

Original Research Article

<https://doi.org/10.20546/ijcmas.2019.812.119>

## Response of Chemical Fertilizers and Micronutrients on Yield, Yield Attributes and Economics under Maize-Wheat Cropping System

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### ABSTRACT

A field experiment entitled Response of chemical fertilizers and micronutrients on yield, yield attributes and economics under maize-wheat cropping system was conducted at Pot house of the Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur for two consecutive year of 2016-17 in *kharif* season and 2017-18 in *rabi* seasons in micro plots. The objectives of the experiment were (i) to find out most suitable dose of nutrients for grain and stalk/straw yield of maize and wheat, (ii) to find out benefit cost ratio of maize and wheat crops. The investigation consisted of 9 treatments viz. Control, N<sub>(150)</sub>, N<sub>(150)</sub>+P<sub>(75)</sub>, N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>, N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>, N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+Zn<sub>(5)</sub>, N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(5)</sub>, N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(5)</sub>+Fe<sub>(10)</sub> and N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(5)</sub>+Fe<sub>(10)</sub>+Az. which were replicated four times in randomised block design (RBD). Maize (*cv*-Azad Kamal) and wheat (*cv*. PBW-343) were taken as test crops. The results revealed that the significant improvement in the physical properties (Bulk density, Hydraulic conductivity and Water stable aggregates) and chemical properties like cation exchange capacity and total organic carbon content of the soil were recorded by silty clay loam in texture, neutral in reaction (pH 7.8), medium in organic carbon (0.40%) with 180, 10.11 and 170.0 kg ha<sup>-1</sup> of available N, P and K, respectively. Nine treatment combinations were replicated four times in RBD. Surface (0-15cm) and subsurface (15-30cm) soil samples taken after the harvest of wheat (*rabi*, 2017-18) were analysed for pH, organic carbon, cation exchange capacity, available N, P and K using standard analytical methods. Besides, different fractions of N, P, K, S, Zn and Fe were also determined in the soil samples taken after the wheat harvest (2017-18) and the composite soil samples drawn from adjacent fallow plots. Further increase in grain yield was observed by addition of P. Application of K with N and P fertilizers did not improve the crop yield significantly compared to 150% nitrogen but further addition of S, Zn and Fe to NPK fertilizers improved the grain yield. Application of 150:75:75%NPK and combination with S, Zn, Fe and Az produced the highest average crop yield of maize (33.22 q/ha) and wheat (59.26 q/ha). These treatments also provided significant improvement in yield attributes of major and micronutrients by the crops. Incorporation of the zinc along with 150:75:75%NPK fertilizers gave the maximum benefit-cost ratio and sustained the soil productivity of the maize-wheat cropping system.

#### Keywords

Wheat, Maize,  
Nitrogen,  
Phosphorus,  
Potassium, Sulphur,  
Zinc, Iron and  
Azotobactor

#### Article Info

Accepted:  
10 November 2019  
Available Online:  
10 December 2019

## Introduction

Soil is the key natural resource and soil quality is the integrated effect of management on most soil properties that determine crop productivity and sustainability. A significant decline in soil quality has occurred worldwide through adverse changes in its physical, chemical and biological properties and contamination by inorganic and organic chemicals. In the past century, about 2 billion of the 8.7 billion ha of agricultural land, permanent pastures, and forests and woodlands have been degraded (Arshad and Martin, 2002). Green revolution has brought about spectacular increase in food grain production in the Indo-Gangetic plain of India, continuous use of NPK fertilizers has remarkably increased production but simultaneously developed secondary and micronutrient deficiencies due to restricted use of organic manures. There is an apprehension that the use of chemical fertilizer over the years may impair the soil health. In continuous cropping, use of imbalanced nutrient (N or NP alone) through chemical fertilizers without organic manure resulted in reduction in the desired level of crop productivity (Tiwari *et al.*, 2002; Panwar, 2008). Growing of crops one after another without giving due consideration to nutrient requirements has resulted in decline in soil fertility (Ghosh *et al.*, 2003). There commended dose of NPK fertilizers alone does not sustain productivity under continuous intensive cropping system (Yaduwanshi 2003) whereas inclusion of organic manures improves physical properties (Mandal *et al.*, 2003), the biological soil status, soil fertility and crop yields (Mandal *et al.*, 2003). Stagnation or decline in yield of crops has been observed in many cropping systems in many parts of the country, due to nutrient depletion, soil structure deterioration, imbalanced use of plant nutrients, acidification and suboptimal addition of micronutrients and fertilizers to soil. It is also, well established

that chemical fertilizers or micronutrients alone cannot sustain the desired levels of crop production under continuous cropping as observed in many long term fertilizer experiments (Singh and Wanjari, 2013).

