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Effects of different rates of plant nutrients on yield attributes and yield of Maize (*Zea mays* L.)

Abstract

An investigation was carried out to study the effect of different rates of plant nutrients on yield attributes and yield of Maize (*Zea mays* L.). The experiment was undertaken at RRS, Karnal during *kharif* 2015 consisting of 12 treatment combinations *viz.*, T_1 - Control (no fertilizer), T_2 - N (150 kg/ha), T_3 - NP (150, 60 kg/ha), T_4 - NPK (150, 60, 60 kg/ha), T_5 - NPK + S (160, 60, 60, 40 kg/ha), T_6 - NPK + Zn (150, 60, 60, 25 kg/ha), T_7 - NPK (150, 60, 60 kg/ha) + Fe (foliar application of $FeSO_4$ @ 1% twice i.e. 30 and 45 DAS), T_8 - NPK (150, 60, 60 kg/ha) + Mn (foliar application of $MnSO_4$ @ 0.5 % twice i.e. 30 and 45 DAS), T_9 - NPK + S + Zn (150, 60, 60, 40, 25 kg/ha), T_{10} - NPK + S (150, 60, 60, 40, 25 kg/ha) + Zn + Fe (foliar application of $MnSO_4$ @ 0.5 % twice i.e. 30 and 45 DAS), T_{11} - NPK + S + Zn (150, 60, 60, 40, 25 kg/ha) + Fe + Mn (foliar application of $FeSO_4$ @ 1% and $MnSO_4$ @ 0.5 % twice i.e. 30 and 45 DAS) and T_{12} - soil test based fertilizer application (150, 60, 40 kg/ha) laid out in randomized block design. The results of the study revealed that application of recommended NPK in combination with micronutrients (Fe, Zn, Mn) were statically at par to alone application on NPK in terms of yield and yield attributes i.e. cob length, cob girth and test weight. Maximum grain yield (73400 kg/ha), cob length (15.7cm), cob girth (3.6 cm) and test weight (21.0g) was recorded in treatment T_5 [NPK + S (160, 60, 60, 40 kg/ha)] which was significantly superior over treatments T_1, T_2 and T_3 where at least single primary macro nutrient lacking. Application of N - alone, NP and NPK results in significantly higher grain yield (51.2, 56.5 and 71.8 q/ha), straw yield (76.0, 84.0 and 107.0 q/ha), cob length (12.4, 13.5 and 14.5 cm), cob girth (2.8, 3.0 and 3.4 cm) and test weight (14.2, 18.4 and 20.4 g) over control, N - alone and NP application respectively. Application of NPK with S resulted in highest yield attributes and yield of maize crop. No. of rows/cob, no. of kernel/cob, no. of cobs/ha and shelling percentage does not affected by different rate of nutrient application.

Key words: Maize, Plant nutrients, Yield attributes, NPK

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Introduction

Globally, maize is referred as 'Miracle crop' or 'Queen of the Cereals' due to its high productivity potential compared to other family members of *Poaceae*. Maize is a dual purpose crop used as grain for human consumption and stover solely fed to the livestock. It also serves as a basic raw material to thousands of industries *viz.*, starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package, paper industries *etc*. (Kumar *et al*., 2012). Maize was grown in an area of 12 thousand ha in Haryana, with production of 27 thousand tonnes and productivity of 2.25 tonnes/ha during the year 2016 (Anonymous, 2016). Haryana state has an ample scope to increase its acreage and productivity. Strong market demand and resilience of maize to abiotic and biotic stresses have increased the area and production of maize in the country over the past decade. Productivity of maize, however, has not increased proportionately and significant yield gaps are evident across maize growing areas in the country. Adaptation of 4R principle-based site-specific nutrient management decision support tools provides the opportunity for large-scale adoption of improved nutrient management across maize ecologies (Jat *et al.*, 2013).

