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Research Article

Impact of phosphorus and zinc application and their interactions on yield and uptake of nutrients by maize in vertisols

SARIKA M. PONGDE AND R.M. GHODPADE

ABSTRACT : Field experiment was carried out to study the effect of phosphorus and zinc application and their interactions on yield and uptake of nutrients by maize during *Kharif season* of 2006-2007 at Extra Assistant Director (EAD) Farm, College of Agriculture, Nagpur. Response of maize was found significant due to application of P and Zn. Application of P @ 40, 60 and 80 kg ha^{-1} resulted in increased grain yield to the tune of 11, 18 and 20 per cent, respectively, over no use of P. The highest grain yield of 59.44 q ha^{-1} was obtained with P applied @ 80 kg ha^{-1}. Increasing levels of zinc gave significantly increased grain yield of maize. The highest grain yield 58.10 qha^{-1} was obtained by the application of 20 kg $ZnSO_4$ ha^{-1}. The increase in grain yield of maize was to the extent of 9 per cent with increasing levels from 0 to 20 kg $ZnSO_4$ ha^{-1}. Interaction effect of phosphorus and zinc levels on grain yield revealed significant. The maximum grain yield 61.28 qha^{-1} was recorded with P_{60} Z_{20} combination followed by P_{80} Z_{20} combination 60.77 qha^{-1}. The highest fodder yield (135.55 q ha^{-1}) was obtained with P application of 80 kg ha^{-1} which was found significantly at par with P level receiving 60 kg P ha^{-1} having yield (129.68 q ha^{-1}). With the application of 0 to 20 kg $ZnSO_4$ ha^{-1}, the increase in fodder yield wasfrom 117.72 q $ha^{-1}$to 128.53 q ha^{-1}, which accounted for 5 to 9 per cent. Results regarding the interaction effects of phosphorus and zinc levels on fodder yield indicate that, the higher fodder yield 136.39 q ha^{-1} was obtained with the application of 80 kg P ha^{-1} coupled with 20 kg $ZnSO_4$ ha^{-1}. Highest total uptake of N 165.77 kg ha^{-1}, P 30.71 kg ha^{-1} and K 161.18 kg ha^{-1} were obtained with P applied @ 80 kg ha^{-1}. Treatment receiving 20 kg Zn SO_4 ha^{-1} recorded highest total uptake of N 160.52kg ha^{-1}, P 27.88 kg ha^{-1} and K 155.69 kg ha^{-1}. Treatment combination P_{60} Z_{20} recorded maximum total uptake of N 171.56 kg $ha^{-1}$where as P_{80} Z_{10} recorded total uptake of P 31.22 kg ha^{-1}.

KEY WORDS : Fodder yield, Nitrogen, Phosphorus, Vertisols, Zinc

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INTRODUCTION

Maize (*Zea mays* L.) is an important crop among the cereals in India. It is also known as "Queen of Cereals". It is one of the important food, fodder, industrial and table purpose crop and fetches very good price in the market. Maize is an exhaustic nature and requires balanced supply of major plant nutrients on most of the soils. It responds well to various agronomic practices and has capacity for bulk production, in short span of 90-110 days. It can be successfully grown in area receiving an annual rainfall of 60mm provided it should be well distributed throughout the growth period. It may tolerate an annual rainfall of 250-400 mm. Thus, there is tremendous scope to exploit its production potential in Maharashtra and Vidarbha region with rich natural resources.

MEMBERS OF RESEARCH FORUM

Address of the Correspondence :
SARIKA M. PONGDE, Agro-ecology and Environment Centre, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, AKOLA (M.S.) INDIA
Email: pongdesarika@gmail.com

Address of the Coopted Authors :
R.M. GHODPADE, College of Agriculture, NAGPUR (M.S.) INDIA

An adequate supply of phosphorus early in plant life is important in laying down the primordial for the reproductive parts of plants. Phosphorus stimulates the early root development and growth thereby helping to establish seedlings quickly and improving the quality of food grain (Yawalkar *et al*., 2002).

