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Production and Profitability of Maize as Influenced by Different Levels of Nitrogen, Phosphorus and Zinc in Central Plateau Zone of Maharashtra

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Abstract

A field experiment was carried out on clayey soil at the experimental farm, AICRP on integrated farming systems, VNMKV, Parbhani during *kharif* 2014 to evaluate the effect of nitrogen, phosphorus and zinc on yield attributes, yield and economics of maize crop. The experiment was laid out in split plot design comprising two main plot factors (N and Zn) and P as Sub-plot factors. Nitrogen was applied at three levels (100, 125 and 150 kg ha^{-1}), Zinc was applied at two levels (25 and 35 kg $ZnSO_4$ kg ha^{-1}) and phosphorus was applied at three levels (50, 75 and 100 kg ha^{-1}). Application of nitrogen at 150 kg and 125 kg ha^{-1} was found at par for maize grain yield and were significantly superior over 100 kg N ha^{-1}. The application of 25 and 35 kg $ZnSO_4$ ha^{-1} did not affect maize grain yield significantly. Similarly, application of 100 and 75 kg P ha^{-1} were at par in respect to grain yield and was significantly superior over 50 kg P ha^{-1}. Gross monetary returns, net monetary returns and B:C ratio increased with increasing level of N, P and Z except in B:C ratio where 75 kg P ha^{-1} recorded maximum value (2.83). A significant N×P interaction was observed in respect to no. grains cob^{-1} and grain weight plant^{-1}. The interaction effect between nitrogen and zinc was also significant on maize spindle yield.

Keywords: Little millet, organic, inorganic, biofertilizers

1. Introduction

Maize is called as queen of cereal due to its great importance in human, animal diet and high yielding ability. It is the crop of the future as mentioned by the Father of Green Revolution, Renounced Nobel Laureate Dr. Norman E. Borlaug. Maize plays a vital role in ensuring food security as well as nutritional security through quality protein Manan et al. (2013). It has an important role in the industry as more than 35 products of daily use are derived from maize. It is raw material for a no. of products via. Starch, lactic acid, glucose, acetic acid, dextrose, sorbitol, dextrine, high fructose syrup, maltodextrine, germ oil, germ application in industries such as alcohol, textile, paper, pharmaceutical, organ chemical, cosmetics and edible oil. On an average, 1 t maize gives 400 l. ethanol while 1 t sugar beet/sugarcane gives only 100 l. Ethanol. In general, 15 thousand ha area gives 13400 l. ethanol (Kadam, 2008).

Maize is principally a rainy season crop and requires a minimum soil temperature of 13 °C for germination and root development (optimum range 21 °C–27 °C). It response well to warm conditions (optimum of 21 °C–30 °C) as growth increases with temperature up to 30 °C. In Maharashtra, the area and production of maize is about 1.21 mha and 3.98 mt productions with the productivity of 2544 kg ha^{-1} (Anonymous, 2014).

As maize is more exhausting in its demand for growth promoting factors, it is very crucial to determine the optimum rate of nitrogen fertilizer application as exceeding dosage may result in crop lodging, delayed silking, enhanced no. of barren ears, poor grain quality and subsequently, lower grain productivity. Furthermore, in Maharashtra, predominantly in Marathwada region, sorghum (most important staple food crop) is being replaced by maize in *kharif* season. Nitrogen, phosphorus and zinc have been reported as the third most important limiting nutrient elements in crop production. Zinc is the important micro nutrient for cereals particularly maize. Therefore, the knowledge of nitrogen, phosphorus and zinc, their dose, method and application rate must be properly evaluated for maize crop. In view of the above, these study was undertaken.

2. Materials and Methods

The field experiment was conducted at AICRP on integrated farming systems, VNMKV, Parbhani during *kharif,* 2014. The soil of the experimental field was clayey in texture, low in available N (186.42 kg ha^{-1}), medium in available P (17.18 kg ha^{-1}), and high in available K (519.18 kg ha^{-1}) with pH 7.9. A split plot design with three replications for eighteen treatments combinations was followed. Treatments include combinations of various levels of nitrogen, phosphorus and zinc. The levels of nitrogen include 100, 125 and 150 kg ha^{-1} and zinc levels are 25 and 35 kg ha^{-1} in main plot and three phosphorus levels (50, 75 and 100 kg ha^{-1}) in sub-plots. Nitrogen was applied through neem coated urea-46% as treatments^{-1} in two equal splits at sowing (basal) and knee height stage (top dress). The full dose of phosphorus and zinc were applied through single super phosphate (SSP-16%) and Zinc sulphate ($ZnSO_4$-23%) as treatment^{-1} at the time of sowing respectively. A common dose of potassium was applied through muriate of potash at the rate of 75 kg ha^{-1} to all treatment plots at sowing. Fertilizer application was done by peg method. Maize hybrid, RASI-3022 was dibbled along a row spacing of 60×30 cm^2, with a seed rate of 18 kg ha^{-1}. The statistical analysis was done as suggested by Panse and Sukhatme (1967). Cost of cultivation, gross and net monetary returns and B:C ratio was calculated on ha^{-1} basis using the prevailing market prices of input and output. The harvest index, net monetary returns and benefit cost ratio were worked out by using the following equations:

$$\text{HI (\%)}= \frac{\text{Economic yield}}{\text{Biological yield}} \times 100 \text{..........(1)}$$

NMR=GMR-cost of cultivation.......... (2)

B:C=GMR/cost of cultivation.......... (3)

3. Results and Discussion

3.1. Effect on yield attributes

Variations in grain and biological yield can be determined from differences in yield attributes, as yield of maize is a function of yield attributing characters viz., no. of cobs plant^{-1}, cob weight plant^{-1}, husk weight plant^{-1}, spindle weight plant^{-1}, grain rows cob^{-1}, number of grains cob^{-1}, grain weight plant^{-1} and 1000 seeds weight.

The yield attributing characters (Table 1 and 2) stated above were influenced significantly by varying rate of nitrogen. There was a significant variation in yield contributing characters with increasing N rate. Application of 150 kg N ha^{-1} recorded highest values over 125 kg and 100 kg N ha^{-1}, though it was at par with 125 kg N ha^{-1} in some cases. This may be attributed to the beneficial effects of higher levels of N on dry matter accumulation, ultimately reflected in increasing the yield attributing characters, the higher availability of source under the higher N rates created more sink than the lower N rates. These findings are in agreement with reports of Meena et al. (2011).

Yield attributes viz., cob weight plant^{-1}, and grain weight plant^{-1} increased with application of 35 kg $ZnSO_4$ ha^{-1} over 25 kg $ZnSO_4$ ha^{-1}. Zinc is involved in protein synthesis and biosynthesis of Indole 3-acetic acid (a growth hormone, involved in cell division and cell elongation), which may have caused an increase in plant height, no. of leaves, leaf area and dry matter accumulation, resulting in higher yield attributes. These findings are in agreement with Masood et al. (2011). Thousand seeds weight did not vary statistically with increasing Z level, indicating that 25 kg $ZnSO_4$ ha^{-1} was the optimum range. Similar report was observed by Olusegun et al. (2014).

Table 1: No. of cob, cob weight, husk weight and spindle wt. plant^{-1} (g) as influenced by different treatments in maize

Treatments	Yield attributes			
	No. of cobs	Cob wt.	Husk wt.	Spindle wt.
N levels (kg ha^{-1})-main plot				
N_1: 100	1.20	186.62	11.7	15.8
N_2: 125	1.64	224.83	14.3	20.5
N_3: 150	1.72	238.44	15.5	24.8
SEm±	0.06	3.53	0.41	0.63
CD*	0.19	11.1	1.29	1.97
Z levels (kg ha^{-1})-main plot				
Z_1: 25	1.47	210.60	13.4	20.3
Z_2: 35	1.49	223.03	14.2	25.4
SEm±	0.05	2.88	0.34	0.51
CD*	NS	9.05	NS	NS
P levels (kg ha^{-1})-sub plot				
P_1: 50	1.40	206.62	13.2	19.0
P_2: 75	1.48	218.99	13.7	20.9
P_3: 100	1.56	224.82	14.5	21.2
SEm±	0.04	2.22	0.25	0.54
CD*	0.12	6.47	0.73	1.57
Interaction				
N×Z				
SEm±	0.08	4.99	0.58	0.88
CD*	NS	NS	NS	NS
N×P				
SEm±	0.07	3.84	0.44	0.93
CD*	NS	NS	NS	NS
Z×P				
SEm±	0.06	3.14	0.36	0.76
CD*	NS	NS	NS	NS
N×Z×P				
SEm±	0.10	5.44	0.62	1.32
CD*	NS	NS	NS	NS
General mean	1.50	216.74	13.8	20.4

CD*: CD (*p*=0.05)

Perusal of the data revealed that different levels of phosphorus had significant effect on yield attributes of maize.