Nutrient removal is far excess of their replenishment under intensively cropped cereal systems in India, which has led to wide spread multi-nutrient deficiencies in soils. As a result of improved agronomic, breeding, and biotechnological advancements in maize systems, yields have reached at far higher levels than achieved ever before. However, greater yields of maize have always been accompanied by a significant removal of macro and micro nutrient from the soil. While managing plant nutrients in maize systems, nitrogen (N), phosphorus (P), and potassium (K) remain the major ones for increased productivity. However, cultivation of high yielding maize systems will likely exacerbate the problem of secondary and micronutrient deficiencies, not only because larger amounts are removed, but also because the application of large amounts of N, P, and K to achieve higher yield targets often stimulates the deficiency of secondary and micronutrients. Information on crop yield response to fertilizer application, agronomic efficiency and return on investment (ROI) to fertilizer application is also essential for determining optimum dose of nutrients. Soils of the major maize growing areas in India are inherently low in soil organic matter and nitrogen. Nitrogen is the major limiting plant nutrient routinely supplemented through application of fertilizers. Through the

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yield increase in maize due to N fertilization was substantial (92%), the average agronomic efficiency of N in maize, indicated low N use efficiency (Jat *et al.*, 2013). Satyanarayana *et al.* (2013) reported variable maize yield response to N fertilizer application, ranging from 4000-5160 kg per ha with an average response of 2154 kg per ha.

Phosphorous response is highly variable and is influenced by soil characteristics and growing environment of the crop. Phosphorus application rate, therefore, must be based on expected response of a particular location. Phosphorus application based on yield response alone does not take into account the nutrient removal by crops where response is low or negligible. Finally, management of phosphorus fertilizer for maize systems must take account of residue and organic amendments applied to the soil (Walia and Kler 2010).

2. MATERIAL AND METHODS

A field experiment in randomized block design consists of 12 treatments combination with three replications was conducted at the Regional Research Station, Karnal of CCS Haryana Agricultural University during *kharif* seasons of year 2015. The treatments were T_1 - T_{12} i.e. T_1 - Control (no fertilizer), T_2 - N (150 kg/ha), T_3 - NP (150, 60 kg/ha), T_4 - NPK (150, 60, 60 kg/ha), T_5 - NPK + S (160, 60, 60, 40 kg/ha), T_6 - NPK + Zn (150, 60, 60, 25 kg/ha), T_7 - NPK (150, 60, 60 kg/ha) + Fe (foliar application of $FeSO_4$ @ 1% twice i.e. 30 and 45 DAS), T_8 - NPK (150, 60, 60 kg/ha) + Mn (foliar application of $MnSO_4$ @ 0.5 % twice i.e. 30 and 45 DAS), T_9 - NPK + S + Zn (150, 60, 60, 40, 25 kg/ha), T_{10} - NPK + S (150, 60, 60, 40, 25 kg/ha) + Zn + Fe (foliar application of $MnSO_4$ @ 0.5 % twice i.e. 30 and 45 DAS), T_{11} - NPK + S + Zn (150, 60, 60, 40, 25 kg/ha) + Fe + Mn (foliar application of $FeSO_4$ @ 1% and $MnSO_4$ @ 0.5 % twice i.e. 30 and 45 DAS) and T_{12} - soil test based fertilizer application (150, 60, 40 kg/ha). The experimental site was located at latitude of 29^0 43' 42.19″ N longitude of 76^0 58' 49.88″ E and at an altitude of 253 m above mean sea level. The soil of experimental field was deep with silty clay loam in texture, slightly alkaline pH (8.2), medium in organic carbon (0.46%), available P_2O_5 (15 kg/ha), K_2O (127 kg/ha) and low in available N (120 kg/ha).The experimental site had been used over the years for continuous maize cropping. Maize crop was in alternation with wheat crop grown in *rabi* season.

