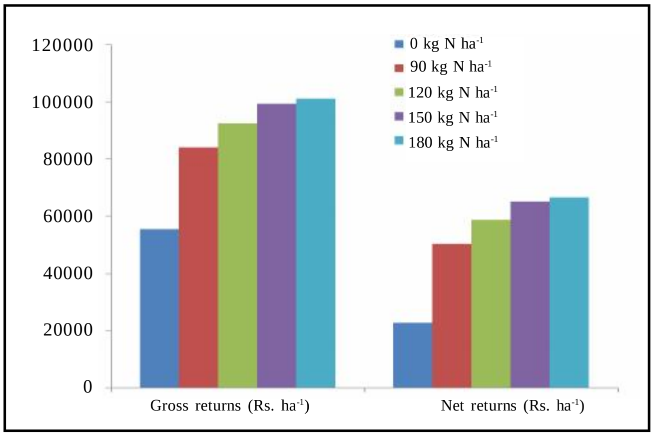


Fig. 1 : Effect of planting methods and nitrogen levels on gross and net returns in *Kharif* maize

Benefit cost ratio:

The data revealed that different planting methods did not significantly influence the benefit cost ratio (Table 2). However, the bed planting (2.63) and ridge planting (2.58) methods showed numerically higher values of benefit cost ratio compared to flat sowing (2.43) method. Nitrogen application significantly influenced the benefit cost ratio only upto 150 kg N ha^{-1}. However, maximum benefit cost ratio of 2.92 was recorded with the application of 180 kg N ha^{-1} which was at par with 150 kg N ha^{-1} (2.90) but significantly better than 120 kg N ha^{-1} (2.73), 90 kg N ha^{-1} (2.50) and control (1.68). The results are in agreement with the findings of Kaur (2013). The interaction was not significant.

Available nitrogen status after harvesting of maize:

The data given in Table 3 revealed that the available nitrogen status in soil at depth of 0-15 cm and 15-30 cm after harvesting of maize crop was not affected significantly by different planting methods. Different nitrogen levels significantly influenced the available nitrogen status in soil after harvesting of maize. Maximum

Table 3: Effect of planting methods and nitrogen levels on available nitrogen, phosphorus and potassium status in soil after harvesting and nitrogen uptake in *Kharif* maize

Treatments	Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})		Nitrogen uptake (kg ha^{-1})	
	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	Grain	Stover
Planting methods								
Flat sowing	135.4	120.5	19.0	13.8	176.0	166.7	99.2	35.2
Ridge sowing	129.0	114.4	18.5	13.1	176.0	166.2	111.1	39.2
Bed planting	126.1	111.4	18.1	12.8	174.1	165.2	115.3	40.4
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	11.2	3.5
Nitrogen levels (kg ha^{-1})								
0	105.7	89.9	17.7	12.3	172.9	162.9	63.0	27.7
90	122.0	107.8	17.9	12.6	174.3	165.1	104.7	35.9
120	135.3	120.5	18.6	13.4	175.4	166.0	116.8	39.9
150	141.2	126.7	19.0	13.7	176.5	167.6	127.3	43.0
180	146.8	132.4	19.4	14.1	175.7	168.4	130.9	44.9
C.D. (P=0.05)	10.2	9.6	NS	NS	NS	NS	10.3	3.0
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

NS= Non-significant

available nitrogen status in soil at depth of 0-15 cm and 15-30 cm (146.8 and 132.4 kg ha^{-1}) was recorded after the application of 180 kg N ha^{-1} to maize which was significantly higher than control (105.7 and 89.9 kg ha^{-1}), 90 kg N ha^{-1} (122.0 and 107.8 kg ha^{-1}) and 120 kg N ha^{-1} (135.3 and 120.5 kg ha^{-1}) but was at par with 150 kg N ha^{-1} (141.2 and 126.7 kg ha^{-1}). However, Kumar (2009) reported highest actual residual soil nitrogen content in maize at 120 kg N ha^{-1}. The interaction between planting methods and nitrogen levels was not significant.

Available phosphorus status after harvesting of maize:

The data (Table 3) revealed that neither the planting methods nor the nitrogen levels significantly influenced the available phosphorus status in soil at depth of 0-15 cm and 15-30 cm after harvesting of maize crop. The interaction between planting methods and nitrogen levels was not significant respect to the available phosphorus status in soil.

Available potassium status after harvesting of maize:

Data presented in Table 3 indicated that different planting methods and nitrogen levels did not significantly influence the available potassium status in soil at depth of 0-15 cm and 15-30 cm after harvesting of maize. The interaction between planting methods and nitrogen levels was not significant with respect to the available potassium status in soil.

Nitrogen uptake by the crop:

A perusal of data given in Table 3 revealed that on quantitative basis nitrogen uptake followed the trend grains > stover. Maximum nitrogen uptake in grains (115.3 kg ha^{-1}) and stover (40.4 kg ha^{-1}) was observed under bed planting method which was statistically at par with ridge sowing but significantly higher than flat sowing method. The results are in agreement with the findings of Kaur (2013). Kaur and Mahey (2005) also observed higher N, P and K uptake in bed planted maize as compared to flat planting method. Nitrogen uptake by the plant was significantly affected by different nitrogen levels. Maximum nitrogen uptake in grains (130.9 kg ha^{-1}), stover (44.9 kg ha^{-1}) and total nitrogen uptake 175.9 kg ha^{-1} were recorded with the application of nitrogen at 180 kg ha^{-1} which was significantly higher than under control, 90 and 120 kg N ha^{-1} but was at par with 150 kg N ha^{-1}. Contrary to the above findings, Brar *et al.* (2001) reported that N, P and K uptake by maize crop increased significantly with application of nitrogen at 100 kg ha^{-1} on sandy loam soil. Further increasing the nitrogen dose upto 150 kg ha^{-1} did not show any significant increase in the nutrient uptake. However, Ramu and Reddy (2007) conducted a field experiment at Tirupati (Andhra Pradesh) on sandy loam soil testing low in available nitrogen and observed that total nitrogen uptake by maize was increased with each increment of nitrogen level upto 240 kg ha^{-1} but it was statistically at par with the application of 180 kg N ha^{-1}. Parija (2011) also reported that total nitrogen uptake was significantly increased with increase in nitrogen levels upto 150 kg ha^{-1}. The interaction between planting methods and nitrogen levels was not significant with respect to nitrogen uptake by crop.

So, it may be concluded that for getting higher gross returns, net returns and benefit cost ratio, maize may be grown on beds with application of 150 kg N ha^{-1}.

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