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ORIGINAL RESEARCH ARTICLE



Response of maize (*Zea mays* L.) hybrids to different levels of nitrogen

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ABSTRACT

Nitrogen is one of the key factors for higher grain production of hybrid maize (*Zea mays* L.). The use of improved varieties and optimal use of nitrogen (N) fertilizer is important for exploiting yield potential of maize. This work was carried out to evaluate the effects of N rates on grain yield and yield attributing traits of hybrid maize. Two hybrids (RML-86/RML-96 and RML-95/RML-96) and five levels of nitrogen (120, 150, 180, 210 and 240 kg N/ha) were evaluated at research field of National Maize Research Program (NMRP), Rampur, Chitwan, Nepal in spring season of 2017 and 2018. The experiments were conducted in two factorial randomized complete block design (RCBD) with three replications under rainfed condition. The pooled analysis (2017 and 2018) showed that the highest grain yield 10.5 and 10.5 t/ha were given by hybrids RML86/RML96 and RML95/RML96, respectively with the use of 150 kg N/ha in 2017. The hybrids RML-86/RML-96 and RML-95/RML-96 produced the highest grain yield 7.49 and 7.68 t/ha, respectively with the use of 150 kg N/ha in 2018. The mean grain yield (2017 and 2018) showed that both maize hybrids produced the highest grain yield 10.5 t/ha in 2017 and 7.58 t/ha year in 2018 with the application of 150 kg N/ha. The application of nitrogen fertilizer on grain yield was found significant ($P < 0.05$) in both years. Therefore, the application of 150 kg N/ha has significantly increased grain yield of maize, Therefore, this dose of nitrogen can be recommended for higher maize production in Chitwan, Nepal in spring season under rainfed condition.

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INTRODUCTION

Maize (*Zea mays* L.) is second most important crop of Nepal after rice. It is grown in 0.9 million ha with the production of 2.3 million ton (t) and Productivity of 2.56 t/ha (MOALD, 2018). Ecologically, it is commonly cultivated in terai, mid hills and high hills as well. Maize is mostly grown under rain fed conditions and mostly on marginal land with very little use of commercial fertilizers. Spring maize can be incorporated in a most common rice wheat cropping system in lowland conditions. It is generally harvested for green cob and get economic return and to utilize time between wheat harvesting and rice planting. The productivity of maize is largely dependent on its nutrient management. Among the fertilizers, nitrogen (N) is very important because this

element is responsible on major activities for growth and development of maize crop (Jat *et al.*, 2013). The use of N-fertilizers along with other nutrients has been suggested to enhance the crop productivity (Marschner, 1995). The response of maize plant to application of N fertilizers varies from variety to variety, location to location and also depends on the availability of the nutrients (Onasanya *et al.*, 2009). Previous findings indicated that the increase in maize grain yield after nitrogen fertilization is largely due to an increase in the number of ears per plant, increase in total dry matter distributed to the grain and increase in average ear weighing (Nxumalo *et al.*, 1993). The nitrogen affects various physiological and biochemical processes in plant cells and, ultimately, affects growth and development (Brady, 1990). A higher level of Nitrogen (180 kg N/ha) improved seed

yield to 2.85 t/ha of inbred (NML-1) maize (Adhikary and Adhikary, 2013). Nitrogen response by maize differs due to growth stages, environment and genotype of maize. Hybrid and improved maize varieties are more nitrogen-responsive than local varieties of maize (Shrestha et al., 2018a). Grain yield, days to flowering, plant height, ear height, kernel rows per ear, no. of kernels per row, ear length and thousand grain weight significantly affected due to growing seasons and split applications of nitrogen (Adhikari et al., 2016). The application of nitrogen significantly increased the physiological growth indices of maize hybrids (Abubakar et al., 2019). The information on optimum rate of nitrogen on hybrid maize was not sufficient in Nepal. Therefore, this study was carried out to determine the effect of various levels of nitrogen application on grain yield and yield attributing traits in hybrid maize during spring season.