Agricultural sustainability is influenced by a number of factors, particularly soil quality. Understanding soil quality is very important as it directly influences crop production (Statish *et al.*, 2016). Soil quality research has focused on the linkages among management practices and observable soil characteristics, soil processes and performance of soil functions. Soil quality assessment has been suggested as an effective tool for evaluating sustainability of soil and crop management practices (Hussain *et al.*, 1999). Soil quality assessment is purpose oriented and site-specific (Karlen *et al.*, 1994). Soil quality cannot be measured directly but must be inferred from measuring changes in its attributes or attributes of ecosystem referred to as indicators (Sharma *et al.*, 2008).

Maize-wheat is the third most important cropping system after rice-wheat and rice-rice in India, and is grown on about 1.80 million ha each year (Jat *et al.*, 2011). It is also prevalent cropping system adopted in uplands of Uttar Pradesh. Increasing crop productivity, reducing production costs and improving environmental quality are the three inter linked components determining the sustainability of cropping system.

## Materials and Methods

A field experiment was conducted at Pot house of the Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur for two consecutive year of 2016-17 in *kharif* season and 2017-18 in *rabi* seasons in micro plots. The investigation consisted of 9 treatments viz. Control, N<sub>(150)</sub>,

$N_{(150)} + P_{(75)}$ ,  $N_{(150)}+P_{(75)}+K_{(75)}$ ,  $N_{(150)}+P_{(75)}+K_{(75)}+S_{(60)}$ ,  $N_{(150)}+P_{(75)}+K_{(75)}+Zn_{(5)}$ ,  $N_{(150)}+P_{(75)}+K_{(75)}+S_{(60)}+Zn_{(5)}$ ,  $N_{(150)}+P_{(75)}+K_{(75)}+S_{(60)}+Zn_{(5)}+Fe_{(10)}$  and  $N_{(150)}+P_{(75)}+K_{(75)}+S_{(60)}+Zn_{(5)}+Fe_{(10)}+Az$  which were replicated four times in randomized block design (RBD). Maize (*cv*-Azad Kamal) and wheat (*cv*. PBW-343) were taken as test crops. The soil of experimental farm was silty clay loam in texture, neutral in reaction (pH 7.8), medium in organic carbon (4.0 g kg<sup>-1</sup>) with 180, 10.11 and 170.0 kg ha<sup>-1</sup> of available N, P and K, respectively.

Nine treatment combinations were replicated four times in RBD. Surface (0-15cm) and subsurface (15-30cm) soil samples taken after the harvest of wheat (*rabi*, 2017-18) were analysed for pH, organic carbon, cation exchange capacity, available N, P and K using standard analytical methods. Besides, different fractions of N, P, K, S, Zn and Fe were also determined in the soil samples taken after the wheat harvest (2017-18) and the composite soil samples drawn from adjacent fallow plots. Productivity of maize (2016-17) and wheat (2017-18) was also recorded.

## Results and Discussion

### Maize

#### Number of cobs plant<sup>-1</sup>

Table 1 indicated that the number of cobs plant<sup>-1</sup> takes important role of yield production. The application of  $N_{(150)}+P_{(75)}+K_{(75)}+S_{(60)}+Zn_{(5)}+Fe_{(10)}+Az$  was obtained maximum number of cobs plant<sup>-1</sup> as compared to control which was 26.3 and 15.6 percent higher during first and second year. It ranged varied from 1.09 to 1.48 during first year and 1.29 to 1.53 during second year under control to  $N_{(150)}+P_{(75)}+K_{(75)}+S_{(60)}+Zn_{(5)}+Fe_{(10)}+Az$ , respectively. Similar results have been collaborated with Itnal and Palled

(2001), Ma *et al.*, (2007) and Owla *et al.*, (2015).

