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EFFECT OF NITROGEN, PHOSPHORUS AND ZINC ON YIELD, UPTAKE BY MAIZE AND POST HARVEST NUTRIENT STATUS IN A VERTSIOL OF MARATHWADA REGION

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ABSTRACT

A field experiment was conducted at Experimental Farm, AICRP on Integrated Farming Systems, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experiment was laid in split plot design comprising two main plot factors *i.e.,* Nitrogen, Zinc and Phosphorus as Sub-plot factor. Nitrogen was taken at three levels (100,125 and 150 kg ha^{-1}), Zinc at two levels (25 and 35 kg $ZnSO_4$ kg ha^{-1}) and Phosphorus at three levels (50, 75 and 100 kg ha^{-1}). Application of 150 kg N ha^{-1}, 100 kg P ha^{-1} and 35 kg Zn ha^{-1} recorded significantly higher grain yield (6705.8 kg ha^{-1}) and Stover yield (7161 kg ha^{-1}). The uptake of the nutrients *viz.,* Nitrogen (167.41 kg ha^{-1}), Phosphorus (49.72 kg ha^{-1}) and Zinc (17.4 kg ha^{-1}) as well as nutrient status post harvest of maize was highest with the 150 kg N ha^{-1}, 75 kg P ha^{-1} and 35 kg $ZnSO_4$ ha^{-1}. But the results were at par with the 125 kg N ha^{-1}, 75 kg P ha^{-1} and 25 kg $ZnSO_4$ ha^{-1}. From the results, it was concluded that the maximum yield, uptake by maize & post harvest nutrient status could be achieved by judicious application of chemical fertilizers (N, P & Zn).

INTRODUCTION

Maize (*Zea mays* L.) is one of the most crucial and strategic crops in the world. It is ranked 3rd to wheat and rice in area under production but productivity, it surpass all cereals. Maize has the highest genetic yield potential among cereals and is refereed as the "Queen of Cereal". It is cultivated in 160 countries on almost 150 m ha and contributes 36 % to the world total grain production. Also plays a vital role in ensuring food security through quality protein (Rawool, 2004).In Maharashtra, the area and production of maize is about 0.58 million hectares and 1.15 million tonnes production with the productivity of 2066 kg ha^{-1} (Anonymous, 2009). The productivity of maize in Marathwada is low (1983 kg ha^{-1}) as compared to Maharashtra *i.e.* 2066 kg ha^{-1}.

The main challenge before India is to increase the production of quality food in a sustainable manner and feeding the country's large population and increasing the income of the farmer. The requirements of fertilizers in maize are important for the early growth and total production of yield. Maize requires heavy feeding for its potential production of yield. Indiscriminate use of inorganic fertilizers leads to nutrient imbalance in soil causing ill effect on soil health and micro flora (Choudhary *et al.,* 2015). In addition to the above, in Maharashtra, lower yields are recorded due to lack of adoption of improved technology, particularly in optimal use of fertilizer at farmer levels and poor economic conditions of the farmers.

Moreover, the availability of phosphorus is influenced by many factor of which pH is the predominant one, particularly in black cotton soil of Maharashtra. Phosphorus use efficiency in black cotton soil ranges from 18-20% and hence the importance to find out the optimum level of phosphorus for maize under edapho-ecological conditions of the Maharashtra regions to increase the phosphorus use efficiency. In Maharashtra, wide spread zinc deficiency is observed in major soil groups (Malewar, 1989). Zinc deficiency causes loss in yield up to 50% in maize (Parthasanthy *et al*., 1984). Therefore, the knowledge of nitrogen, phosphorus and zinc, their dose, method and application rate must be properly evaluated for maize crop as information on the influence of these nutrients levels on yield components and yield of maize is lacking in Marathwada region.

Manan *et al*. (2013) concluded that significant increase in grain yield was found with application of increased level of Nitrogen, Phosphorus up to 60% higher than the control. Therefore, application of ample quantities of plant nutrients is a key aspect of increasing maize productivity. So, the knowledge of Nitrogen, Phosphorus and Zinc, their dose and application rate must be properly evaluated for maize crop as information on the influence of these nutrients level is lacking in Marathwada region. Keeping in this view, the present investigation was planned to assess the effect of Nitrogen, Phosphorus and Zinc in terms of yield, nutrient uptake and post harvest nutrient status.

