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Yernam Sowjanya
M.Sc. Student, School of Agriculture, ITM University Gwalior, Madhya Pradesh, India

Nikita Nehal
Assistant Professor, School of Agriculture, ITM University Gwalior, Madhya Pradesh, India

SS Tomar
Dean, School of Agriculture, ITM University Gwalior, Madhya Pradesh, India

Lokendra Singh Gurjar
M.Sc. Student, School of Agriculture, ITM University Gwalior, Madhya Pradesh, India

Sandhya
M.Sc. Student, School of Agriculture, ITM University Gwalior, Madhya Pradesh, India

Corresponding Author:
Yernam Sowjanya
M.Sc. Student, School of Agriculture, ITM University Gwalior, Madhya Pradesh, India

Effect of nitrogen and phosphorous levels on yield and economics of maize (*Zea Mays* L.)

Yernam Sowjanya, Nikita Nehal, SS Tomar, Lokendra Singh Gurjar and Sandhya

Abstract
Field experiment was conducted during the *kharif* season of 2019-20 at Crop Research Centre (CRC), School of Agriculture, ITM University Gwalior, Madhya Pradesh on sandy loam soils with 3 levels of nitrogen (0, 60 and 120 kg ha^{-1}) and 3 levels of phosphorus (0, 40 and 80 kg ha^{-1}) in Factorial randomized block design with three replications. Results indicated that the increasing doses of nitrogen and phosphorus increased the grain and biological yield and maximum value was noted with 120 kg Nitrogen combined with 80 kg Phosphorus ha^{-1}. This treatment combination was also recorded the maximum higher net monetary returns (Rs 53088 ha^{-1}) and highest B: C ratio (3.16) under present study.

Keywords: Maize, nitrogen, phosphorus, biological and grain yield

Introduction
Maize (*Zea mays* L.) is under cultivation since prehistoric time in India and widely cultivated in more than 150 countries of the world including tropical and temperate regions. Maize is the American Indian word for corn means literally "that which sustains life". It is referred as the "Miracle crop" one of the most important cereal grains grown world-wide in a wider range of environments because of its greater adaptability and its higher yield potential than any other cereal crop. The potentiality of maize manifested in the form of growth, grain yield and yield attributes is remarkably affected by various biotic and abiotic factors, of which nutrient management is prime one. Maize has better yield response to fertilizers due to which a trend of application of heavy doses of chemical fertilizers to crop is observed. It is generally observed that maize fails to produce worthwhile grain yield in plots without fertilizer application. Chemical fertilizer cannot be avoided completely since they are the potential sources of high amount of nutrients in easily available forms. The productivity of maize largely depends on optimal management of inputs such as nitrogen (N) and water (Kumar and Singh, 2003) [3]. Phosphorus (P) is one of the major essential macro-elements required for maximizing crop growth and production. Phosphorous fertilization improves the metabolic and physiological process of plant. Generally, phosphorus is the second crop limiting nutrient in most of the soils. Phosphorus is needed for growth, utilization of sugar and starch, photosynthesis, metabolic process which leads to higher yield potential (Ayub *et al*., 2002) [1]. Keeping in views the present study was carried out.

Materials and Methods
A field experiment was conducted at the Agriculture Research Farm, School of Agriculture, ITM University, Gwalior, (M.P.) during the year 2019-20. The experimental soil was sandy clay loam in texture and normal to reaction and low in organic carbon content (0.42 %). The available N, P & K was 188.2, 15.4 & 242.4 kg ha^{-1} respectively. Total nine treatment 3 levels of nitrogen i.e. 0, 60 and 120 kg ha^{-1} and 3 levels of phosphorus i.e. 0, 40 80 kg ha^{-1} were laid out in randomized block design with three replications. Maize variety Chetak was sown in rows at 60 cm apart using 20 kg seed ha^{-1} on June 20, 2019. Half of the recommended dose of nitrogen and full of phosphorus and potassium were applied at the time of sowing. Remaining half dose of N was applied one month after sowing. The nitrogen and phosphorus was applied as per treatments. The source of nitrogen and phosphorus was Urea and Dia Ammonium Phosphate (DAP). All the agronomic practices except those under study were kept normal and uniform for all the treatments. The data gathered in each observation were statistically analyzed using analysis of variance technique and significant differences among treatments mean were tested using least significant difference (LSD) test at 5% probability (Panse and Sukhatme, 1985).