#### Number of grains cob<sup>-1</sup>

The number of grains cob<sup>-1</sup> (Table 1) was increased with increasing doses of fertilizers and it's varied from 114.25 to 19.76 during first year and 14.31 to 19.95 during second year. The number of grains cob<sup>-1</sup> was obtained significantly maximum with the application of  $N_{(150)}+P_{(75)}+K_{(75)}+S_{(60)}+Zn_{(5)}+Fe_{(10)}+Az$  which was 28% higher over control as per mean basis. In addition of S, Zn and Fe with 150:75:75 NPK increased higher number of grains cob<sup>-1</sup> as compared to alone 150:75:75 NPK which was 12.43% lower than combined application. It helps in chlorophyll synthesis and plays an important role in N metabolism thereby resulting into increased uptake of N by the plants. These results are in close conformity to the findings of Nanjappa *et al.*, (2001), Wagh (2002) and M. Ayub *et al.*, (2002).

#### Cob length and cob width

Results of cob length presented in Table 1 indicated that cob length and width provide suitable place to adjustment for grains setting which will directly affected to yield productivity. The effects of nutrients were responded similar in respect of cob length and width during both of the years. The cob length and width was recorded significantly maximum with the application of  $N_{(150)}+P_{(75)}+K_{(75)}+S_{(60)}+Zn_{(5)}+Fe_{(10)}+Az$  (22.9 and 3.87 cm, respectively) which was significantly superior over all the nutrient management. All the treatments responded higher cob length and width in comparison to control. When micronutrients sulphur, zinc and iron combined with 150 N: 75 P: 75 K enhanced 9.04% cob length and width over control. This might be due to all micro nutrient provide essential component to increase both

parameters. Similar results have also been reported by Singh and Brar (2006) and Jena *et al.*, (2013).

### Test weight

The test weight represented in Table 1 as weight of 100 grain in gram varied from 20.31 to 32.44 and 20.90 to 33.08 in control and N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(50)</sub>+Fe<sub>(10)</sub>+Az during first and second year, respectively. This treatment gave 37% higher test weight over control. This indicated that nutrient application in balanced proportion resulted in enhancing the process of grain setting and filling process and production of maize grain. This might be due to combined application initiates the activity absorption and photosynthesis during grain formation. Similar results have been reported by Sahoo and Mahapatra (2004) and Rashid and Iqbal (2012).

### Yield

The yield data reported in Table 1. Among the application of N<sub>150</sub> to 150:75:75 NPK the grain yield was enhanced about 20 percent. In addition 150:75:75 NPK added with S or Zn alone or combined S+Zn caused significantly increased grain yield 7% and 4% over alone application of Zn and S with NPK Further, Combined application of S, Zn and Fe with 150:75:75 NPK, 51.16% higher over control treatment in respect of grain yield.

During second year, the grain yield was ranged between 15.76 and 33.23 q ha<sup>-1</sup> with general mean 24.49 q ha<sup>-1</sup>. Among N<sub>150</sub> to 150:75:75 NPK levels, 150:75:75 NPK levels gave significantly higher yield over N<sub>150</sub> to tune about 19.23% in grain yield. The micro nutrients viz. S, Zn and Fe added with 150:75:75 NPK level enhanced 52.57% grain yield over control. The alone micro nutrient S

or Zn or S+Zn with 150:75:75 NPK level, the N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(5)</sub> gave significantly 7 and 4 percent higher over N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub> and N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+Zn<sub>(5)</sub>. The highest yield attributes of maize crop *i.e.*, number of cobs plant<sup>-1</sup>, number of grain cob<sup>-1</sup>, cob length and cob width as well as test weight obtained with the application of treatment 9 (N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(50)</sub>+Fe<sub>(10)</sub>+Az) during both year. These results are in close conformity to the findings of Zhang *et al.*, (2011) and Almeida H.J. *et al.*, (2015).

### Wheat

#### Number of grains plant<sup>-1</sup>

The number of grains plant<sup>-1</sup> was takes important role of yield production and presented in Table 2. The application of N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(50)</sub>+Fe<sub>(10)</sub>+Az was obtained maximum number of grains plant<sup>-1</sup> as compared to control which was 8.83 and 8.84 percent higher during first and second year. Its ranged varied from 42.23 to 46.32 during first year and 42.26 to 46.36 during second year under control to N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(50)</sub>+Fe<sub>(10)</sub>+Az, respectively. The application of 150:75:75 NPK was 2.47% higher over alone 150 N. Similar results have been collaborated with Itnal and Palled (2001), Ma *et al.*, (2007) and Owla *et al.*, (2015).