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}) and low in available Zn (1.42 ppm) with pH 7.9. A split plot design with three replications for eighteen treatments combinations was followed by using the maize cultivar RASI-3022. Treatments include combinations of various levels of nitrogen, phosphorus and zinc. The levels of nitrogen are 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 per treatments 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 per treatment 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.

Nutrient content and uptake was measured at harvest and soil samples (0-15 cm) were collected after harvest. Total Nitrogen was determined by Micro-Kjeldhal method, Phosphorus by Vanadomolybdate method phosphoric acid yellow colour method and micronutrient (Zn) by Atomic absorption spectrophotometer method as described by Tandon (1998). Available Nitrogen was estimated by alkaline permanganate method (Sharawat and Burford.1982), available Phosphorus by Olsen's method as described by Sparks, 1996 and available micronutrient Zinc was extracted with DTPA and determined by Atomic absorption spectrophotometer as described by Lindsay and Norvell, 1978. The standard method of analysis of variance technique appropriate to split plot design as described by Panse and Sukhatme (1967) was used.

RESULTS AND DISCUSSION

Effect of nitrogen, phosphorus and zinc on yield

The highest grain and straw yield was obtained by enriching the soil with 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 with application of Nitrogen at 150 kg ha^{-1} and were significantly superior over 125 kg and 100 kg ha^{-1}.

Increased foliage might have resulted in production of more photosynthates enhancing the yield potential. As, Nitrogen is the chief constituent of protein, essential for protoplasm formation which leads to cell enlargement, cell division and ultimately resulting in increased plant growth and yield. The other reasons may be the soil conditions inclusive of improved soil fertility, Phosphorus solubilization, enhanced the efficacy of applied nutrients. The results are in close conformity with findings of Manan *et al.*(2013). Janas (2010) also reported a good response of maize to Nitrogen under semiarid environment.

Maize grain yield did not differ significantly with different zinc application levels (Table 1). The zinc application rate at 35 kg $ZnSO_4$ ha^{-1} recorded a grain yield of (6105.6 kg ha^{-1}) and was at par with of 25 kg $ZnSO_4$ ha^{-1} (5652.2 kg ha^{-1}). The increase in yield parameters might be owing to involvement of zinc in various enzymatic processes which helps in catalyzing reaction for growth finally leading to development of superior yield attributing characters. Increasing the amount of Zinc 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 was significantly superior with 35 kg $ZnSO_4$ ha^{-1}. The result of present research confirms the previous works of Jakhar *et al.* (2006). Zinc is reported to enhance the absorption of native as well as added major nutrients such as Nitrogen and