MATERIALS AND METHODS

Experimental site

The experiments were carried out at the research field of National Maize Research Program (NMRP) Rampur, Chitwan in the spring season from March to June of the years of 2017 and 2018. Geographically the experimental site is located at 27° 37' North Latitude and 84° 29' East longitude at an altitude of 225 meter above sea level (Kandel et al., 2017). This site contains only sandy loam soil with acidic reaction. This research location is characteristics of subtropical climate. The plant materials were collected from NMRP, Rampur, Chitwan, Nepal. Maize can be grown throughout the year in Chitwan district and can also be grown in other similar environments (Govind et al., 2015). The weather parameters recorded during the field experiments was given in Table 1.

Plant materials

Two pipeline hybrids RML-86/RML-96 and RML-95/RML-96 were used in this study. The plant materials were derived from National Maize Research Program (NMRP) Rampur, Chitwan, Nepal.

Experimental detail and field trial management

The experiments were conducted in two factorial randomized complete block design (RCBD) with three replications. Two hybrids (RML-86/RML-96 and RML-95/RML-96) and five levels of nitrogen (120, 150, 180, 210 and 240 kg N/ha) were used in these experiments. The hybrids were planted in the spacing of 60 cm × 25 cm. The plot size was 3.6 m × 5 m used for the cultivation. The irrigation system was rainfed. Farm Yard Manure (FYM) was applied as 10 t/ha as recommended. The treatments were allotted according to the recommended phosphorus and potassium for maize (60:40 kg P₂O₅: K₂O/ha. Phosphorus and potassium were applied at the rate of 60 kg/ha and 40 kg/ha respectfully. Half of the Nitrogen and full phosphorus and potassium were applied at the basal dose. Other crop management practices were carried out as per recommendation of National Maize Research Program (NMRP) Rampur, Chitwan, Nepal.

Data collection and statistical analysis

Grain yield of maize was estimated using formula adopted by Carangal et al. (1971) and Shrestha et al. (2018b) by adjusting the grain moisture at 15% and converted to the grain yield kg per hectare. The analysis of variance was performed using RCBD design to derive variance components derived using GenStat statistical package (12th edition) (Payne et al., 2009). The mean comparisons among treatment means were estimated by the least significant difference (LSD) test at 5% levels of significance (Gomez and Gomez, 1984; Baral et al., 2016).

Table 1. Weather data of experimental site during maize growing period at Rampur, Chitwan, Nepal in spring seasons of 2017 and 2018.

Month/year	Max. Temp (°C)	Min. Temp (°C)	Rainfall (mm)	Relative humidity (%)
February 2017	26.91	10.38	3.40	92.51
March 2017	29.58	13.45	64.50	87.08
April 2017	33.46	18.77	77.60	88.17
May 2017	34.77	21.29	86.30	86.81
June 2017	35.39	24.83	179.70	90.03
February 2018	26.40	12.64	0.00	86.83
March 2018	32.62	17.99	26.00	70.60
April 2018	34.48	22.27	35.10	68.07
May 2018	34.32	24.98	137.70	75.63
June 2018	35.16	26.55	212.20	82.85

(Source: NMRP, 2017; NMRP, 2018).

RESULTS AND DISCUSSION

Different yield attributing parameters like grain yield (t/ha), numbers of cob/ha and thousand grain weights (g) of maize were estimated for each varieties in both years. The results are presented in Tables 2, 3 and Figure 1.

Yield and yield attributes of maize in 2017

Grain yield (t/ha)

Hybrid maize is a heavy feeder and more responsive to nutrients (Sarkar et al., 2000). Muza et al. (2004) and Shrestha et al. (2018a) found that the commercial maize hybrids require high nitrogen levels and fertile soils and hybrids are more responsive to nitrogen fertilizer. In the year 2017, both the hybrids RML86/RML96 and RML95/RML96 produced the highest yield of maize with the use of 150 kg N/ha. The yield of hybrid RML86/RML96 maize was highest (10.5 t/ha) with the application of 150 kg N/ha and that was lowest (8.81 t/ha) with the use of nitrogen 240 kg N/ha. At the same time, RML95/RML96 produced the highest yield of 10.5 t/ha with application of 150 kg N/ha and the least yield of 9.18 t/ha with application of 240 kg N/ha.