#### Test weight

Results on Table 2 revealed that the test weight was increased with increasing doses of fertilizers and it's varied from 29.93 to 33.49 g during first year and 30.26 to 33.51 g during second year. The number of test weight was obtained significantly maximum with the application of N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(50)</sub>+Fe<sub>(10)</sub>+Az which was 10.63% and 9.69% higher over control during both the year.

**Table.1** Effect of different treatment on yield and yield attributes along with benefit-cost ratio of maize crop during both of the year

Treatments combination	No. of cob plant <sup>-1</sup>		No. of grains cob <sup>-1</sup>		Cob length (cm)		Cob width (cm)		Test weight (g)		Grain yield (q/ha)		B:C ratio	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
<b>Control</b>	1.09	1.29	14.25	14.31	13.42	14.62	3.51	3.53	20.31	20.90	15.24	15.76	1.08	1.14
<b>N<sub>(150)</sub></b>	1.29	1.39	15.86	15.79	13.96	14.91	3.56	3.58	21.87	22.04	19.99	21.12	1.36	1.46
<b>N<sub>(150)</sub> + P<sub>(75)</sub></b>	1.31	1.39	16.53	16.93	14.68	15.72	3.62	3.63	23.63	24.05	24.37	25.82	1.51	1.62
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub></b>	1.32	1.40	17.21	17.56	14.79	15.87	3.67	3.69	24.95	25.61	24.95	26.15	1.47	1.57
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub></b>	1.34	1.43	17.98	18.97	15.83	16.53	3.72	3.74	26.84	26.57	25.56	26.81	1.41	1.51
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+Zn<sub>(5)</sub></b>	1.35	1.42	18.82	18.21	16.94	16.53	3.75	3.78	26.23	27.34	26.28	27.58	1.50	1.60
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(5)</sub></b>	1.39	1.48	19.46	19.56	17.31	17.68	3.79	3.81	27.74	28.24	27.41	28.71	1.43	1.52
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(5)</sub>+Fe<sub>(10)</sub></b>	1.44	1.52	19.87	19.87	20.48	22.14	3.82	3.85	31.15	32.25	29.93	31.63	1.48	1.59
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(50)</sub>+Fe<sub>(10)</sub>+Az</b>	1.48	1.53	19.76	19.95	22.45	23.54	3.86	3.89	32.44	33.08	31.21	33.23	1.53	1.60
<b>SE(m)</b>	<b>0.066</b>	<b>0.036</b>	<b>0.875</b>	<b>0.652</b>	<b>0.822</b>	<b>0.672</b>	<b>0.145</b>	<b>0.132</b>	<b>0.58</b>	<b>0.86</b>	<b>1.048</b>	<b>0.988</b>		
<b>C.D. (P=0.05)</b>	<b>0.204</b>	<b>0.111</b>	<b>2.689</b>	<b>2.005</b>	<b>2.526</b>	<b>2.066</b>	<b>NS</b>	<b>NS</b>	<b>1.77</b>	<b>2.64</b>	<b>3.077</b>	<b>2.902</b>		

**Table.2** Effect of different treatment on yield and yield attributes along with benefit-cost ratio of wheat crop during both of the year