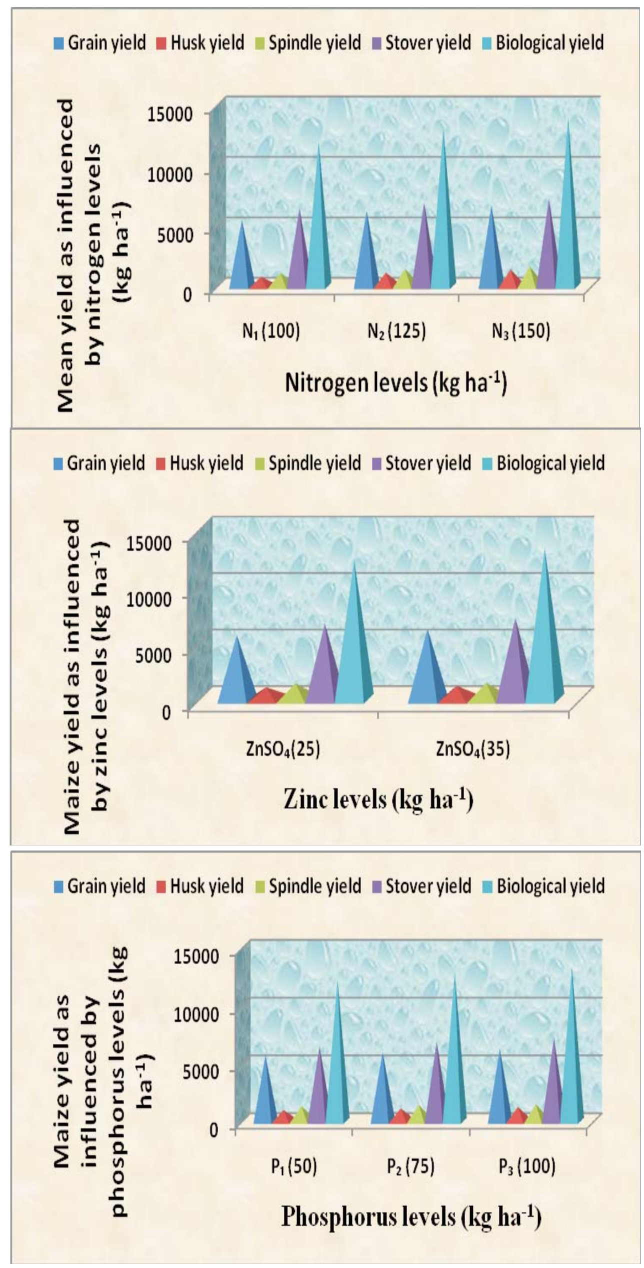

Figure 1: Maize yield (kg ha^{-1}) as influenced by different treatments

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

Treatments	Grain yield	Husk yield	Spindle yield	Stover yield	Biological yield
N levels (kg ha^{-1}) - Main plot					
N_1 - 100	5509.7	766.9	1092.2	6477.8	11987.5
N_2 - 125	6428.4	1127.1	1454.2	6811.2	13299.6
N_3 - 150	6705.8	1378.2	1642.6	7161	13866.8
S.E. ±	215.9	29	28.4	111.1	26.2
C.D. at 5%	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
Z_2 - 35	6105.6	1153.6	1417.1	6940.6	13046.2
S.E. ±	176.3	23.7	23.2	67.3	21.4
C.D. at 5%	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
P_2 - 75	6003.2	1094.7	1413.5	6782.2	12785.4
P_3 - 100	6126	1211.2	1476.2	6843	12969
S.E. ±	88.19	35.8	41.2	82.4	27.1
C.D. at 5%	257	104.3	120.1	291.2	84
Interaction					
N x Z					
S.E. ±	305.4	41	40.2	157.1	37
C.D. 5%	NS	NS	126.5	NS	NS
N x P					
S.E. ±	152.8	62	71.4	192.5	65.9
C.D. 5%	NS	NS	NS	NS	NS
Z x P					
S.E. ±	124.7	50.6	58.3	116.5	53.8
C.D. 5%	NS	NS	NS	NS	NS
N x Z x P					
S.E. ±	216	87.6	100.9	272.2	81.2
C.D. 5%	NS	NS	NS	NS	NS
General mean	6009.7	1090.7	1396.4	6776.7	12800.1

Phosphorus, thereby increased yield attributes and production of maize (Bhattacharaya *et al.*, 2008).

As far as Phosphorus is concerned, similar kind of trend is observed with that of Nitrogen. Phosphorus application at the rate of 100 kg and 75 kg ha^{-1} recorded at par higher grain yield of 6126 and 6003.2 kg ha^{-1} respectively and were significantly superior over 50 kg ha^{-1} (5716.6 kg ha^{-1}). Among Stover and biological yield application of Phosphorus at the rate of 100 Kg ha^{-1} showed significantly higher results. Increase in grain yield of maize might be due to the increased availability of essential nutrients from the enhanced level of nutrients applied to the crop. The increase in grain yield due to increase Phosphorus application was also reported by Nsanzabaganwa *et al*. (2014). Nitrogen and Phosphorus play vital role in different metabolic activities and in improving nutritional status of plants. Application of 150 kg Nitrogen + 100 kg Phosphorus ha^{-1} might have supplied Nitrogen and Phosphorus to the plants to the level of sufficiency that was able to improve yield attributes and finally the yield. The present findings are in close agreement with that of Suthar *et al.* (2014) and Owla *et al.* (2015). The increase grain yield of maize might be due to the increased availability of essential nutrients from the enhanced level of nutrients applied to the crop. These findings are in close conformity with the earlier findings of Ramachandrappa *et al.* (2007).