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Maize variety HPQM 1 was sown on flat bed at the spacing of 70cm x 20cm with seed rate of 20 kg/ha. Pre-sowing irrigation was applied to the field to facilitate preparatory tillage and seed germination. The seed bed was prepared by four harrowing followed by cultivator twice and planking. Furrows were opened in dry condition to facilitate the dibbling of maize. 1/4th dose of nitrogen (37.5 kg/ha), full dose of phosphorus (60 P_2O_5 kg/ha) and full dose of potash (60 K_2O kg/ha) through urea, DAP and MOP respectively, were applied as a basal dose at the time of sowing and remaining 3/4th dose of N (112.5 kg/ha) was top dressed through urea in 3 equal splits i.e. knee high stage, tasseling stage and dough stage. Maize hybrid as per treatment was sown by dibbling method on dry ridges opened at 70 cm with plant to plant spacing of 20 cm immediately followed by irrigation up to half of the ridge to ensure proper soil moisture for better germination of seed. Crop received very good rainfall during the crop growth period. Recommended package of practices were followed for all other operations. The length of ten randomly selected cobs from each net plot was measured from base to tip and average was recorded as cob length. Cob girth was measured for 5 cobs from each net plot and average of 5 cobs was recorded as cob girth. Numbers of rows/cob were counted for 5 cobs from each net plot and average of 5 cobs was calculated. Number of kernels per cob was calculated by multiplying the number of grains/row by the number of rows/cob. All the cobs were harvested from net plot area and converted on hectare basis. The weight of 100 seeds drawn at random from the grains of 10 cobs from each plot was recorded. Five cobs were selected from each plot and after sun drying to 15% moisture, the grains were separated from cobs and weight of grains was measured and converted on hectare basis. Straw yield was recorded after remaining the cobs at harvest from net plots after sun drying to 15% moisture and expressed in kg/ha. The shelling was calculated by the given formula on sun dry weight basis:

$$\text{Shelling (\%)} = \frac{\text{Grain yield}}{\text{Cob yield without husk}} \times 100$$

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The data was analyzed using analysis of variance (ANOVA) as applicable to randomized complete block design. The significance of the treatment effects was determined using F-test at 5% significance level.

RESULTS AND DISCUSSION

YIELD AND YIELD ATTRIBUTES

Cob length and Cob girth:

The perusal of data (Table 1) indicates that cob length was significantly higher in all nutrient treatments compared to control. Highest cob length (15.7 cm) was recorded in treatment T_5 followed by T_6 (15.5 cm), T_9 (15.5 cm) and lowest in T_1 (10.5 cm). Paramasivan *et al*. (2012) and Balai *et al.* (2011) also reported that highest cob length (19.0 cm) was obtained from the treatment with 250-76-88-7.4 kg N-P-K-Zn/ha. Results also indicate that cob girth differed significantly in different nutrient treatments. Treatment T_5 recorded highest cob girth (3.6 cm) followed by T_6 (3.5 cm) and T_9 (3.5 cm). Significantly lower cob girth compared to other nutrient treatments were recorded in control (2.6 cm) followed by N (2.8 cm) and NP (3.0 cm) treatments. The result obtained during the investigation were similar with the finding of Paramasivan *et al*. (2012) in reference of cob girth who obtained maximum cob girth (3.2 cm) from the treatment with 250-76-88-7.4 kg N-P-K-Zn/ha.

Table 1: Effect of different rate of nutrient on yield attributing characteristics of maize

Treatments	Cob length (cm)	Cob girth (cm)	Number of rows/cob	No. of kernels /cob	No. of cobs /ha(000/ha)
T_1	10.5	2.6	12.7	373.3	67.9
T_2	12.4	2.8	12.7	422.7	67.6
T_3	13.5	3.0	12.8	441.3	68.7
T_4	14.5	3.4	14.8	448.0	68.1
T_5	15.7	3.6	15.7	527.3	69.8

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T_6	15.5	3.5	15.8	474.0	69.4
T_7	14.9	3.4	15.3	504.7	68.9
T_8	14.6	3.4	14.5	504.7	68.7
T_9	15.5	3.5	15.5	497.3	69.0
T_{10}	15.1	3.4	15.4	491.3	68.6
T_{11}	15.0	3.4	14.7	505.3	68.7
T_{12}	15.1	3.4	15.5	504.7	68.6
SE(m)±	0.58	0.65	2.0	40.6	0.67
CD (P=0.05)	1.71	0.25	NS	NS	NS

Number of rows/cob, kernels/cob, cobs/ha

The no. of rows/cob, no. of kernel/cob and cobs/ha did not affect by different rates of nutrients (Table 1). Ghaffari *et al*. (2011) and Paramesh *et al.* (2014) also reported highest number of rows/cob in treatment of recommended dose of fertilizer + 1 spray of multi-nutrients whereas lowest no. of rows/cob observed in control. Application of different nutrients in maize produced significantly higher no. of kernels/cob compared to control treatment. Treatment T_5 recorded highest no. of kernels/cob (527.3) followed by T_{11} (505.3), T_8 (504.7) and T_{12} (504.7). Similar results were also reported by Iqbal *et al*. (2013) and Maqsood *et al*. (2001).