Number of cobs/ha

The highest number of cobs per hectare of maize found in hybrid RML86/RML96 was 69347 cobs/ha with application of 150 kg N/ha and number of cobs/ha for RML95/RML96 was 73722 cobs/ha. These findings are in agreement with those of Bakht et al. (2007), Abbas et al. (2005) and Khan et al. (2014) who reported that numbers of cobs/plant of maize increased with increased in nitrogen rates as compared to control and other treatments.

Thousand grain weights (g)

In case of thousand grain weight of maize, the maximum thousand grain weight for RML86/RML96 was 360 gram with application of 150 kg N/ha and that for RML95/RML96 was 355 gram with the use of 150 kg N/ha. The heaviest grains of maize may be due to the utilization of nitrogen which resulted in bold and robust (healthy) seed size at 150 kg N/ha. Amoruwa et al. (1987) reported that thousand grains weight increased with increasing nitrogen rate. Different yield attributing parameters like grain yield (t/ha), numbers of cobs/ha and thousand grain weights (g) were calculated for each varieties in spring season of 2018 spring.

Yield and yield attributes of maize in 2018

Grain yield (t/ha)

In the year 2018, both maize hybrids RML86/RML96 and RML95/RML96 produced the highest yield with application of 150 kg N/ha. The yield of hybrid RML86/RML96 was highest i.e. 7.49 t/ha with the use of 150kgN/ha and that was the lowest i.e. 15.0 t/ha with application of nitrogen 120 kg N/ha. At the same time, RML95/RML96 gave the highest yield of 7.68 t/ha of maize with application of 150 kg N/ha and the lowest i.e. 6.22 t/ha with use of 210 kg N/ha. Application of nitrogen provided better nutrition to maize which resulted in higher grain yield. Increase in grain yield of maize with the application of nitrogen may be attributed to better growth of plant. The improvement in growth resulted in significant increase in yield attributes like number of cobs per plant, grains per cob, cob length and cob girth and test weight of *Z. mays* which ultimately contributed to higher grain yield of *Z. mays* with the application of nitrogen. The beneficial effect of nitrogen on grain yield of maize has also been reported by Sahoo and Mahapatra (2004) and Kumar (2008).

Table 2. Yield and yield components of hybrid maize under different rates of nitrogen fertilizer at Rampur, Chitwan, Nepal in spring season of 2017.

Nitrogen levels (kg N/ha)	Grain yield (t/ha)			Number of cobs/ha			Thousand grain weight (g)		
	RML86/ RML96	RML95/ RML96	Mean	RML86/ RML96	RML95/ RML96	mean	RML86/ RML96	RML95/ RML96	mean
120	9.96	10.07	10.2	63542	70486	67014	331	351	341
150	10.5	10.5	10.5	69347	73722	71535	360	355	358
180	9.53	10	9.76	68056	70139	69097	347	335	341
210	9.94	9.41	9.67	65625	65069	65347	337	340	338
240	8.81	9.18	8.99	57708	63889	60799	346	331	338
Grand mean	9.75	9.83	9.79	64856	68661	66758			342
F-test		*			NS			NS	
CV%		7.1			9.2			6.7	
LSD (0.05) Nitrogen		0.841			7425.2			27.77	
LSD (0.05) Nitrogen × Variety		1.190			10500			39.27	

NS = non-significant at 5% level of significance, *=Significant at 5% level of significance.

Table 3. Yield and yield components of hybrid maize under different rates of nitrogen fertilizer at Rampur, Chitwan, Nepal in spring season of 2018.