Zinc is now been reported as the third most important limiting nutrient element in crop production after N and P. Under Zn deficiency condition, flowering and yield are reduced and growth period is prolonged resulting in delayed maturity and quality of the crop may also suffer. In order to ameliorate the zinc deficiency in soils as well as to meet up the crop requirement for obtaining high yield of the field crops, the application of zinc fertilizers in soils is highly economic and profitable. Among the micronutrients, zinc is predominant in almost all types of soils in country (Anonymous, 2004). Vertisols in Vidarbha were deficient in P and Zn; hence, the study on effect of P and Zn on yield and uptake of nutrients by maize in vertisols was initiated.

EXPERIMENTAL METHODS

The field experiment was laid out in Factorial Randomized Block Design with 4 levels of phosphorus (0, 40, 60 and 80 kg P_2O_5 ha^{-1}) and three levels of zinc (0, 10 and 20 kg $ZnSO_4$ ha^{-1}) and their combinations. The experimental site was clay in texture, having organic carbon 4.2 kg ha^{-1}, available N 188.0 kg ha^{-1}, P 10.18 kg ha^{-1}, K 403.0 kg ha^{-1} and $CaCO_3$ 9.03 per cent. Soil was significantly alkaline in reaction having pH 7.8. A recommended dose of 120 kg N ha^{-1} through urea, 40 kg K_2O ha^{-1} through muriate of potash and P_2O_5 were applied through single super phosphate. N was applied to all plots in three split doses *viz.*, 50 % at sowing, 25% at 30 DAS and remaining 25% at 45 DAS (Days after sowing). Full dose of 40 to 80 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} were applied as a basal to all plots. Treatment wise micronutrient in the form of $ZnSO_4$ was mixed in the soil and applied in the soil row wise before start of sowing. Maize variety PKVM-Shatak was sown on 1st July, 2006 with the seed rate of 20 kg ha^{-1}. All the recommended practices were followed. Crop was harvested on the 18th Oct 2006. Plant samples were processed and analysed for major nutrient status by standard analytical techniques (Piper, 1966).

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present study have been discussed in detail under following heads :

Table 1: Grain and fodder yield of maize (qha^{-1}) as influenced by P and Zn levels

Treatments	Grain yield (qha^{-1})				Fodder yield (qha^{-1})			
Levels of phosphorus (kg ha^{-1})								
P_0	49.55				109.49			
P_{40}	54.90				120.57			
P_{60}	58.79				129.68			
P_{80}	59.44				132.55			
'F' test	Sig.				Sig.			
S.E.+	0.612				2.14			
C.D. at 5%	1.95				6.88			
Levels of zinc (kg ha$^{-1)}$								
Z_0	53.30				117.72			
Z_{10}	55.60				122.98			
Z_{20}	58.10				128.53			
'F' test	Sig.				Sig.			
S.E.+	0.530				1.85			
C.D. at 5%	1.69				5.94			
Interaction (PxZi)	P_0	P_{40}	P_{60}	P_{80}	P_0	P_{40}	P_{60}	P_{80}
Z_0	47.15	52.25	55.97	57.86	104.04	115.55	123.25	128.03
Z_{10}	49.85	54.28	58.59	59.69	109.10	119.60	129.98	133.24
Z_{20}	51.67	58.77	61.82	60.77	115.35	126.57	135.80	136.39
'F' test	Sig.				Sig.			
S.E.+	1.06				3.71			
C.D. at 5%	3.40				11.91			

Grain yield:

The result indicates that, (Table 1) response of maize was significant due to P levels as well as Zn application. The highest grain yield of maize 59.44 qha^{-1} was recorded with P applied @ 80 kg ha^{-1} which found at par with P level of 60 kg ha^{-1} (58.79 q ha^{-1}). Application of P @ 40, 60 and 80 kg ha^{-1} resulted in increased grain yield of maize to the tune of 11, 18 and 20 per cent, respectively over no use of phosphorus. This trend indicates that balance use of N, P and K encourages the root formation, growth and development of maize plant. Mehta et *al*. (2005) reported that 60 kg P ha^{-1} increased significantly the grain yield of maize over 20 kg P ha^{-1} representing an increase of 17.26 per cent.

Increasing levels of zinc (Table 1) gave significantly increased grain yield of maize. Highest grain yield of maize 58.10 qha^{-1} was obtained by the application of 20 kg $ZnSO_4$ ha^{-1} .The increase in grain yield of maize was to the extent of 9 per cent with increasing levels from 0 to 20 kg $ZnSO_4$ ha^{-1}. Patil *et al*. (2006) reported that, the increase in grain yield may be due to application of zinc which was related to better utilization of applied N, P and K nutrients.