Results and Discussion

Effect of nitrogen

Growth and yield attributes characters

The application of different levels of nitrogen increased almost all growth and yield attributing characters significantly; however, the trend of increase was towards positive direction. The increasing level of nitrogen up to 120 kg ha^{-1} increase the plant height and number of leaves $plant^{-1}$ significantly at harvest stage. A maximum value was observed with 120 kg N ha^{-1} which was significantly higher to control and 60 kg N ha^{-1}. Application of 120 kg N ha^{-1} showed the best results in different yield attributes component i.e. Number of cobs $plant^{-1}$, cob length and number of kernel per cob which was significantly higher over control and 60 kg N ha^{-1}. Application of 60 kg N ha^{-1} also recorded significantly higher growth and yield attributes parameters as compared to control. Availability of higher nutrition to the growing plant might have resulted in better growth of plant resulted in terms of higher plant height and yield attributing characters. Similar results of increased plant height and yield attributing characters with higher doses of nitrogen and phosphorus, fertilizers were reported by Mahesh *et al.* (2010) [4].

Yield parameters

Application of nitrogen significantly increased the grain and biological yield with N levels up to 120 kg ha^{-1}. Application of 120 kg N ha^{-1} significantly increased the grain yield by 69.6 and 15.0% over control and 60 kg N ha^{-1}, respectively. Maximum grain (46.95 q ha^{-1}) and biological yield (104.48 q ha^{-1}) was observed with the application of 120 kg N ha^{-1} which was significantly higher to control and 60 kg N ha^{-1} treatments. Under different levels of nitrogen, harvest index was noted in the range of 40.22 to 44.91 per cent. Maximum harvest index (44.91%) was observed with 120 kg N ha^{-1} which was significantly higher to control but was at par with 60 kg N ha^{-1} treatments. Application of 60 kg N ha^{-1} also recorded significantly higher harvest index as compared to control. Since N is the major structural constitute of cells, as N level increased, the rate of vegetative and reproductive growth also increased in plant due to increase in assimilating surface of plant as well as total photosynthesis. In physiological terms, the grain yield of maize is largely governed by source (photosynthesis) and sink (grain) relationship as it directly related to N. These resulted in more grain yield when N was higher. This might be due to the fact that higher levels of N led to adequate supply of nutrients to the plant resulting in better growth which in turn led to better physiological process and movement of photosynthates to sink (Paramasivan *et al*. 2011) [8]. Singh *et al.* (2000) indicated that grain and stover yield increased with the increase in nitrogen level from 0-200 kg/ha. Ullah *et al.* (2007) [11] also reported the increased grain and stover yield with increasing nitrogen levels.

Effect of phosphorus

Growth and yield attributes characters

Application of phosphorus recorded significantly higher taller plant and higher number of leaves as compared to control. Maximum height and number of leaves were noted with 80 kg P_2O_5 ha^{-1} treatment but was statistically at par with 40 kg P_2O_5 ha^{-1} levels. The yield attributes *viz*. Number of cobs $plant^{-1}$, cob length and number of kernel per cob increased due to increasing levels of phosphorus. Maximum values were observed with 80 kg P_2O_5 ha^{-1} but was at par with 40 kg P_2O_5 ha^{-1} levels and both levels were significantly higher to control. The findings confirm the results of by Maqsood *et al.* (2001) [5] and Khan *et al*. (2014) [2].

Yield parameters

Application of phosphorus significantly increased the grain and biological yield with P levels up to 80 kg ha^{-1}. Application of 80 kg P_2O_5 ha^{-1} significantly increased the grain yield by 24.5 and 10.8% over control and 40 kg P_2O_5 ha^{-1}, respectively. Maximum grain (42.68 q ha^{-1}) and biological yield (95.24 q ha^{-1}) was observed with the application of 80 kg P_2O_5 ha^{-1} which was significantly higher to control and 40 kg P_2O_5 ha^{-1} treatments. Under different levels of phosphorus, harvest index was noted in the range of 42.05 to 44.66 per cent. Maximum harvest index (44.66%) was observed with 80 kg P_2O_5 ha^{-1} which was significantly higher to control and 40 kg P_2O_5 ha^{-1} treatments. This might be due to more accumulation of amino acids and amide substances and their translocation to reproductive organs which influenced growth and yield due to application of phosphorus. Similar results were also reported by Sharma *et al.* (2003) [9] and Mahala *et al.* (2006).

Interaction effect of nitrogen and phosphorus

It is revealed from table-3 that the different treatment combination of nitrogen and phosphorus, maximum grain (51.20 qha^{-1}) and biological yield (110.95 q ha^{-1}) was obtained with Nitrogen @ 120 kg ha^{-1} with combined application of Phosphorus @ 80 kg ha^{-1} (N_2 P_2) followed by N_2 P_1 (120 kg N x 40 kg P_2O_5) with 45.77 and 103.58 q ha^{-1} grain and biological yield. The grain yield is a cumulative effect of different growth and yield attributing characters. Significant increase in grain yield was recorded with incremental N and P levels. The linear increase in grain yield could be observed with the increasing levels of N and P. The probable reason may be that the increasing N and P levels resulted in greater accumulation of carbohydrates, protein and their translocation to the productive organs, which in turn, improved all growth and yield attributing characters, resulting more grain yield. The findings confirm the results of Maqsood *et al.* (2001) [5] and Sharar *et al.*, (2003) [9] and Mukhtar *et al.* (2011) [6].