Treatments combination	No. of grains plant <sup>-1</sup>		Test weight (g)		Grain yield (q/ha)		B:C ratio	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
<b>Control</b>	42.23	42.26	29.93	30.26	23.59	23.84	1.27	1.28
<b>N<sub>(150)</sub></b>	42.96	42.93	29.98	30.32	27.67	28.19	1.46	1.51
<b>N<sub>(150)</sub> + P<sub>(75)</sub></b>	43.56	43.59	30.44	30.62	39.38	39.41	1.89	1.94
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub></b>	44.05	44.08	30.46	30.92	43.58	43.63	1.99	2.04
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub></b>	44.15	44.18	30.97	31.05	50.68	50.74	2.12	2.18
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+Zn<sub>(5)</sub></b>	45.32	45.36	31.50	31.90	54.28	54.54	2.45	2.52
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+ Zn<sub>(5)</sub></b>	46.08	46.12	31.76	32.15	54.84	54.86	2.27	2.34
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(5)</sub>+Fe<sub>(10)</sub></b>	46.15	46.18	32.38	32.85	55.37	55.70	2.19	2.27
<b>N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub> +S<sub>(60)</sub>+Zn<sub>(50)</sub>+Fe<sub>(10)</sub>+Az</b>	46.32	46.36	33.49	33.51	58.76	59.76	2.29	2.40
<b>SE(m)</b>	<b>1.12</b>	<b>1.18</b>	<b>0.832</b>	<b>1.014</b>	<b>2.12</b>	<b>2.09</b>		
<b>C.D. (P=0.05)</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>6.21</b>	<b>6.15</b>		

In addition of S, Zn and Fe with 150:75:75 NPK increased higher number of test weight as compared to alone 150:75:75 NPK which was 1.75% lower than combined application on the mean basis. Sulphur, Zinc and iron also enhances the absorption of essential nutrients by increasing CEC of roots. These results are in close conformity to the findings of Nanjappa *et al.*, (2001), Wagh (2002) and Ayub *et al.*, (2002).

### Grain yield

The grain yield was varied from 23.59 and 58.76 q ha<sup>-1</sup> with a mean value of 41.17 q ha<sup>-1</sup> during 2016-17. Among the application of N<sub>150</sub> to 150:75:75 NPK the grain yield was enhanced about 35.94 percent over N<sub>150</sub>. In addition 150:75:75 NPK added with S or Zn alone or combined S+Zn caused significantly increased grain yield 25.83% over alone application NPK. Further, Combined application of S, Zn and Fe with 150:75:75 NPK, 59.85% higher over control treatment in respect of grain yield. During second year, the grain yield was ranged between 23.84 and 59.76 q ha<sup>-1</sup> with general mean 41.80 q ha<sup>-1</sup>. Among N<sub>150</sub> to 150:75:75 NPK levels, 150:75:75 NPK levels gave significantly higher yield over N<sub>150</sub> to tune about 35.38% in grain yield. The micro nutrients viz. S, Zn and Fe added with 150:75:75 NPK level enhanced 60.10% grain yield over control. The highest yield attributes of wheat crop *i.e.*, number of grains plant<sup>-1</sup>, test and yield obtained with the application of treatment<sup>9</sup> (N<sub>(150)</sub>+P<sub>(75)</sub>+K<sub>(75)</sub>+S<sub>(60)</sub>+Zn<sub>(50)</sub>+Fe<sub>(10)</sub>+Az) during both year. These results are in close conformity to the findings of Zhang *et al.*, (2011) Almeida *et al.*, (2015) and Liu H. *et al.*, (2016).

### Economics

Benefit: cost ratio range was varied between 1.08 and 1.14 to 1.53 to 1.62 in maize and 1.27 to 1.28 to 2.45 to 2.52 in wheat during

first and second year of observations. All the application which was applied over maize and wheat crop increased grain and stover that of enhanced the benefit: cost ratio as compared to control treatment where not applied any nutrient management practices during both of the years. Results in this study are agreement with those of following workers Kachroo and Razdan (2006) and Thirupathi *et al.*, (2016).

There was a significant build-up in available phosphorus and organic carbon, decline in available nitrogen and available potassium through integrated use of inorganics and micro nutrients for the years. Integrated use of inorganics and micro nutrients has sustained the crop yields. On the other hand, use of recommended dose of nutrients through inorganic fertilizers though sustained the yields, but does not improved the soil physical, chemical and microbiological properties to the extent of the combined use of the micro nutrients and inorganics.

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**How to cite this article:**

Ashok Kumar, R. K. Pathak, A. K. Sachan, Hanuman Prasad Pandey, Manish Rao and Lalit Krishna Yadav. 2019. Response of Chemical Fertilizers and Micronutrients on Yield, Yield Attributes and Economics under Maize-Wheat Cropping System. *Int.J.Curr.Microbiol.App.Sci*. 8(12): 931-939. doi: <https://doi.org/10.20546/ijcmas.2019.812.119>