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Influence of Different Dose of Plant Nutrient on Growth Rate, Nutrient Uptake and Yield of Maize (*Zea mays* L.)

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ABSTRACT

Experiment was conducted to study the effect of different doses of plant nutrients on growth rate, nutrient uptake and productivity of Maize (Zea mays L.), at Regional Research Station, Karnal during Kharif 2015. Application of recommended NPK with micronutrients (Fe, Zn, Mn) was statically at par with alone NPK application in terms of phonological studies, yield and quality parameters. Maximum grain yield (73400 kg/ha), crop growth rate at 30, 60 and 90 days after sowing (3.41, 12.76 and 16.18 g/m^2/day), relative growth rate at 30, 60 and 90 days after sowing (0.120, 0.052 and 0.009 g/m^2/day), 50 % tasseling (53.3), 50 % silking (55.3) and days to maturity (96.7) was recorded under NPK + S (160, 60, 60, 40 kg/ha) which was significantly superior over treatments control (no fertilizer), N 150 kg/ha alone and NP (150, 60 kg/ha), where at least single primary macro nutrient lacking. So, finding suggests that use of recommended NPK in combination with sulphur increase phonological factors and productivity of kharif maize.

Key words: *Macronutrients, Maize, NPK, Silking, Tasseling.*

INTRODUCTION

Globally, maize (*Zea mays* L.) is referred as 'Miracle crop' or 'Queen of the Cereals' due to its high productivity potential compared to other family members of *Poaceae*[1]. Maize is a dual-purpose crop used as grain for human consumption and stover solely fed to the livestock. The total utilization of maize in India is 52% in poultry feed (poultry, pig and fish etc), 24% for food, 11% for cattle feed, 11% for starch, 1% each for brewery and seed purposes. It also serves as a basic raw material to thousands of industries *viz.*, starch, oil, protein, pharmaceutical, cosmetic, film, textile, gum, package, paper industries *etc*[2]. 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 [3]. 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.

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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[4].

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 yield increase in maize due to N fertilization was substantial (92%), the average agronomic efficiency of N in maize, indicated low N use efficiency[5.6] 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[7].

Potassium (K) fertilizer management is beneficial for improving growth, yield and yield components of field crops under moisture stress condition in semiarid climates. Two major reasons of low maize productivity under semiarid condition are: (1) imbalanced use of chemical fertilizers and (2) water stress (dryland) condition[8]. Keeping the above aspects in view, an investigation with the following objectives: To study the effect of different nutrients on growth rate, nutrient uptake and productivity of maize in Haryana locality.

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 *spring* season.

In experiment gross plot size was 4.2 m x 5.0 m with net plot size 2.8 m x 5.0 m. Maize variety HPQM 1 available from Regional Research Station, Karnal was sown on flat bed at the spacing of 70 cm x 20 cm 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. $1/4^{th}$ 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 $3/4^{th}$ 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 was followed for all other operations

Crop growth rate (g/m^2/day)

It represents the dry weight gained by plant material per unit of time. It was computed as:

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{\text{Land area } (m^2)}$$

Where,

W_1 and W_2 dry mater accumulation at time t_1 and t_2 respectively.

Relative growth rate (g/g/day)

Relative growth rate is the rate of increase in dry weight per unit dry weight and is expressed in gram per gram per day. RGR was calculated by using the formula suggested by Blackman (1919).

$$RGR = \frac{\text{Log}_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where,

W_1= Dry weight of plant at time t_1

W_2 = Dry weight of plant at time t_2

The number of days from sowing to tassel emergence in 50 per cent of the plants with in net plot were recorded as day to 50 per cent tasseling. The number of days from sowing to silk emergence in 50 per cent of the plants with in net plot was recorded as day to 50 per cent silking. The numbers of days from sowing to maturity were recorded as and when most of the cob husk turns yellow and starts drying. 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 q/ha.