Nitrogen Levels (kg N/ha)	Grain yield (t/ha)			Number of cobs/ha			Thousand grain weight (g)		
	RML86/ RML96	RML95/ RML96	Mean	RML86/ RML96	RML95/ RML96	Mean	RML86/ RML96	RML95/ RML96	Mean
120	5.01	7.09	6.05	84722	91111	87917	349.3	364	356.7
150	7.49	7.68	7.58	90000	94722	92361	403.3	432	417.7
180	7.07	6.46	6.76	81389	88333	84861	366.7	402	384.3
210	6.99	6.22	6.6	88056	88889	88472	350.7	313.3	332
240	7.37	7.46	7.42	83056	89444	86250	358	389.3	373.7
Grand mean	6.79	6.98	6.88	85444	90500	87972	365.6	380.1	372.9
F test (Nitrogen × Variety)		**			NS			NS	
CV%		8.8			6.3			9.8	
LSD (0.05) Nitrogen		0.845			6686.6			44.5	
LSD (0.05) Nitrogen × Variety		1.195			9456.2			62.94	

NS= non-significant at 5% level of significance, **= significant at 1% level of significance.

Number of cobs/ha

Various nitrogen levels affected the number of cobs/ha. The highest number of cobs i.e. 94722 and 90000 cobs/ha of maize were produced by hybrids RML95/RML96 and RML86/RML96, respectively with application of 150 kg N/ha

Thousand grain weight (g)

The maximum thousand grain weight of maize obtained from RML86/RML96 was 403.3 g with the use of 150 kg N/ha and that trait from RML95/RML96 was 432 g with the application of 150 kg N/ha. Such positive role of nitrogen in enhancing the test weight of maize is also recorded by Arif *et al.* (2010) and Salam *et al.* (2010). The pooled analysis (2017 and 2018) showed that highest grain yields of 9.0 and 9.1 t/ha were produced by hybrid RML86/RML96 and RML95/RML96, respectively with use of 150 kg N/ha (Figure 1).

The results of this experiment indicated the positive response of various yield attributes of maize to higher nitrogen fertilization that was accordance findings of several researchers (Chillar and Kumar, 2006; Bindhani *et al.*, 2007; Gosavi and Bhagat, 2009; Prophan *et al.*, 2007) who found the higher green cob yield with application of higher nitrogen. They noticed nitrogen had its profound influence on vegetative and reproductive growth of the crop. Yield attributes of maize increased with increased rates of N might be due to the fact that application of nitrogen to the maize plants maintained greenness of leaves for longer period which in turn helped in greater dry matter accumulation and this might have contributed much as a major source for the development of sink and thereby improved the yield attributes (Asaduzzaman *et al.*, 2014)

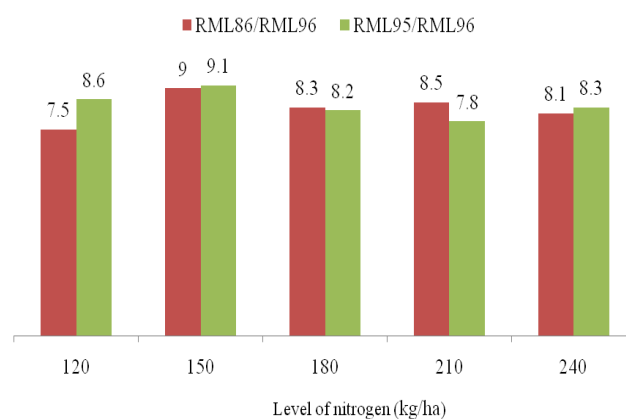


Figure 1. Effects of different levels of nitrogen on grain yield of different maize hybrids at Rampur, Chitwan, Nepal in spring seasons of 2017 and 2018.

Conclusion

Nitrogen fertilizer application had profound effects on grain yield and yield attributing traits of maize hybrids. The application of nitrogen fertilizer at the rate of 150 kg/ha increased the grain yield and yield attributing traits namely number of cobs/ha and thousand grain weight in both hybrids RML86/RML96 and RML95/RML96 in 2017 and 2018. Therefore, the use of this level of nitrogen is beneficial to get the higher maize production.

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Conflict of interest

All the authors would like to declare that there is no conflict of interest among them that could possibly arise in future.

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