Economics

The results (Table-2) revealed the maximum net return was found under 120 kg N ha^{-1} followed by 60 kg N ha^{-1} whereas, maximum B:C ratio (3.07) was obtained under 12 kg N ha^{-1} followed by 60 kg N ha^{-1} treatment with 2.83 B: C ratio. This may be because of the difference in yield between 120 and 60 kg N ha^{-1} was significantly and low difference between cost of cultivation of 120 and 60 kg N ha^{-1}. Under different levels of phosphorus, maximum net return and B:C ratio obtained under 80 kg P_2O_5 ha^{-1} followed by 40 kg P_2O_5 ha^{-1}. This may be because of the difference in yield between 80 and 40 kg P_2O_5 ha^{-1} was significantly differ. It is revealed from table-3 that the different treatment combination of nitrogen and phosphorus, maximum net return (Rs. 53088/-ha) and B:C ratio (3.16) was obtained with Nitrogen @ 120 kg ha^{-1} with combined application of Phosphorus @ 80 kg ha^{-1} (N_2 P_2) followed by N_2 P_1 (120 kg N x 40 kg P_2O_5) with 50298 Rs./ha net return and 3.03 B:C ratio.

Table 1: Effect of different levels of nitrogen and phosphorus on growth and yield attributes parameters of maize at harvest

Treatment	Plant height (cm)	Number of leaves plant^{-1}	Cob length (cm)	Number of cobs plant^{-1}	Number of kernels cob^{-1}
Nitrogen levels (N)					
N_0 : Control	153.21	13.38	10.82	1.11	280.27
N_1 : 60 kg N ha^{-1}	173.52	14.60	12.09	1.33	294.18
N_2 : 120 kg N ha^{-1}	178.39	15.84	12.63	1.53	342.62
S.E m.±	2.30	0.22	0.14	0.05	4.66
C.D. (5%)	6.75	0.65	0.41	0.15	13.67
Phosphorus levels (P)					
P_0 : Control	157.60	14.11	11.35	1.22	293.82
P_1 : 40 kg P_2O_5 ha^{-1}	172.60	14.80	11.90	1.33	305.64
P_2 : 80 kg P_2O_5 ha^{-1}	174.91	14.91	12.29	1.42	317.60
S.E m.±	2.30	0.22	0.14	0.05	4.66
C.D. (5%)	6.75	0.65	0.41	0.15	13.67

Table 2: Effect of different levels of nitrogen and phosphorus on yield and economical parameters of maize

Treatment	Yield parameters			Economical parameters	
	Grain yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)	Net returns (Rsha^{-1})	B:C ratio
Nitrogen levels (N)					
N_0 : Control	27.69	68.09	40.22	33961	2.39
N_1 : 60 kg N ha^{-1}	40.84	92.07	44.36	43603	2.83
N_2 : 120 kg N ha^{-1}	46.95	104.48	44.91	50971	3.07
S.E m.±	0.70	1.62	0.55	-	-
C.D. (5%)	2.05	4.75	1.61	-	-
Phosphorus levels (P)					
P_0 : Control	34.19	79.66	42.05	40101	2.62
P_1 : 40 kg P_2O_5 ha^{-1}	38.61	89.74	42.78	43158	2.79
P_2 : 80 kg P_2O_5 ha^{-1}	42.68	95.24	44.66	45276	2.89
S.E m.±	0.70	1.62	0.55	-	-
C.D. (5%)	2.05	4.75	1.61	-	-

Table 3: Interaction effect of nitrogen and phosphorus on yield and economical parameters of maize

Treatment combination	Yield parameters		Economical parameters	
	Grain yield (q ha^{-1})	Biological yield (q ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
N_0P_0	19.74	52.24	30800	2.20
N_0P_1	29.17	72.53	34364	2.42
N_0P_2	34.15	79.50	36720	2.55
N_1P_0	38.93	87.84	39976	2.63
N_1P_1	40.91	93.10	44814	2.91
N_1P_2	42.69	95.28	46020	2.95
N_2P_0	43.89	98.90	49528	3.02
N_2P_1	45.77	103.58	50298	3.03
N_2P_2	51.20	110.95	53088	3.16

Conclusion

With a view to draw definite conclusion from the results of present investigation, the grain yield, net returns and B:C ratio have been the major considerations. On the basis of the experimental findings, it is concluded that the application of 120 kg N and 80 kg P_2O_5 ha^{-1} can be recommended for maize in sandy clay loam soil of Gwalior region of Madhya Pradesh.

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