The interaction effect between phosphorus and zinc (Table 1) levels on grain yield revealed significant. The maximum grain yield 61.28 q ha^{-1} was recorded with P_{60} Z_{20} combination followed by P_{80} Z_{20} combination 60.77 q ha^{-1}, P_{80} Z_{10} 59.69 qha^{-1}, P_{60} Z_{10} 58.59 qha^{-1}, P_{40} Z_{20} 58.77 qha^{-1} and these combinations were found at par with each other. Response of zinc application under P_{60} and P_{80} was more pronounced. The increase in grain yield in these combinations may be due to balance use of N, P and K supplemented by adequate dose of $ZnSO_4$ influenced the growth and development of maize plant. Parthasarthy *et al*. (1984) also reported that, application of 22.5 kg $ZnSO_4$ ha^{-1}+100:60:30 kg NPK ha^{-1} resulted increase in grain to the tune of 8 per cent over control.

Fodder yield:

The highest fodder yield 132.55 qha^{-1} was obtained with P application of 80 kg ha^{-1} which was found significantly at par with P level receiving 60 kg P ha^{-1} having yield 129.68 q ha^{-1}. Application of P fertilizer consisting 40 and 80 kg ha^{-1} recorded 10 and 21 per cent more fodder yield, respectively over no use of phosphorus. Patel *et al*. (2000) observed that, the highest dry matter production 3680 kg ha^{-1} was obtained upon treatment with 60 kg ha^{-1}. Arya and Singh (2000) found that, application of 90 kg P ha^{-1} resulted in significantly more fodder yield of maize.

With the application of 0 to 20 kg $ZnSO_4$ ha^{-1}, the increase in fodder yield was from 117.72 to 128.53 q ha^{-1}, which

Table 2: Uptake of N (kg ha^{-1}) by maize as influenced by different P and Zn levels

Treatments	N uptake (Grain) kg ha^{-1}				N uptake (Fodder) kg ha^{-1}				Total N uptake (G+F) kg ha^{-1}			
Levels of phosphorus (kg ha^{-1})												
P_0	78.95				56.11				135.06			
P_{40}	87.80				62.50				150.30			
P_{60}	94.23				68.66				162.89			
P_{80}	95.45				70.32				165.77			
'F' test	Sig.				Sig.				Sig.			
S.E.±	0.96				1.01				1.03			
C.D. at 5%	3.09				3.55				3.29			
Levels of zinc (kg ha^{-1})												
Z_0	85.21				61.43				146.64			
Z_{10}	88.99				64.36				153.35			
Z_{20}	93.12				67.40				160.52			
'F' test	Sig.				Sig.				Sig.			
S.E.+	0.83				0.95				0.90			
C.D. at 5%	2.68				3.07				2.87			
Interaction (P x Zn)	P_0	P_{40}	P_{60}	P_{80}	P_0	P_{40}	P_{60}	P_{80}	P_0	P_{40}	P_{60}	P_{80}
Z_0	75.04	83.53	89.48	92.79	53.27	59.73	64.99	67.15	128.31	143.20	154.52	160.54
Z_{10}	79.45	86.77	93.87	95.85	55.85	61.96	68.76	70.87	135.30	148.70	162.63	166.72
Z_{20}	82.36	93.09	99.33	97.71	59.20	65.83	72.23	72.34	141.56	158.90	171.56	170.05
'F' test	Sig.				Sig.				Sig.			
S.E.+	1.67				1.91				1.79			
C.D. at 5%	5.34				6.15				5.72			

accounted for 5 to 9 per cent increase in yield. The fodder yield of maize recorded highest under 20 kg $ZnSO_4$ ha^{-1}(128.53 qha^{-1}) and was found at par with 10 kg $ZnSo_4$ ha^{-1} (122.98 qha^{-1}). Shrinivasan (1992) reported that, 30 kg $ZnSO_4$ ha^{-1} shows significantly superior growth and straw yield of maize.

