Annals of Plant and Soil Research 19(3): 307-310 (2017)

Effect of nitrogen and its scheduling on growth, yield and economics of rabi maize (*Zea mays* L.)

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Received: December, 2016; Revised accepted: March, 2017

ABSTRACT

A field experiment was conducted during Rabi season of 2012-13 and 2013-14 at Crop Research Station, Bahraich to evaluate the effect of nitrogen levels and its split application on growth, yield attributes and yield of hybrid maize. The treatments consisting four levels of nitrogen (150, 200, 250 and 300 kg ha^{-1}) and three scheduling were evaluated in split plot design with three replications. Results revealed that the application of 300 kg N ha^{-1} was more productive and remunerative than other levels of nitrogen. The maximum values of plant height (180.4 cm), cobs/plot (136.0), cob length (19.2 cm), grains/row (34.2), grain row/cobs (20.0), cobs girth (13.2 cm), test weight (244.7 g), grain yield (9.5 t ha^{-1}) and stover yield (10.1 t ha^{-1}) were recorded with 300 kg N ha^{-1}. Among the nitrogen scheduling, five splits were more effective and maximum values of plant height (185.4 cm), cobs/plot (129.0), cobs length (19.8 cm), grains/row (30.7), grains row/cobs (18.8), cob girth (12.2), test weight (238.7 g), grain yield (8.4t ha^{-1}) and stover yield (9.5 t ha^{-1}) were recorded with 5 splits of nitrogen. The lowest values of plant height (165.4cm), cobs/plot (128), cobs length (17.5cm) grains/row (28.5), grain row/cob (18.2), cob girth (11.8cm), test weight (232.5g), shelling percentage (78.2%), grain yield (6.9 t ha^{1}) and stover yield (8.05 t ha^{1}) were recorded under 150kg N ha^{-1}. The three splits produced the lowest plant height (176.6cm), cobs/plot (124), cobs length (17.8cm) grains/row (27.8), grain row/cob (17.9), cob girth (11.5cm), test weight (231.7g), shelling percentage (80.4%), grain yield (6.7 t ha^{1}) and stover yield (7.90 t ha^{1}). The maximum net returns of Rs 106.3 x 10^{3} ha^{-1} and B:C ratio (3.87) were recorded with 300 kg N ha^{-1}Among nitrogen splits, maximum net returns of Rs.91.1x10^{3} ha^{-1} and B:C ratio (3.5) were recorded under 5 splits of N dose.

Keywords: Levels of nitrogen, split dose, yield, economics, rabi maize

INTRODUCTION

In India maize (*Zea mays* L.) is the third most important food crop after rice and wheat and cultivated in a wide range of agro-ecological situations. In addition to staple food for human and quality feed for animals, maize serves as basic raw materials to the industries for production of starch, oil, protein, alcoholic beverages, food sweeteners and, more recently, bio-fuel. In India it is cultivated over an area of 8.5 m ha with a production and productivity of 21.5 mt and 2.52 t ha^{-1}, respectively. However, in U.P., it covers an area of 1.8 m ha with production and productivity of 4.8 mt and 1.4 t ha^{-1}, respectively (Anonymous, 2015). Area under winter maize is increasing at a faster rate in Eastern U.P. The productivity of winter maize is low due non-availability of suitable production technology. In northern India farmers generally followed the rice-wheat cropping system which is posing a serious threat to natural resources like water and soil during winter season. Winter maize is one of the best alternatives to diverse the rice-wheat cropping system. Among the different inputs, nutrients play vital role in crop productivity. The inadequate management of nitrogen (N) is considered a major limiting factor for maize grain yield. Nitrogen is important for the plant metabolism as it participates in proteins and chlorophyll biosynthesis. It also participates in several major metabolic pathways of plant biochemistry and demonstrated that under appropriate levels of other nutrients in the soil, nitrogen provides the greatest increment to the yield. Nitrogen is considered as a dynamic and complex element generating debates and controversies regarding on its best source and moment of application in maize. On soil-plant system, the N dynamics is influenced by many features of cropping system (tillage or no-tillage farming), crop management techniques, edaphoclimatic conditions and the fertilizer type. Currently, urea is the main source of nitrogen in maize. As urea is subjected to loss in soil by leaching, runoff and microbial immobilization, split application of nitrogen is one of the methods to improve nitrogen

use efficiency by reducing its loss through leaching and volatilization. Split application is an essential approach to increase the N use efficiency in crops including maize (Chaudhary *et al.*, 2013). It improves the grain yield and increased the economic benefit from increased grain yield. A field experiment was, therefore laid out to evaluate the levels of nitrogen and it's splitting for harvesting maximum yield of rabi maize.

