
*International Journal of Plant & Soil Science*

*21(5): 1-8, 2018; Article no.IJPSS.39441*
*ISSN: 2320-7035*

# Impact of Different dose of Plant Nutrient in Terms of Growth, Quality, Yield and Economics of Maize (*Zea mays* L.)

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author Harender designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors SS and Kavinder managed the analyses of the study. Authors KM and NR managed the literature searches. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/IJPSS/2018/39441
Editor(s):
(1) Scd Victoria Anatolyivna Tsygankova, Department for Chemistry of Bioactive Nitrogen-Containing Heterocyclic Compounds, Institute of Bio-organic Chemistry and Petrochemistry, Plant Physiology, NAS, Ukraine.
Reviewers:
(1) Onesmus Semalulu, Uganda.
(2) Amanullah, The University of Agriculture Peshawar, Pakistan.
(3) Leyla Idikut, Sutcu Imam Universty, Turkiye.
Complete Peer review History: http://www.sciencedomain.org/review-history/23375

***Original Research Article***

***Received 27th November 2017***
***Accepted 17th February 2018***
***Published 28th February 2018***

## ABSTRACT

Experiment was conducted to study the effect of different doses of plant nutrients on growth, yield and economics of Maize (*Zea mays* L.), at Regional Research Station, Karnal during *Kharif* 2015 consisting of 12 treatments combination *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 days after sowing (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 revealed that application of recommended NPK with micronutrients (Fe, Zn, Mn) to compare alone application of recommended NPK($T_4$) have no significant effect on plant height and dry matter accumulation, cob yield, grain

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yield and straw yield of Protein content in grain was not significantly affected by different treatments. Maximum B:C ratio was obtained from $T_5$ [NPK + S (160, 60, 60, 40 kg/ha)] because of relatively highest grain (7340 kg/ha) and straw yield (10980 kg/ha) in comparison to cost.

*Keywords: Growth; maize; NPK; protein; yield and economics.*

## 1. 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 12000 ha in Haryana, with production of 27000 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. 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]. Satyanarayana et al. [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 was undertaken with the following objective:

It was aimed to study the effect of different doses of plant nutrient on growth, quality, yield and economics of maize.

Finding from the experiment revealed that treatment $T_5$ (received comparatively higher dose of nitrogen with sulphur) perform better over rest of the other treatments in terms of plant height, dry matter accumulation, productivity, protein content in grains and protein yield. Treatments received foliar spray of a particular micronutrient (Zn/Fe/Mn) in maize increases its uptake into plant. So it is concluded and recommended to apply treatment $T_5$ in maize for higher productivity and protein quality and foliar application of micronutrients for better uptake of these.

## 2. MATERIALS AND METHODS

A field experiment in randomized block design consisting of 12 treatments combinations with three replications was conducted at the Regional Research Station, Karnal of CCS Haryana Agricultural University during *kharif* (a crop sown in early summer for harvesting in the autumn) 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 + Zn (150, 60, 60, 40, 25 kg/ha) + 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 29º 43' 42.19˝ N longitude of 76º 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. The crop received very good rainfall during the growth period. Recommended package of practices was followed for all other operations.

The periodical plant height of main shoot was recorded from the base of the plant up to flag leaf. For this, five plants were tagged at random in each plot. The plants which were taken at periodical growth stages were kept for dry matter accumulation and data was recorded after drying them first in the sun and then in oven at 70ºC till constant weight was realized. All the cobs were harvested from net plot area and cob weight with husk was measured and converted on hectare basis. 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 removing the cobs at harvest from net plots after sun drying to 15% moisture and expressed in $10^2$ kg/ha.

Micronutrient (Zn, Fe and Mn) were determined in Diethylenetriaminepentaacetic Acid (DTPA) solution using atomic adsorption spectrophotometer as proposed by [9].

