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Research Article

Response of Maize to the Soil Application of Nitrogen and Phosphorous Fertilizers

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Abstract

Poor nutrient management is one of the key factors contributing to decline in the productivity of maize in Nepal. Few studies have been done on developing site and variety specific fertilizer recommendation. Therefore, a field experiment was conducted at National Maize Research Program (NMRP) Rampur, Chitwan during winter season in September 2016 to study the response of hybrid maize (RML95/RML96) to different doses of soil application of nitrogen (N) and phosphorous (P). The treatments included were 120:60, 120 :(40+20), 160:60, 160 :(40+20), 200:60, 200 :(40+20), 240:60, and 240 :(40+20) N: P kg ha^{-1}. Potassium fertilizer was fixed and applied as per the Government recommendation i.e., 40 kg K ha^{-1}.Eight treatments were replicated three times in randomized complete block design and maize was planted in six rows of four meter long plot. The research findings revealed that each level of N significantly increased grain yield up to 240 kg N ha^{-1}. The grain yield (8.8 t ha^{-1}) obtained under 240 kg N ha^{-1} was significantly higher than that obtained under 120,160 and 200 kg N ha^{-1}. However, the results revealed that split application of P failed to bring about any significant difference in the grain yield as well as yield parameters of maize. We can, thus conclude that the addition of increasing rate of N increases the yield and yield attributing characters of maize.

Keywords: Maize; N; P; Split application; Grain yield

Introduction

Nitrogen (N) and phosphorous (P) deficiency are key constraints in Maize production (Adediran *et al.*, 1995; Asghar *et al.*, 2010) which covers nearly 0.9 million hectare with low productivity (2.5 t/ha) (MOAD, 2015/16) in Nepal as compared to other countries. Maize- as a heavy feeder- demands high amount of N and P. Farmers in Nepal still have no or little practice of replenishing the harvested nutrients either due to resources constraint or due to the lack of knowledge. Therefore, soil has become more and more deficient in plant nutrients (Karki *et al.*, 2002). N is a vital plant nutrient that determines the yield; important for maize production (Adediran *et al.*, 1995). A sufficient quantity of N throughout the growing season is a must for optimum maize growth. It plays an important role in plant growth as an essential constituent of cell components and require for the synthesis of chloroplast, amino acids, proteins and cell division (Schrader, 1984; Marschner, 1986).When N

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deficiency occurs, maize will be stunted, photosynthesis gets reduced and consequently has a profound influence on grain yield. Reduced N is also associated with lower protein content of seeds and vegetative parts (Warren et al., 1975 and Gangwar and Kalra, 1988). Also, low level of N causes early maturity which results in a significant reduction in yield and quality. Further, N deficiency in maize may develop thin and spindly stems which could be prone to lodging by wind. Moreover, maize plants deficient in N will develop poor root system, which reduces their anchorage capacity (Brady and Weil, 2000).

Besides N, P is another most important nutrient for maize production (Chen et al., 1994). P has a significant role in reproductive system in plants; and in majority of soils it is the second most crop-limiting element (Wojnowska et al., 1995). P is the constituent of ADP and ATP and required for the carbohydrate synthesis. An inadequate P supply decreases synthesis of RNA, leading to depressed growth (Hue, 1995). P deficient plants, therefore, are stunted with a limited root system. Also, maize plants deficient in P can produce smaller ears containing fewer kernels than usual.

Masood et al., 2011; Jones et.al, 2003 has also reported that grain yield was severely reduced due to low rate of P application. In case of Nepalese soils, levels of these nutrients are reported to be continuously declining (NMRP, 2014).

Various studies illustrate that inputs of N and P in the soil under different soil and management condition showed increased grain yield, number of kernels ear^{-1}, ear diameter, thousand grain weight and plant height of maize (Ayub et al., 2002; Alias *et al.*, 2003; Muhammad et al. 2004). An important problem associated with P is its fixation in the soil and the amount of inherent P is very low in the soils, most of which present in the soil in unavailable form, and added soluble forms of P are quickly fixed by many soils (Brady, 1990).

Muhammad et al. (2004) found that in soils which are deficient in available P, application of higher level of P enhances emergence of seedlings through its effect on development of root, and thereby enhances days to flowering and maturity and also increases the grain yield of maize. Ayub *et al*., 2002, has also reported that the grain yield of maize was increased with the increased P levels. It was also evidenced that P uptake from the soil has been increased due to the N application (Onasanya *et al*., 2009). Hence, optimum levels of N and P fertilizers application are important to achieve desirable crop growth and productivity. However, In case of Nepal, the existing fertilizer recommendation for maize is general without considering these important governing factors (NMRP, 2014). Although basal application of P at the time of planting is recommended practice for many crops including maize, its split application can also contribute to higher grain yield. Kethi et, al (2016) has also explained that split application of P in case of cereal crop like Rice has proved to be successful. However, the detailed study in case of maize is yet to be carried out. Therefore, a location specific and variety specific fertilizer recommendation and its management are very important. Hence, it is very essential to address the nutrients deficiency especially N and P in order to obtain the maximum production of maize. Thus, this study was undertaken to determine the optimum levels of N fertilizer for maize production and to see the response of split application of P on growth and yield of maize.