MATERIALS AND METHODS

A field experiment was conducted during the winter season of 2012-13 and 2013-14 at Crop Research Station, Bahraich. Eastern Uttar Pradesh, particularly Bahraich district is situated at 22^0 45N, 88^0 16 E longitude and 30 m altitude. The experimental soil was sandy loam in texture having pH 7.5. The soil was low in nitrogen (260 kg ha^{-1}) medium in available phosphorus (13.8 kg ha^{-1}) and available K (270 kg ha^1). The annual rainfall of 950 mm and 920 mm was received during 2012-13 and 2013-14, respectively. The experiment was laid out in split plot design with three replications. In main plot levels of nitrogen were located and in sub plot split of nitrogen was located. The treatments consisted 4 levels of nitrogen (150, 200, 250 and 300 kg N ha^{-1}) along with split application of N (S_1-3 splits 33.3 % at sowing , 33.3 % at knee high, +33.3 % at tassling stage), (S_2-4 splits 25% at sowing, 25% at 4-6 leaf stage, 25 % at knee high, 25 % at 50% tassling stage) and (S_3-5 splits 10 % at basal, 20% at 4-6 leaf stage, 30 % at knee high stage, 30 % at 50 % tassling stage, 10% at grain filling stage). The hybrid HM-7705 was sown on November 10 with line to line 60cm and plant to plant 10cm in both the years of experimentation. Common doses of 75 kg P_2O_5 and 75 kg K_2O ha^{-1} were applied through single superphosphate and muriate of potash, respectively. Nitrogen was applied as urea as per treatments. The crop was irrigated as per requirements of crop and other cultural operations were done two times in crop as well as weed control was carried out as per need of crop time to time. The growth character (Plant height) and yield attributing characters (Cobs/plot, cobs length, grains/row, grain row/cob, grains/row, cob girth, shelling percentage and test weight) were recorded at maturity of crop. The yields of grain and stover were recorded after harvesting of crop. The economics of the treatments was calculated on the basis of prevailing market price of the inputs and output. The data on different parameters were statistically analysed as per procedure given by Gomez and Gomez, 1984.

RESULTS AND DISCUSSION

Effect of nitrogen

Growth and yield attributes: The data on growth and yield attributes (Table 1) indicated that significant variations in growth and yield attributes were recorded under different levels of nitrogen.The tallest plants (180.4 cm) were recorded with 300 N kg ha^{-1}, which was superior to lower level of nitrogen (150, 200 and 250 kg N ha^{-1}). It might be due to higher nitrogen availability in soil. Similar results were reported by Singh *et al.* (2013), Singh *et al.,* (2014) and Singh *et al.* (2016). The yield attributes such as cobs/plot, cobs length, grain/row, grains row/cob, cob girth and test weight were significantly higher with 300 kg N ha^{-1} over its lower levels. The maximum cobs/plot (136.0), cobs length (19.2 cm), grains/row (34.2), grains row/cob (20.2), cob girth (13.2 cm), test weight (244.7 g) and shelling percentage (84.2 %) were noted with 300 kg N ha^{-1}. The lowest values of growth and yield attributes such as plant height (165.4cm), cobs/plot (128), cobs length (17.5 cm), grains/row (28.5), grains row/cob (18.2), cob girth (11.8 cm), test weight (232.5 g) and shelling percentage (78.2 %) were recorded with 150 kg N ha^{-1}. This might be due to favourable vegetative growth and development as they received adequate and sufficient nitrogen in proper amount and at critical stage. As the results, the plant height and yield attributing characters improved through increased photosynthetic activity of leaves. Better performance under 300 kg N ha^{-1} in respect of growth and yield attributes confirms the findings of Chaudhary *et. al*. (2013), Singh *et al.* (2013) and Singh *et al*, (2014).

Yield The data on yield revealed that the higher grain (9.5t ha^{-1}) and stover (10.1t ha^{-1}) yields were recorded with 300 kg N ha^{-1}. The increases in grain and stover yields due to 300 kg N ha^{-1} were 38.1, 20.3 and 7.7 % and 25.2, 16.1 and 8.9 % respectively over 150, 200 and 250 kg N ha^{-1}. The lower values of grain (6.9 t ha^{-1}) and stover (8.05 t ha^{-1}) yield were recorded with 150 kg N ha^{-1}. The increased yield due to nitrogen levels might be due to sufficient dose of N as per requirement at the different stages of growth of the crop. The findings of Singh *et al.* (2013) and Singh *et al.* (2014) also supported our findings.