NPK & S uptake

Oven dried sample weighed 0.5 g for straw was digested in diacid mixture of H_2SO_4 and $HClO_4$ in the ratio of 9:1 for NPK estimation. After digestion, a known volume was made with distilled water and filtered through Whatman's filter paper No. 42. Nitrogen content in digested plant material was determined by Nessler reagent method [9]. Phosphorus and potassium content were determined by Vanadomolybdo phosphoric acid yellow color method [10] and flame photometric method [11]. Sulphur content was determined by Calcium chloride method [12].

RESULTS AND DISCUSSION

Table 1: Effect of different doses of nutrient on crop growth rate and relative growth rate of maize

	Crop growth rate (g/m^2/day)			Relative growth rate (g/m^2/day)		
Treatments	**0-30 DAS**	**30-60 DAS**	**60-At maturity**	**0-30 DAS**	**30-60 DAS**	**60-At maturity**
T_1	2.28	10.51	12.87	0.106	0.037	0.003
T_2	2.57	11.08	13.33	0.110	0.040	0.005
T_3	2.76	11.49	13.71	0.112	0.043	0.006
T_4	3.26	12.68	16.04	0.118	0.047	0.007
T_5	3.41	12.76	16.18	0.120	0.052	0.009
T_6	3.37	12.74	16.14	0.119	0.050	0.007
T_7	3.22	12.68	16.09	0.117	0.046	0.007
T_8	3.38	12.70	16.09	0.118	0.045	0.007
T_9	3.39	12.73	16.15	0.119	0.051	0.008
T_{10}	3.36	12.68	16.13	0.118	0.046	0.008
T_{11}	3.33	12.66	16.13	0.119	0.047	0.007
T_{12}	3.32	12.64	16.12	0.118	0.048	0.008
SE(m)±	0.12	0.14	0.16	0.001	0.001	0.001
CD (P=0.05)	0.35	0.43	0.49	0.004	0.004	0.002

Highest Crop growth rate (3.41, 12.76 and 16.18 g/m^2/day) was recorded by treatment T_5 at different growth period i.e. 0-30 DAS, 30-60 DAS and 60 DAS to maturity respectively, which is significantly superior over all the treatment lacking at least one primary macronutrient (N, P, K) viz., T_1, T_2 and T_3 (Table 1). Chaudhary *et al*[13] and Kumar *et al* [14] also reported that crop growth rate increased significantly at 60 DAS to maturity in maize. Same calculations were observed with Relative growth rate, during initial growth period (0-30 DAS) highest relative growth rate was observed in T_5 (0.120 g/m^2/day). But in later stages it was found that T_5 with additional S (secondary macronutrients) give significantly higher relative growth rate over T_4 (where only NPK supplied) as well. Maximum relative growth rate was obtained in the treatment of T_5 followed by T_{12}, T_9 and T_{10} and minimum in the T_1. Similar results were also reported by Chaudhary *et al*[13] and Kumar *et al* [14] in respect of relative growth rate, they found that RGR increased significantly by recommended dose of fertilizer (RDF) at all crop growth stage. Highest CGR and RGR in treatment T_5 may be due to relatively readily availability of macronutrient for growth at all stages.

Table: 2 Effect of different dose of nutrient on tasseling, silking of maize and productivity of maize

Treatments	Days to 50% tasseling	Days to 50 % silking	Days to maturity	Grain yield (q/ha)	Straw yield (q/ha)
T_1	55.0	57.0	93.3	40.9	61.3
T_2	54.0	56.0	94.3	51.2	76.8
T_3	54.3	56.3	95.0	56.5	84.7
T_4	54.0	56.0	95.7	71.8	107.8
T_5	53.3	55.3	96.7	73.4	109.8
T_6	53.3	55.3	96.3	72.8	109.1
T_7	53.3	55.3	94.0	72.0	108.0
T_8	53.7	55.7	95.3	71.3	107.0
T_9	53.3	56.3	96.3	73.2	110.0
T_{10}	53.3	55.3	96.7	71.0	106.6
T_{11}	53.3	55.3	96.3	72.2	108.3
T_{12}	53.3	55.3	96.0	71.4	107.1
SE(m)±	0.42	0.42	0.7	1.78	2.24
CD (P=0.05)	NS	NS	2.08	5.25	6.63