Table 2: Grain row cob^{-1}, no. of grains cob^{-1}, grain weight $plant^{-1}$ and 1000 seeds weight as influenced by different treatments in maize

Treat-ments	Yield attributes			
	Grain row cob^{-1}	No. of grains cob^{-1}	Grain wt. $plant^{-1}$ (g)	1000 seeds wt. (g)
N levels (kg ha^{-1})-main plot				
N_1: 100	12.21	424.68	138.27	299.81
N_2: 125	13.70	475.11	171.04	301.97
N_3: 150	15.39	536.88	192.03	302.27
SEm±	0.16	4.41	4.94	0.13
CD*	0.51	13.9	15.5	0.42
Z levels (kg ha^{-1})-main plot				
Z_1: 25	13.65	474.68	166.03	300.64
Z_2: 35	13.88	483.09	180.86	300.75
SEm±	0.13	6.24	4.04	0.10
CD*	NS	NS	12.7	NS
P levels (kg ha^{-1})-sub plot				
P_1: 50	13.29	451.43	153.36	300.23
P_2: 75	13.93	481.76	173.06	300.98
P_3: 100	14.10	503.47	187.29	301.18
SEm±	0.19	4.60	4.93	0.07
CD*	0.54	13.4	14.3	0.22
Interaction				
N×Z				
SEm±	0.23	6.24	6.99	0.21
CD*	NS	NS	NS	NS
N×P				
SEm±	0.32	7.97	8.53	0.13
CD*	NS	23.2	24.8	NS
Z×P				
SEm±	0.26	6.51	6.96	0.10
CD*	NS	NS	NS	NS
N×Z×P				
SEm±	0.45	11.27	12.06	0.17
CD*	NS	NS	NS	NS
General mean	13.77	478.89	170.24	300.97

CD*: CD (p=0.05)

Phosphorus application at 100 kg ha^{-1} recorded higher values in husk weight $plant^{-1}$, grain no. cob^{-1} and grain weight $plant^{-1}$ over 75 kg ha^{-1}. A rise in P level increased yield attributing characters as observed. The possible reason could be that higher P level might have resulted in greater assimilates partitioning to the cobs which increase the no. of rows and grains no. cob^{-1} compared with that obtained with lower P level. Amanullah and Muhammad Zakirullah (2010) also report that yield attribute of maize increased with increasing levels of P. Phosphorus being responsible for good root growth directly affected the thousand grain weight because P rate at 50 kg ha^{-1} resulted in the least thousand grain weight. The highest thousand grain weight of 301.18 g was obtained from P rate at 100 kg ha^{-1} but was statistically at par with 75 kg P ha^{-1}. Highest grain weight with higher P level probably may be due to the higher P translocation into the fruiting areas which resulted in highest grain weight (Sushila Sepat and Rai, 2013).

3.2. *Effect on yield*

A significant difference in maize grain yield, husk yield, spindle yield and biological yield ha^{-1} were observed due to different N levels (Table 3). Application of 125 kg N ha^{-1} being on par with 150 kg N ha^{-1} significantly improved grain and stover yield over 100 kg N ha^{-1}. The nitrogen application at 125 kg and 150 kg ha^{-1} recorded (6705.8, 6428.4 and 7161, 6811.2 kg ha^{-1}) grain and stover yield respectively. Maximum husk, spindle and biological yield of (1378.2, 1642.6 and 13866.8 kg ha^{-1}) were obtained by N application at 150 kg ha^{-1} and were significantly superior over 125 kg and 100 kg ha^{-1}.

The increment in grain and biological yield with a rise in N level might be attributed to the optimum utilization of solar light, higher assimilates production due to higher growth character and it conversion to starches resulted in higher yield attributes, biomass and seed yield. Lower N fertilization decreased the grain and stover yield because it affects the no. of endospermatic cell and starch granules in the early post flowering period and also causes the reduction of source assimilation during grain filling period. These results are corroborated with Manan et al. (2013). Harvest index was highest at 150 kg N ha^{-1} (48.4%). It was significantly higher with application of 255 kg N ha^{-1} over 75 kg and 150 kg N ha^{-1} as reported by Olusegun et al. (2014).