Table 1: Effect of nitrogen and its scheduling on growth and yield attributes of Rabi maize (Mean of 2 years)

Treatments Nitrogen (kg ha^{-1})	Plant Population/ plot	Plant height (cm)	Cobs /plot	Cobs length (cm)	Grains /row	Grain rows /cob	Cob girth (cm)	Shelling %	Test weight (g)
150	120	165.4	128.0	17.5	28.5	18.2	11.8	78.2	232.5
200	118	172.8	130.0	18.2	32.6	19.4	12.2	81.6	240.6
250	120	175.7	134.0	18.5	33.8	19.8	12.8	83.5	242.8
300	120	180.4	136.0	19.2	34.2	20.2	13.2	84.2	244.7
CD (P=0.05)	N.S.	2.25	1.28	0.25	1.75	1.20	0.35	1.75	1.35
Nitrogen Scheduling									
3 Split	118	176.6	124.0	17.8	27.8	17.9	11.5	80.4	231.7
4 Split	119	180.8	128.0	19.5	29.5	18.2	11.8	81.5	236.5
5 Split	120	185.4	129.0	19.8	30.7	18.8	12.2	82.4	238.7
CD (P=0.05)	N.S.	2.28	1.15	0.21	1.62	1.15	0.28	1.68	1.32

The higher yields can also be attributed to the availability of nitrogen in adequate amounts which might be beneficial to crop growth and yield of maize.

Economics: Data (Table 2) revealed that the highest net income of Rs.106.3x10^3 ha^{-1} was recorded under 300kg N ha $^{-1}$, which was 52.8, 27.7 and 11.2 % higher over the doses of 150, 200 and 250 kg N ha^{-1}, respectively. The lower income of Rs. 69.6x10 ^{3} were recorded under 150 kg N ha^{-1}. The higher net income under aforesaid treatment might be due to the higher grain and stover production. The highest B: C ratio of 3.8 was noted under 300 kg N ha $^{-1}$ and lowest value (2.99) under 150 kg N ha^{-1}. The net profit under the maize hybrid was gradually increased with each successive dose of nitrogen application. The similar findings were reported by Singh *et al.* (2013), Chaudhary *et al.* (2013) and Singh *et al.* (2014).

Table 2: Effect of nitrogen and its scheduling on yield and economics of Rabi maize (Mean of 2 years)

Treatments Nitrogen (kg ha^{-1})	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Total profit (Rs ` X 10^3)	Net profit (Rs` X 10^3)	Benefit cost ratio
150	6.9	8.05	104.4	69.6	2.99
200	7.9	8.7	118.7	83.2	3.33
250	8.8	9.3	131.8	95.5	3.63
300	9.5	10.1	143.2	106.3	3.87
CD (P=0.05)	0.45	0.48	14.50	8.50	0.12
Scheduling					
3 Split	6.7	7.9	101.2	65.3	2.8
4 Split	7.4	8.5	111.3	75.5	3.1
5 Split	8.4	9.5	127.3	91.4	3.5
CD (P=0.05)	0.43	0.48	13.40	7.48	0.10

Effect of Nitrogen splitting

G**rowth and yield attributes:** The data (Table 1) indicated that the tallest plant (185.4 cm) was recorded with the N application in 5 splits which was significantly superior to 3 and 4 split. The lowest plant height (176.6cm) was noted under 3 splits of nitrogen. The maximum values of yieldattributes cobs/plot (129.0), length of cobs (19.8 cm), grains/row (30.7), grain row/cob (18.8), cob girth (12.2 cm), test weight (238.7 g), shelling percentage (82.4 %) were recorded under 5 splits of N which was significantly superior to other splits of nitrogen. The lowest values of these characters were recorded under three N splits. The higher values of yield attributes under the 5 splits might be due to more availability of nitrogen to the crop at different stages of crop growth. These results were also supported by Singh *et al.,* (2013).

Yield: Data (Table 2) revealed that the highest yields of grain (8.4 t ha^{-1}) and stover (9.5 t ha^{-1}) were noted under 5 splits of nitrogen. The increases in grain and stover yields due to 5 splits were 26.5 and 14.5 % and 20.5 and 11.9 % over the 3 and 4 splits, respectively. The lowest grain (6.7 t ha^{-1}) and stover yields (7.9 t ha^{-1}) were recorded with 3 splits. The increase in yield might be due to nitrogen availability at different stages of crop requirement.

Economics: The net returns and benefit: cost ratio of maize under different splits of nitrogen differed significantly. Highest net profit of Rs.91.4x10^3 ha^{-1} was recorded under 5 splits of N application, which was 23.9, 21.1 % higher over the 3 and 4 splits, respectively. The maximum B: C ratio of 3.5 was noted under 5 splits and lowest (2.8) under 3 splits. It is obvious that realization of higher net returns was the result of higher grain and stover yield with the best treatment (nitrogen split).

On the basis of results, it may be concluded that application of 300 kg N ha^{-1} in 5 splits was found optimum as it has resulted in the highest growth of maize and higher productivity besides enhancing profitability. Therefore, it is recommended to maize growers to use 300 kg N ha^{-1} in five splits for obtaining higher yield as well as net profit.

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