Results regarding the interaction effects of phosphorus and zinc levels on fodder yield indicate that, the higher fodder yield 136.39 qha^{-1} was obtained with the application of 80 kg P ha^{-1} coupled with 20 kg $ZnSO_4$ ha^{-1}. However, this treatment found at par with treatment combinations P_{60} Z_{20}135.80 qha^{-1}, P_{60} Z_{10} 133.24 qha^{-1}, P_{60} Z_{10} 129.98 q ha^{-1}. Similar findings on fodder yield of maize between P and Zn rates also reported by Sankhyan and Sharma (1997).

Uptake of nutrient:

Nitrogen uptake:

From the results, (Table 2) it revealed that, significant differences were observed due to various level of phosphorus on nitrogen uptake. Highest total uptake of N 165.77 kg ha^{-1} was obtained by P applied @ 80 kg ha^{-1} which found at par with P_{60} 162.89 kg ha^{-1}. The total uptake of N were increased by 11.28, 20.60 and 22.73 per cent with the application of P @ 40, 60 and 80kg ha^{-1}, respectively over no supply of phosphorus. The favourable effect of phosphorus fertilizer on N uptake might due to better nutritional environment in plant and significant effect on root formation. Mehta *et al.* (2005) found that, the total uptake of N showed 20.87 per cent more when p applied @ 60 kg ha^{-1} over P applied 20 kg ha^{-1}.

The application of different levels of zinc significantly affected the total uptake of N. The highest total uptake of nitrogen 160.52 kg ha^{-1} was found in the treatment receiving zinc @ 20 kg ha^{-1}. Increase in Zn level from 0 to 20 kg ha^{-1} increased the total uptake by 13.88 kg ha^{-1} (9.46 %). This trend indicates that, increased supply of micronutrients encourages the growth and utilization of nutrients.

The interaction effect of phosphorus and zinc total uptake of N was affected significantly. Maximum total N uptake of maize 171.56 kg ha^{-1} was recorded with treatment receiving 60 kg P and 20 kg $ZnSO_4$ ha^{-1} being at par with treatment receiving 80 kg P and 20 kg $ZnSO_4$ ha^{-1}.

Phosphorus uptake:

The results revealed that, (Table 3), total uptake of phosphorus found significantly more in treatment P_{80} (30.71 kg ha^{-1}). The total uptake of P was increased by 13.55, 26.7, and 37.40 per cent with the application of P at the rate of 40, 60 and 80 kg ha^{-1}, respectively over no supply of phosphorus.

Table 3: Uptake of P (kg ha^{-1}) by maize as influenced by different P and Zn levels

Treatments	P uptake (Grain) kg ha^{-1}				P uptake (Fodder) kg ha^{-1}				Total P uptake (G+F) kg ha^{-1}			
Levels of phosphorus (kg ha^{-1})												
P_0	6.96				15.39				22.35			
P_{40}	7.94				17.44				25.38			
P_{60}	8.83				19.49				28.32			
P_{80}	9.53				21.18				30.71			
'F' test	N.S.				Sig.				Sig.			
S.E.±	0.96				0.34				0.65			
C.D. at 5%	-				1.11				2.08			
Levels of zinc (kg $ha^{-1)}$												
Z_0	7.92				17.50				25.42			
Z_{10}	8.33				18.44				26.77			
Z_{20}	8.69				19.19				27.88			
'F' test	Sig.				Sig.				Sig.			
S.E.±	0.08				0.29				0.18			
C.D. at 5%	0.27				0.96				0.57			
Interaction (P x Zn)	P_0	P_{40}	P_{60}	P_{80}	P_0	P_{40}	P_{60}	P_{80}	P_0	P_{40}	P_{60}	P_{80}
Z_0	6.59	7.52	8.33	9.25	14.56	16.63	18.36	20.47	25.15	24.15	26.69	29.72
Z_{10}	7.02	7.81	8.84	9.66	15.38	17.22	19.62	21.56	22.4	25.03	28.46	31.22
Z_{20}	7.28	8.49	9.32	9.69	16.25	18.48	20.5	21.52	23.53	25.76	30.84	31.21
'F' test	Sig.				Sig.				Sig.			
S.E.±	0.17				0.59				0.38			
C.D. at 5%	0.55				1.92				1.21			

Mehta *et al.* (2005) reported that, with the increase in the P from 40 to 60 kg ha^{-1}, there was increase in total uptake of P from 18.32 and 24.42 per cent over P applied @ 20 kg ha^{-1}.