The protein content was measured by NIR analyzer (Infratec$^{TM}$ 1241 grain analyzer) developed by Foss solution and protein yield by using below formula:

$$\text{Protein yield (kg/ ha)} = \frac{\text{Protein content (\%) x grain yield (kg/ ha)}}{100}$$

Gross returns (Rs. /ha) and cost of cultivation (Rs. /ha) for different treatments were calculated on the basis of approved market rates for inputs and outputs (produce). Net profit (Rs. /ha) was worked out by subtracting the cost of cultivation of each treatment from the gross returns of respective treatment. Benefit-cost ratio was also worked out to ascertain the economic viability of different treatments.

All the experimental data for various growth, yield and quality parameters were statistically analysed using the Analysis of Variance (ANOVA) procedure as described by [10]. The significance of treatment effects was tested with the help of 'F' (variance ratio) test.

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of Different Treatments on Growth and Productivity of Maize

The data on plant height recorded with successive growth stages are presented in Table 1. Results indicated that plant height increased with advancement of crop growth. The magnitude of plant height increase was nearly 3 times between 30 and 60 DAS and increase was marginal between 60 DAS and maturity stage irrespective of different nutrient treatments. Plant height varied significantly with different nutrient treatments at 30 DAS, 60 DAS and at maturity. Treatment $T_5$ recorded significantly tallest plants *viz*. 48.7 cm, 180.3 cm and 184.4 cm at 30 DAS, 60 DAS and at harvest respectively, over treatments $T_1$, $T_2$ and $T_3$ (where at least one primary macronutrient lacking). Application of micronutrients (Zn, Fe and Mn) along with macronutrients (N, P, K and S) did not affect plant height significantly. Kalsoom et al. [11]; Maqsood et al. [12] and Haque et al. [13] also recorded maximum plant height in NPK treated plots while minimum plant height was recorded in control. Similarly, Shanti et al. [14] and Iqbal et al. [15] also observed maximum plant height in N treated plots and minimum plant height in control plots. Dry matter increased as the plant age increase, the magnitude of dry matter was increased nearly 3 times between 30 to 60 DAS and increase was observed at slower rate between 60 DAS and maturity stage. Dry matter accumulation differed significantly at different nutrient treatments at 30 DAS, 60 DAS and at maturity over treatments $T_1$, $T_2$ and $T_3$. Rate of dry accumulation was maximum during period 30-60 DAS. Highest dry matter accumulation was observed in treatment $T_5$ at all growth stages which was significantly superior over all the treatments lacking at least one macro nutrient viz., $T_1$, $T_2$ and $T_3$.

Application of micronutrient in combination with NPK did not affect the dry matter accumulation significantly. Results on dry matter accumulation were confirmed with findings of [16]; they reported higher dry matter accumulation in leaf, stem and reproductive parts at maturity. The results obtained during the investigations were also in close accordance with the finding of [17,13,18] as they also reported higher dry matter accumulation per plant due to 125% RDF. Significantly highest cob yield (98.8 q/ha) was recorded by treatment $T_5$ followed by $T_{11}$ (98.4 q/ha) over treatment $T_1$, $T_2$ and $T_3$. Findings were correlated with work of [19], they reported maximum cob weight (with and without husk) was found at 120 kg $ha^{-1}$ but was statistically equivalent with 90 kg N $ha^{-1}$.

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 1. Treatments where at least one primary macro nutrient lacking ($T_1$, $T_2$ and $T_3$) produced significantly lower grain and straw yield compared to rest of the other treatments. Likewise, treatment $T_5$ recorded highest straw yield (109.8 q/ha) which is significantly superior over treatments lacking at least one primary macronutrient ($T_1$, $T_2$ and $T_3$). The results were confirmed with the finding of [5] and [20] as they found maximum grain yield and biological yield was also influenced which might be attributed to the additional availability of nutrients.