Effect of nitrogen, phosphorus and zinc on nutrient uptake

The growth of maize is intense from 35-75 DAS. Therefore, synchronizing the nutrient supply at these stages through fertilize application resulted in growth and consequently higher yields and nutrient uptake. Further, these periods coincides with the silking and cob development stages. Where in the crop requires higher amount of nutrients. Nutrient uptake by maize was affected significantly due to various treatments (Table 2). The uptake of Nitrogen, Phosphorus and Zinc by plants increased significantly with successive increase in fertility levels, which led to maximum Nitrogen, Phosphorus and Zinc uptake.

Significant increase in Nitrogen uptake in maize (grain + Stover) was noticed with increase in the levels of N up to 150 kg ha^{-1}. Total uptake of Nitrogen, Phosphorus and Zinc increased significantly with successive increase in nitrogen level, which led to maximum Nitrogen, Phosphorus and Zinc uptake at 150 kg ha^{-1}. This might be ascribed to the higher grain and Stover yield of maize with application of 150 kg ha^{-1}. Nutrient accumulation in maize grain was greater than in the Stover. It can be attributed to the mobilization of large proportion of nutrients from other parts of the plant to the grains during development. Improvement in Zinc uptake with increase level of Nitrogen suggests a synergistic effect of Nitrogen on Zinc uptake. This could be owing to adequate availability of nutrients for better growth and thereby resulting in an increased uptake values. The above findings are in accordance to the results

Table 2: Uptake of Nitrogen, Zinc and Phosphorus (kg ha^{-1}) by Maize at harvest as influenced by different treatments

Treatments	Nitrogen			Zinc			Phosphorus		
	Grain	Fodder	Total	Grain	Fodder	Total	Grain	Fodder	Total
N levels (kg ha^{-1}) - Main plot									
N_1 - 100	77.54	45.65	123.19	6.7	4.39	11.1	24.84	14.47	39.31
N_2 - 125	96.11	52.37	148.48	9.4	5.41	14.8	30.37	16.51	46.88
N_3 - 150	107.5	59.91	167.41	11.5	6.1	17.6	35.73	18.83	54.56
S.E. ±	1.67	1.01	3.49	0.19	0.11	0.39	0.36	0.36	0.4
C.D. at 5%	5.24	3.19	10.9	0.59	0.35	1.22	1.13	1.16	1.26
Z levels (kg ha^{-1}) - Main plot									
Z_1 - 25	87.76	48.3	136.06	7.9	4.99	11.9	28.68	15.88	44.56
Z_2 - 35	92.01	53.99	146	10.7	6.7	17.4	31.95	17.33	49.28
S.E. ±	1.36	0.83	2.85	0.15	0.09	0.32	0.29	0.3	0.33
C.D. at 5%	4.27	2.6	8.96	0.49	0.29	0.99	0.93	0.95	1.03
P levels (kg ha^{-1}) – Sub plot									
P_1 - 50	88.17	49.29	137.46	8.1	5.04	13.1	28.77	16.15	44.92
P_2 - 75	94.2	53.29	147.89	8.8	5.36	14.2	30.24	16.98	46.82
P_3 - 100	97.26	56.95	156.21	9.5	5.49	14.9	31.94	17.78	49.72
S.E. ±	1.56	1.24	3.37	0.17	0.07	0.43	0.57	0.29	0.55
C.D. at 5%	4.97	3.62	9.67	0.52	0.19	1.26	1.67	0.86	1.61
Interaction									
N x Z									
S.E. ±	2.36	1.43	4.93	0.27	0.16	0.55	0.51	0.52	0.57
C.D. 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x P									
S.E. ±	4.7	2.15	7.69	0.31	0.11	0.75	0.99	0.71	0.96
C.D. 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Z x P									
S.E. ±	3.84	1.76	6.29	0.25	0.09	0.61	0.81	0.58	0.78
C.D. 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x Z x P									
S.E. ±	6.65	3.04	10.9	0.43	0.16	1.06	1.4	1	1.35
C.D. 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
General mean	92.94	52.46	145.4	9.08	5.44	14.52	30.32	16.69	47.01

reported by Bindhani *et al.* (2007).