Treatment, T_5 recorded highest no. of cobs/ha (69800) followed by T_6 (69400) and T_9 (69000). Kalhapure *et al*. (2013) and Sujatha *at el*. (2008) also reported similar results, with highest number of cobs/plant from the treatment of 25% RDF+ biofertilizers (*Azotobacter*+PSB) + green manuring with sunhemp+compost.

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Test weight

The data (Table 2) indicated that all the treatments except treatment T_2 produced significantly bolder kernels as compared to control. Treatment T_5 recorded highest test weight (21.0) which was statistically at par with all treatment except T_1, T_2 and T_3 where at least one primary macro nutrient lacking. Ghaffari *et al*. (2011) and Sepat and Rai (2013) also found maximum test weight when maize plants received basal dose of conventional fertilizer with single spray of multi-nutrients solution.

Grain yield and Straw yield (q/ha)

Among all treatments, highest grain yield (73.4 q/ha) was recorded in treatment T_5 followed by T_9 (73.2 q/ha), T_6 (72.8 q/ha), T_{11} (72.2 q/ha) and T_7 (72.0 q/ha) as shown in Table 2. Treatments where at least one primary macro nutrient lacking (T_1, T_2 and T_3) produce significantly lower grain and straw yield compare to rest of the other treatments. The results were confirmed with the finding of Jat *et al*. (2013) and Balai *et al*. (2011) as they found maximum grain yield by the use of farmyard manure and in combination with inorganic fertilizers.

The application of NPK and NPK with micronutrients produced similar straw yield and produced significantly superior to the treatment NP, N and control. Treatment of NPK over NP (107.8 q/ha), NP over N (84.7 q/ha) and N over control (76.8 q/ha) produced significantly higher straw yield. Among the treatments significantly higher straw yield/ha was recorded in T_5 (110.0 q/ha) followed by T_9 (109.8 q/ha) and T_6 (109.1 q/ha). The highest biological yield was also influenced which might be attributed to the additional availability of nutrients. (Ali *et al*. 2012; Mukhtar *et al*., 2011 and Dibaba *et al*., 2014). TreatmentT_5 produce significantly higher grain and straw yield over T_1, T_2 and T_3. Treatment T_5 produce 80%, 40% and 30% higher grain and 79%, 43% and 30% higher straw yield over T_1, T_2 and T_3.

Shelling (%)

Recovery of grains from cob was not affected by different rates of plant nutrients (Table 2). Highest recovery of grains from cob (80.2) was recorded in treatment T_5. Lowest were recovered in treatment T_1 (73.0). Similar, results were reported by Paramesh *et al*. (2014) and Banerjee *et al*. (2014) in respect to shelling per cent, as they also found significantly higher shelling percentage with P_{50}–PEC+P_{50}–F.

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Table 2: Effect of different nutrient treatments on test weight, grain yield, straw yield/ha and shelling percentage of maize

Treatments	Test weight (g) (100 grains)	Grain yield (q/ha)	Straw yield (q/ha)	Shelling (%)
T_1	12.8	40.9	61.3	73.0
T_2	14.2	51.2	76.8	75.6
T_3	18.4	56.5	84.7	76.0
T_4	20.4	71.8	107.8	79.0
T_5	21.0	73.4	109.8	80.2
T_6	19.8	72.8	109.1	79.2
T_7	19.4	72.0	108.0	79.0
T_8	19.8	71.3	107.0	78.9
T_9	19.3	73.2	110.0	79.2
T_{10}	19.3	71.0	106.6	79.1
T_{11}	19.8	72.2	108.3	79.1
T_{12}	20.0	71.4	107.1	79.0
SE(m)±	0.59	1.78	2.24	1.85
CD (P=0.05)	1.75	5.25	6.63	NS

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