### 3.2 Effect of Different Treatments on Micronutrient Uptake and Protein Quality of Maize

Table 2. shows that highest uptake of micronutrients (Zn, Fe and Mn) by leaves was recorded by treatments $T_{11}$ where all the three were applied through foliar application. All the treatments receiving a particular micronutrient through foliar application have significant effect on its uptake over rest of the other treatments. Highest Zn uptake (464.1 g/ha), Fe uptake (9108.2 g/ha) and Mn uptake (970.1 g/ha) was recorded in treatment $T_{11}$ which is significantly superior over rest of the other treatments lacking respective micronutrient foliar spray. The above results were confirmed with the work of [21,22].

**Table 1. Effect of different nutrient treatments on growth and productivity of maize**

| Treatments | Plant height (cm) | | | Dry matter accumulation (g/plant) | | | Cob yield (kg/ha) | Grain yield (kg/ha) | Straw yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | At maturity | 30 DAS | 60 DAS | At maturity | | | |
| $T_1$ | 40.1 | 155.2 | 158.5 | 24 | 110.3 | 134.1 | 6670 | 4090 | 6130 |
| $T_2$ | 42.2 | 157.3 | 160.2 | 27 | 116.3 | 140 | 7540 | 5120 | 7680 |
| $T_3$ | 42.1 | 160 | 161.4 | 29 | 120.6 | 144 | 9130 | 5650 | 8470 |
| $T_4$ | 47.2 | 176.1 | 180 | 34.3 | 133.1 | 168.4 | 9700 | 7180 | 10780 |
| $T_5$ | 48.7 | 180.3 | 184.4 | 35.8 | 134 | 169.9 | 9880 | 7340 | 10980 |
| $T_6$ | 48.1 | 179.5 | 182.9 | 35.4 | 133.7 | 169.5 | 9750 | 7280 | 10910 |
| $T_7$ | 47.5 | 178.7 | 180 | 33.8 | 133.2 | 168.9 | 9730 | 7200 | 10800 |
| $T_8$ | 47.4 | 179.1 | 180.3 | 35.5 | 133.3 | 169 | 9730 | 7130 | 10700 |
| $T_9$ | 48.2 | 180.1 | 181.6 | 35.6 | 133.7 | 169.6 | 9740 | 7320 | 11000 |
| $T_{10}$ | 47.9 | 179.5 | 181.4 | 35.3 | 133.1 | 169.4 | 9780 | 7100 | 10660 |
| $T_{11}$ | 47.7 | 179 | 180.5 | 35 | 133 | 169.4 | 9840 | 7220 | 10830 |
| $T_{12}$ | 48 | 179.2 | 180.3 | 34.9 | 132.7 | 169.3 | 9720 | 7140 | 10710 |
| SE(m)± | 1.2 | 1.8 | 1.9 | 1.27 | 1.52 | 1.76 | 230 | 178 | 224 |
| CD (P=0.05) | 3.7 | 5.4 | 5.7 | 3.76 | 4.51 | 5.2 | 680 | 525 | 663 |

**Table 2. Effect of different nutrient treatments on micronutrients uptake in straw and protein content in grain of maize**

| Treatments | Zn (g/ha) | Fe (g/ha) | Mn (g/ha) | Protein content in grain (%) | Protein yield (kg/ha) |
|---|---|---|---|---|---|
| $T_1$ | 155.3 | 2208.7 | 340.3 | 9.7 | 400 |
| $T_2$ | 220.5 | 2842.3 | 370.6 | 9.9 | 500 |
| $T_3$ | 278.9 | 3204.8 | 489.8 | 10 | 570 |
| $T_4$ | 328.9 | 5084 | 534.2 | 10.3 | 740 |
| $T_5$ | 322 | 5607.6 | 658.7 | 11 | 810 |
| $T_6$ | 419.1 | 4572.4 | 577.4 | 10.8 | 780 |
| $T_7$ | 327.9 | 8234.5 | 723.6 | 10.3 | 740 |
| $T_8$ | 332.2 | 5344.4 | 886.3 | 10.2 | 730 |
| $T_9$ | 453.8 | 5723.8 | 831.5 | 10.7 | 790 |
| $T_{10}$ | 463.9 | 9107.5 | 835.6 | 10.5 | 750 |
| $T_{11}$ | 464.1 | 9108.2 | 970.1 | 10.5 | 750 |
| $T_{12}$ | 350.5 | 5116.4 | 777.7 | 10.6 | 750 |
| SE(m)± | 30.7 | 402.5 | 101.9 | 0.29 | 20 |
| CD (P=0.05) | 90.8 | 1188.1 | 300.7 | NS | 60 |