Materials and Methods

A field experiment was conducted in National Maize Research Program Rampur, Chitwan during winter season on September 2016. A Randomized Complete Block Design (RCBD) was laid out with three replications and eight treatments for RML95/RML96 variety of Maize. Maize was planted in six rows of four meter long plot. Outer two rows were used as border line and remaining four rows were harvested for grain yield and other yield attributing parameters. Individual plot size was 3.6m x 4m and seeds were sown at spacing of 60cm x 25cm on 26 September, 2016 by line sowing. Harvesting was done from 2nd -3rd week of March, 2017.Observations on plant height, ear height, ear length, ear diameter, kernel rows/ear, kernels/ear, test weight, grain yield and soil pH was made.Detailed statistical analysis of data was performed by using GENSTATC™ Discovery version. Analysis of variance was performed with all data to confirm the validity of results. Mean separation was done by TUKEY test at 5% level of significance (Gomez and Gomez, 1984).

Result and Discussion

Plant Height

From the Table 1, significant result was obtained for plant height. The highest plant height (186.2cm) was obtained at $N_{240}P_{60}$ Kg/ha whereas the lowest plant height (155cm) was recorded at $N_{120}P_{(40+20)}$ Kg/ha. $N_{240}P_{60}$ and $N_{240}P_{(40+20)}$ which obtained the highest dose of nutrients had taller plants which were significantly higher than $N_{120}P_{60}$, $N_{160}P_{60}$ and $N_{160}P_{(40+20)}$ but they were at par with $N_{200}P_{60}$ and $N_{200}P_{(40+20)}$. Similarly, $N_{120}P_{60}$, $N_{120}P_{(40+20)}$, $N_{160}P_{60}$ and $N_{160}P_{(40+20)}$ were at par witheach other. The table also depicts that maize plants were relatively taller on nutrients applied on split doses compared to nutrient applied on basal doses except on doses with N amounted 120 and 240 kg ha^{-1}. Bakht and Masood *et al.* (2006, 2011) also reported that plant height of maize increased with increased N levels.

Table 1: Effect of NP combination on growth and yield attributing characters of maize

NP (Kg ha^{-1})	Plant Height(cm)	Ear Height (cm)	Ear diameter (cm)	Kernel rows ear^{-1}	Kernels ear^{-1}	Thousand grain weight (gm)
120:60	158.7b	76.83b	4.293 d	14.13 c	332.6 c	406cd
120:(40+20)	155b	81.83b	4.273 cd	13.3 bc	339.9 c	387.3d
160:60	163.5ab	88ab	4.407 bcd	13.8 bc	348.4bc	416.7bcd
160:(40+20)	168ab	82.17b	4.46 bcd	14.13bc	357.4bc	442bc
200:60	172.8ab	86.83ab	4.533 abcd	14.53abc	373 abc	442bc
200:(40+20)	173ab	90.5ab	4.573 abc	14.9 abc	383 abc	451.3ab
240:60	186.2a	98.67a	4.587 ab	15.2 ab	407.9ab	460.7ab
240:(40+20)	184.8a	99a	4.773 a	16.13 a	427.8 a	488.7a
S Em	4.63	3.3	0.0567	0.347	12.41	8.97
LSD	14.04	10.01	0.1721	1.053	37.64	27.19
CV	4.7	6.5	2.2	4.1	5.8	3.6
Sig	*	*	**	*	**	**

Ear Height, Ear Length and Ear Diameter

There was significant difference among the treatments regarding ear height. The tallest ear (99 cm) was found with the application of $N_{240}P_{(40+20)}$ while the lowest ear height (76.8 cm) was recorded at $N_{120}P_{60}$. However, there is no significant difference among treatments supplied with P at basal and split doses. Similar findings were also obtained by Okumura *et al*. (2011) in Brazil that the ear height was significantly different among the treatments (0, 40, 80, 120, 160 and 200 kg ha^{-1} of N). Also, a positive correlation between N levels and ear height has been reported by Santos *et al*. (2002).

Ear length increased with increasing dose of N. However; no significant difference was recorded among N levels statistically. Similar results were reported by Cruz *et al*., 2008 and Fernandes *et al*., 2005, that ear length remained non-significant by different nitrogen levels.