Application of different levels of zinc significantly affected the uptake of phosphorus. The higher total uptake of P 27.88 kgha^{-1} was obtained with zinc receiving 20 kg $ZnSO_4$ ha^{-1}.

The effect of phosphorus and zinc levels and their combinations on total uptake of phosphorus was found significant. Highest total uptake of P 31.22 kg ha^{-1} was noticed under P_{80} Z_{10} treatment combination which was found at par with P_{80} Z_{20} 31.21 kg ha^{-1}. Application of P and Zn enhanced the total P uptake with the level of 20 kg $ZnSO_4$ and 60 kg P or 80 kg P ha^{-1}. It seems to be associated with increased P and Zn availability from the applied P and Zn with an increase in total P uptake. Thus, P and Zn application at 60 or 80 kg and 10 or 20 kg $ZnSO_4$ appeared to have included better root development and beneficial effect on P uptake. The positive effects of Zn addition on P uptake of maize have been reported by Dwiwedi *et al.* (2002).

Potassium uptake:

Data regarding to total uptake of potassium by maize as affected by different phosphorus levels are presented in (Table 4). From the data, it is revealed that, the total uptake of K found significant. The total uptake of K was found maximum 161.18 kg ha^{-1} with P applied @ 60 kg ha^{-1} which found at par with P applied 80 kg ha^{-1} 161.14 kg ha^{-1}. The total uptake was K was increased by 10.16, 20.27 and 20.24 per cent with P applied @ 40, 60 and 80 kg ha^{-1}, respectively over no use of phosphorus.

In respect of zinc levels Z_{20} level recorded highest total uptake of K 155.69 kg ha^{-1} and exhibited significantly superior to the other levels of zinc. Lath (2003) found the positive effect of Zn addition of N, P, K, Cu, Fe, Mn and Zn uptake in maize.

Results regarding the interaction effect of phosphorus and zinc on total uptake of K were found statistically significant. Highest total uptake of K 169.26 kg ha^{-1} was obtained under P_{60} Z_{20} treatment combination followed by P_{80} Z_{10} 164.42 kg ha^{-1}, P_{60} Z_{10} 163.89 kg $ha^{-1}$and P_{80} Z_{20}

Table 4: Uptake of K (kg ha^{-1}) by maize as influenced by different P and Zn levels

Treatments	K uptake (Grain) kg ha^{-1}				K uptake (Fodder) kg ha^{-1}				Total K uptake (G+F) kg ha^{-1}			
Levels of phosphorus (kg ha^{-1})												
P_0	21.69				112.32				134.01			
P_{40}	24.19				123.31				147.5			
P_{60}	26.10				135.08				161.18			
P_{80}	26.75				134.39				161.14			
'F' test	Sig.				Sig.				Sig.			
S.E.±	0.29				2.61				1.43			
C.D. at 5%	0.94				8.40				4.57			
Levels of zinc (kg $ha^{-1)}$												
Z_0	23.57				120.80				144.37			
Z_{10}	24.78				128.04				125.82			
Z_{20}	25.70				129.99				155.69			
'F' test	Sig.				Sig.				Sig.			
S.E.±	0.25				2.26				1.23			
C.D. at 5%	0.81				7.27				3.93			
Interaction (P x Zn)	P_0	P_{40}	P_{60}	P_{80}	P_0	P_{40}	P_{60}	P_{80}	P_0	P_{40}	P_{60}	P_{80}
Z_0	20.63	22.99	24.85	25.83	107.95	118.73	125.55	130.97	128.58	141.72	150.4	156.8
Z_{10}	21.77	24.60	25.95	26.79	114.19	122.39	137.94	137.63	135.96	146.99	163.89	164.42
Z_{20}	22.67	24.98	27.50	27.64	114.81	128.81	141.76	134.58	137.48	153.79	169.26	162.22
'F' test	Sig.				Sig.				Sig.			
S.E. ±	0.50				4.53				2.51			
C.D. at 5%	1.63				14.53				8.03			

162.22 kg ha^{-1} and these combinations were found at par with each other.

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