Maize grain yield did not differ significantly with different zinc fertility levels. The zinc application @ 35 kg $ZnSO_4$ ha^{-1} recorded a grain yield of (6105.6 kg ha^{-1}) and was at par with (5652.2 kg ha^{-1}) of 25 kg $ZnSO_4$ ha^{-1}. Increasing the amount of Zn applied from (10 to 40 kg ha^{-1}) did not affect grain yield statistically (Olusegun and Chirwa, 2014). However, stover yield and biological yield of maize were significantly superior with 35 kg $ZnSO_4$ ha^{-1}. The highest value of harvest index i.e. 46.7% was noted with 35 kg $ZnSO_4$ ha^{-1}. The result of this research confirms the previous works of Nsanzabaganwa et al. (2014).

Phosphorus levels had significant effect on grain, stover and biological yield of maize. Phosphorus application at 100 and 75 kg ha^{-1} recorded at par higher grain yield of 6126 kg and 6003.2 kg ha^{-1} respectively and were significantly superior over 50 kg ha^{-1} (5716.6 kg ha^{-1}). Further increase in phosphorus from 75 to 100 kg ha^{-1} though increased the grain yield but failed to register statistical significance. In case of stover and biological

Table 3: Grain yield, husk yield, spindle yield, stover yield, biological yield (kg ha^{-1}) and harvest index (%) as influenced by different treatments in maize

Treat-ments	GY	HY	SY	ST*	BY	HI
N levels (kg ha^{-1})-main plot						
N_1: 100	5509.7	766.9	1092.2	6477.8	11987.5	45.9
N_2: 125	6428.4	1127.1	1454.2	6811.2	13299.6	48.3
N_3: 150	6705.8	1378.2	1642.6	7161.0	13866.8	48.4
SEm±	215.9	29.0	28.4	111.1	26.2	-
CD*	679.3	91.2	89.5	323.8	82.3	-
Z levels (kg ha^{-1})-main plot						
Z_1: 25	5652.2	1027.9	1375.6	6692.8	12345.0	45.8
Z_2: 35	6105.6	1153.6	1417.1	6940.6	13046.2	46.7
SEm±	176.3	23.7	23.2	67.3	21.4	-
CD*	NS	74.4	NS	211.6	67.2	-
P levels (kg ha^{-1})-sub plot						
P_1: 50	5716.6	966.3	1299.4	6504.7	12221.3	46.7
P_2: 75	6003.2	1094.7	1413.5	6782.2	12785.4	46.9
P_3: 100	6126.0	1211.2	1476.2	6843.0	12969.0	47.2
SEm±	88.19	35.8	41.2	82.4	27.1	-
CD*	257.0	104.3	120.1	291.2	84.0	-
Interaction						
N×Z						
SEm±	305.4	41.0	40.2	157.1	37.0	
CD*	NS	NS	126.5	NS	NS	
N×P						
SEm±	152.8	62.0	71.4	192.5	65.9	
CD*	NS	NS	NS	NS	NS	
Z×P						
SEm±	124.7	50.6	58.3	116.5	53.8	
CD*	NS	NS	NS	NS	NS	
N×Z×P						
SEm±	216.0	87.6	100.9	272.2	81.2	
CD*	NS	NS	NS	NS	NS	
GM	6009.7	1090.7	1396.4	6776.7	12800.1	46.4

GY: Grain yield; HY: Husk yield; SY: Spindle yield; ST*: Stover yield; BY: Biological yield; HI: Harvest index; CD* : CD (p=0.05); GM: General mean

yield same kind of trend is observed. Harvest index of maize increased up to 100 kg P ha^{-1} (47.2%). The increase in maize yield at higher phosphorus level probably, may be ascribed to the increase in cob number, no. of grains row and no. of grains cob^{-1} as well as heaviest grain weight. A good and optimum supply of phosphorus is associated with increase root growth due to which the plants explore more soil nutrients and water. Chaudhary et al. (2012) observed that increasing phosphorus level enhance maize yield.

3.3. Effect on economic studies

The effect of nitrogen application on GMR and NMR in maize was found significant with different nitrogen levels (Table 4). NMR and B:C ratio increased significantly with each successive

Table 4: Gross and net monetary returns, cost of cultivation (ha^{-1}) and Benefit: Cost ratio of maize as influenced by different treatments