We found significant difference among treatments with regard to ear diameter. Treatment $N_{240}P_{(40+20)}$ produced the greatest ear diameter (4.773cm) whereas treatment $N_{120}P_{(40+20)}$ resulted the least (4.273cm). $N_{200}P_{60}$, $N_{200}P_{(40+20)}$, $N_{240}P_{60}$ were found at par with $N_{240}P_{(40+20)}$ which were significantly better for ear diameter over $N_{160}P_{40}$ and $N_{160}P_{(40+20)}$. Higher ear diameter obtained at T8 ((240 :(40+20) NP Kg ha^{-1}) level might be due to sufficient supply of N to the crop because N is involved in cell division and cell elongation (Shamim *et al*., 2015).

Kernels Rows and Numbers per Ear

Statistical analysis showed that the kernels rows ear^{-1} and kernels ear^{-1} increased with an increase level of Nitrogen from 120 to 240 kg ha^{-1}. $N_{240}P_{(40+20)}$ has got the maximum kernel rows ear^{-1} (16.13cm) and $N_{120}P_{(40+20)}$ has got the minimum value (13.33cm). The highest number of kernel (427.8) was recorded from $N_{240}P_{(40+20)}$ and it was the lowest (332.6) at T1 i.e.; $N_{120}P_{60}$. The increasing kernel numbers with increase in N levels and split application of P over basal application though not significant for the latter one. Similar results were obtained by Sharma *et al*. (1969) that the the number of kernels ear^{-1} increases with increased N levels. However, there is no significant difference between treatment with phosphorous applied in basal and split doses. Gungula *et al*. (2007) and Dawadi (2009) found number kernel rows ear^{-1} increased with increasing N levels.

Thousand Grains Weight

Similar to other agronomic attributes, thousand grains weight also increased significantly at higher N levels. The highest thousand grains weight (488.7gm) was recorded from $N_{240}P_{(40+20)}$ kg ha^{-1} and it was lowest (387.3gm) from $N_{120}P_{(40+20)}$. The increase in thousand grains weight with increase in N rates might be due to relatively higher amount of photosynthates to the grains (Karki, 2002). Such effects of N and P application on thousand grains weight are similar with the findings of Amoruwa *et al*., (1987).

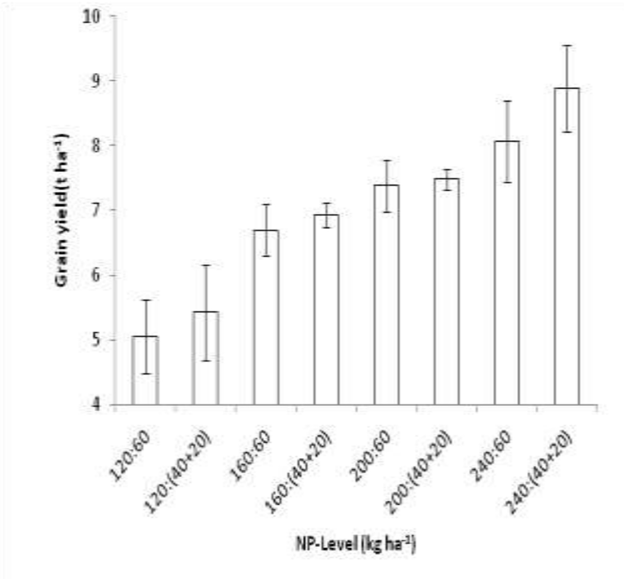

Fig 1: Effect of NPK combination on grain yield of Maize

Grain Yield

Improvement of the yield attributing characters due to higher N levels and split P application stimulated the grain yield. Hence, N_{240} $P_{(40+20)}$ gave significantly highest grain yield (8.85 t ha^{-1}) and it was lowest at $N_{120}P_{60}$ (5.05 t ha^{-1}). Though found insignificant, the split doses of P had contributed to relatively higher grain yield over the same dose of P applied in basal dose. Increased in grain yield of maize significantly with increased N levels might be due to the greater contribution of nitrogen for producing healthier, strong and vigorous grains and thus, more weight. Onasanya and Zaman Khan *et al*. (2009) also reported higher maize grain yield with increase in N rates (Fig.1).

Conclusion

Thus, we can conclude that addition of increasing rate of N increases the yield and yield attributing characters of maize .The grain yield (8.85 t ha^{-1}) obtained under 240 kg N ha^{-1} was significantly higher than that obtained under lower levels. However, no significant difference was obtained with the split application of P although grain yield was highest at 240: (40+20) Kg NP ha^{-1}. Thus, further trial including wider levels of given nutrients is suggested.

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