The perusal of data presented in (Table. 2) indicates that days to 50% Tasseling and Silking were not affected significantly by different doses of nutrients. Maximum time to 50% Tasseling (55.0 Days) and Silking (57 Days) was taken by treatment T_1 where no nutrient was applied obviously. Almost all the treatments took 53.3-55 days to attain 50 per cent tasseling stage. Similar finding was carried out by Chaudhary *et al*[13], Haque *et al* [15] and Jangir *et al*[16] as reported that increase rate from 125 to 175 kg N/ha significantly increased dry matter accumulation at 90 DAS, increase chlorophyll content and reduces days to 50 per cent tasseling. Likewise, minimum number of days to 50 per cent silking was recorded by T_5 because of regular availability of macronutrient. The results were confirmed with the findings [17] [16] who reported that high level of P enhanced days to silking and zinc application reduced number of days to silking.

The perusal of data presented in (Table. 2) indicates that days to maturity varied significantly at different nutrient treatments. Amongst treatments, control took lowest number of days (93.3) to attain maturity stage in effort to complete its life cycle before dying. Other remaining treatments took significantly higher number of days to attain maturity compared to control treatment. Longest time to maturity was observed in treatment T_5 which is significantly at par with all treatments excepts T_1, T_2 and T_7. However,[18] revealed that a gradual increase in dry matter production of crop from knee high to maturity irrespective of fertilizer applications. 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*[5] and Balai *et al*[19] 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[20,21,22]. Treatment T_5 produces 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.

Table: 3 Effect of different dose of nutrient on macronutrients uptake in straw of maize

Treatments	N(kg/ha)	P(kg/ha)	K(kg/ha)	S(kg/ha)
T_1	68.3	42.5	77.5	24.7
T_2	82.7	46.8	86.4	27.1
T_3	84.7	55.8	93.4	27.7
T_4	93.7	58.3	120.3	27.1
T_5	96.0	57.3	116.7	51.2
T_6	94.3	56.4	112.5	37.3
T_7	94.3	53.5	113.0	30.8
T_8	93.3	54.1	115.3	31.7
T_9	95.0	58.1	114.0	40.7
T_{10}	93.3	56.4	110.7	38.3
T_{11}	94.0	53.5	119.3	31.5
T_{12}	93.3	52.7	113.4	33.7
SE(m)±	4.11	2.54	6.57	2.81
CD (P=0.05)	12.1	7.5	19.3	8.3

Significantly highest uptake of nitrogen (96.0 kg/ha) was observed in treatment T_5 which is statistically at par with rest of the other treatments except T_1 and T_2 viz., the treatments receiving relatively no or lower dose of nitrogen respectively. In treatment T_5 uptake of nitrogen was 28% and 12% higher over T_1 and T_2 respectively. Highest uptake in treatment T_5 may be due the higher dose (160 kg/ha) of nitrogen in it. Significantly highest uptake of phosphorus (58.3 kg/ha) was observed in treatment T_4 which is statistically at with all other treatments except T_1 and T_2. Treatment T_4 recorded 27% and 18% more uptake of phosphorus in comparison to T_1 and T_2 respectively. Treatment T_4 recorded 35%, 26% and 17% higher potassium uptake (120.3 kg/ha) over treatment T_1, T_2 and T_3 respectively. In case of sulphur uptake, the highest uptake of sulphur by maize was recorded in treatment T_5 which is significantly superior over rest of the treatments and it recorder 51%, 27 %, 14% and 10% higher uptake over treatment T_1, T_2, T_4 and T_3 respectively. Dose of nutrient significantly affects their availability and uptake by the plants. The above results were confirmed with the work of Behera *et al*[23], Celik *et al*[24] and Rahman *et al*[25].

CONCLUSION

It is concluded that growth rate and productivity of maize was significantly affected by macronutrients. Treatments lacking at least one primary macronutrient (N, P, K) results in significantly decline in productivity and yield attributes of maize. Sulphur a secondary macronutrient significantly increases the Relative growth rate of maize over sole application of only primary macronutrients. Days to 50% Tasseling and Silking were not affected significantly by dose of nutrients. Dose of nutrient significantly affects their uptake by maize.

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