**Table 3. Effect of different nutrient treatments on economic of maize**

| Treatments | Total cost of cultivation (Rs. /ha) | Gross returns (Rs. /ha) | Net returns (Rs. /ha) | B:C ratio |
|---|---|---|---|---|
| $T_1$ | 50664 | 60735 | 10071 | 1.2 |
| $T_2$ | 53070 | 75684 | 22614 | 1.43 |
| $T_3$ | 56157 | 83582 | 27425 | 1.49 |
| $T_4$ | 58206 | 105588 | 47382 | 1.81 |
| $T_5$ | 58996 | 107701 | 48705 | 1.83 |
| $T_6$ | 60308 | 106866 | 46558 | 1.77 |
| $T_7$ | 58355 | 105765 | 47410 | 1.81 |
| $T_8$ | 58298 | 104878 | 46580 | 1.8 |
| $T_9$ | 60913 | 107509 | 46596 | 1.76 |
| $T_{10}$ | 61117 | 104452 | 43334 | 1.71 |
| $T_{11}$ | 61851 | 106078 | 44927 | 1.72 |
| $T_{12}$ | 57648 | 104506 | 46859 | 1.81 |

It is quite apparent from the data presented in Table 2 that different treatments did not differ significantly in protein content. Highest protein content was recorded in $T_5$ (11.0) and lowest protein content were recorded in control (9.7). Treatment $T_5$ recorded significantly highest protein yield (810 kg/ha) over treatments $T_1$, $T_2$ and $T_3$ which is statistically equivalent with treatments $T_6$, $T_9$, $T_{10}$, $T_{11}$ and $T_{12}$. The results were confirmed with the finding of [23,24] in respect to protein yield/ha. Higher content and yield of protein in the treatment NPK+S (160, 60, 60 & 40 kg/ha) may be due to higher application of N in combination with S in the treatment compare to other treatment.

### 3.3 Effect of Different Treatments on Economics of Maize

The data pertaining to various economic parameters *viz*. total cost of cultivation, gross returns, net returns and B: C ratio is presented in Table 3. Highest total cost of cultivation (Rs.61851/ha) was recorded in treatment $T_{11}$ followed by $T_{10}$ (Rs.61117/ha). Highest gross returns (Rs.10770/ha) was observed in treatment $T_5$. Highest net returns (Rs.48705/ha) was observed in treatment $T_5$. Highest B: C ratio was observed in $T_5$ (1.83) followed by $T_4$ (1.81), $T_7$ (1.81) and $T_{12}$ (1.81) because of relatively highest yield over cost of cultivation. Lowest gross returns, net returns and B: C was observed in control treatment followed by $T_2$ and $T_3$. Similar results were obtained by [25], they revealed that highest Benefit-Cost ratio was found to be significant with application of N (160 kg/ha), P (80 kg/ha) and Zn (5 kg/ha).

## 4. CONCLUSION

It is concluded from the findings that application of recommended NPK with micronutrients (Fe, Zn, Mn) compare to alone application of recommended NPK have no significant effect on plant height and dry matter accumulation, cob yield, grain yield and straw yield of maize. Foliar application of a particular micronutrient can improve its uptake in maize crop. Protein content in grain was not significantly affected by application of different doses of nutrient. Treatment $T_5$ [NPK + S (160, 60, 60, 40 kg/ha)] is recommended in maize because of its highest B: C ratio due relatively highest grain (73.4 q/ha) and straw yield (109.8 q/ha) in comparison to cost of cultivation.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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