Treatments	GMR (×10^3)	NMR (×10^3)	B:C Ratio	CC (×10^3)
N levels (kg ha^{-1})-main plot				
N_1: 100	73.6	46.7	2.73	26.9
N_2: 125	80.7	53.2	2.92	27.6
N_3: 150	83.2	55.1	2.95	28.2
SEm±	1.8	0.5		
CD (p=0.05)	5.6	1.6		
Z levels (kg ha^{-1})-main plot				
Z_1: 25	77.1	50.2	2.87	26.9
Z_2: 35	78.7	50.3	2.89	27.2
SEm±	1.5	0.4	-	
CD (p=0.05)	NS	NS	-	
P levels (kg ha^{-1})-sub plot				
P_1: 50	73.7	49.1	2.77	26.6
P_2: 75	77.9	50.2	2.83	27.5
P_3: 100	79.2	51.1	2.82	28.1
SEm±	1.6	0.4	-	--
CD (p=0.05)	4.9	1.0	-	--
Interaction				
N×Z				
SEm±	2.5	0.7	-	--
CD (p=0.05)	NS	NS	-	--
N×P				
SEm±	4.5	0.9	-	--
CD (p=0.05)	NS	NS	-	--
Z×P				
SEm±	3.7	0.7	-	--
CD (p=0.05)	NS	NS	-	--
N×Z×P				
SEm±	6.4	1.3	-	--
CD (p=0.05)	NS	NS	-	--
General mean	78.1	50.8	2.85	27.4

GMR: Gross monetary returns; NMR: Net monetary returns; CC: Cost of cultivation increase in N level which was highest (55.1×10^3 ₹ ha^{-1} and 2.95) with 150 kg N ha^{-1}. Manan et al. (2013) also recorded maximum B:C ratio with increasing levels of nitrogen up to 220 kg ha^{-1}.

GMR and NMR were not influenced significantly by different Zn levels. However, the zinc application rate at 35 kg $ZnSO_4$ ha^{-1} recorded higher GMR, NMR and B:C ratio of (78.7×10^3 ₹ ha^{-1}, 50.3×10^3 ₹ ha^{-1} and 2.89) respectively. Effect of Phosphorus on GMR and NMR in maize was significant with all P rates. Statistically, beneficial response was only up to 75 kg P ha^{-1}. The phosphorus application at 75 kg ha^{-1} registered highest B:C ratio of (2.83) over 100 kg and 50 kg P ha^{-1}. It might be due to the beneficial effect of P on improving growth characters, yield attributes, grain yield and stover yield of maize. Singh et al. (2011) observed similar kind of results. Interaction effects on GMR and NMR due to N, P and Zn levels were not evident.

3.4. Interaction effect

A significant N×P interaction (Table 5 and 6) was observed in respect to no. grains cob^{-1} and grain weight $plant^{-1}$. This may account for the higher yield produced by increasing levels of N and P. These results are in agreement with Nsanzabaganwa et al. (2014) who observed a significant N×P interaction. The interaction effect between nitrogen and zinc was also significant on maize spindle yield. The highest maize spindle yield was recorded with 150 kg N ha^{-1} (1573.8 kg ha^{-1}) and 35 kg $ZnSO_4$ (1711.4 kg ha^{-1}). The least yield was registered with 100 kg N ha^{-1} (1024.6 kg ha^{-1}) and among zinc fertility levels with 25 kg $ZnSO_4$ (1159.9 kg ha^{-1}). Owla et al. (2015) corroborate my results of the present study with respect to significant fertility levels interaction.

Table 5: No. of grains cob^{-1} (g) and grain weight $plant^{-1}$ (g) as influenced by N×P interaction in maize

Treatment	No. of grains cob^{-1}			Grain weight $plant^{-1}$		
	P_1	P_2	P_3	P_1	P_2	P_3
N_1	409.21	425.25	439.57	129.3	134.8	151.5
N_2	428.79	486.38	510.15	145.2	168.6	199.3
N_3	516.29	533.65	560.70	186.5	215.9	219.2
SEm±		7.97			8.1	
CD (p=0.05)		23.2			24.2	

Table 6: Spindle yield ha^{-1} as influenced by N×Z interaction in maize

Treatment	No. of grains cob^{-1}	
	Z_1	Z_2
N_1	1024.6	1159.9
N_2	1393.1	1515.3
N_3	1573.8	1711.4
SEm±	40.2	
CD (p=0.05)	126.5	

4. Conclusion

Application of nitrogen @ 150 kg and 125 kg ha^{-1} being at par were significantly superior over 100 kg N ha^{-1} to influence the maize grain yield. Similarly, phophorous @ 100 and 75 kg ha^{-1} being at par were were significantly superior over 50 kg ha^{-1}. The application of 25 and 35 kg $ZnSO_4$ ha^{-1} did not affect maize grain yield significantly. Gross monetary returns, net monetary returns and B:C ratio increased with increasing level of N, P and Z except in B:C ratio where 75 kg P ha^{-1} recorded maximum value (2.83).

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