Zinc uptake (17.4 kg ha^{-1}) increased up to 35 kg $ZnSO_4$ ha^{-1}. Zn application at 35 kg $ZnSO_4$ ha^{-1} increased Nitrogen and Phosphorus uptake with that of 25 kg $ZnSO_4$ ha^{-1}. This may be due to the higher grain yield and Stover yield of maize with application of kg $ZnSO_4$ ha^{-1} and also, the synergistic effect between Nitrogen and Zinc. Application of Zinc along with recommended dose of nutrients enhanced the total uptake of Nitrogen, Phosphorus and Zinc by maize crop compared to rest of the other treatments. The synergistic effects of major nutrients with Zinc might have significantly increased the availability and uptake of Zinc by the Maize crop. This finding supports the results of Verma *et al.* (2001). Differences in different parameters under test due to different Zinc levels may be attributed due to variations in crop requirement for Zinc as well as different metabolic and physiological roles of Zinc (catalyzing enzymes; transformation of carbohydrates, chlorophyll and protein synthesis). Hossain *et al.* (2011) also reported a good response of maize to zinc fertilization. Zinc uptake by maize significantly varied at each incremental Zinc level and the highest Zinc uptake was recorded at 35 kg $ZnSO_4$. This shows that Zinc uptake is governed by yield and rate of Zinc application. Substantial results were also reported by Meena *et al.* (2013).

Phosphorus uptake (49.72 kg ha^{-1}) was significantly influenced up to 100 kg P ha^{-1}. Maximum significant N uptake was recorded at 75 kg P ha^{-1} while that of zinc was at 100 kg Phosphorus ha^{-1}. The more uptake of nutrient with increased Phosphorus levels might be due to better root establishment, resulting in higher absorption of nutrient to feed and sustain increase maize growth which led to higher grain and Stover yield. Maximum total Phosphorus uptake (77.4 kg ha^{-1}) was observed from the enhanced levels of Phosphorus. The greater mobilization of Phosphorus in the presence of Nitrogen may be another reason for higher uptake of Phosphorus as reported by Hocking & Pinkerton (1993) and Manasa *et al.* (2015). This increase was mainly due to increased maize grain and stover yield and higher concentrations of respective applied nutrients i.e., Nitrogen, Phosphorus and Zinc. A similar result was also reported by Singh *et al.* (2010).

Effect of nitrogen, phosphorus and zinc on post harvest soil status

Soil fertility is a measure of the available nutrient status in soil. It helps to detect the efficiency of fertilizers applied and used by the crop. The soil fertility status after the harvest of maize indicated that there were significant differences in the availability of major nutrient (Nitrogen, Phosphorus) and Micronutrient (Zinc) in soil. The data revealed that available Nitrogen, Phosphorus and Zinc were highest with 150 kg ha^{-1}, 125 kg ha^{-1} and 100 kg ha^{-1} respectively. The nutrient status of the experimental soil after harvest of maize crop indicated a higher available Nitrogen, Phosphorus and Zinc with higher

Table 3: Post harvest Available N, P and Z content in soil as influenced by different treatments

Treatments	kg ha^{-1} N	P	ppm Z
N levels (kg ha^{-1}) - Main plot			
N_1 - 100	131.65	20.92	1.81
N_2 - 125	133.61	21.22	1.87
N_3 - 150	141.8	21.81	1.88
S.E. ±	1.08	0.24	0.04
C.D. at 5%	3.4	0.76	NS
Z levels (kg ha^{-1}) - Main plot			
Z_1 - 25	131.9	21.06	1.77
Z_2 - 35	133.08	21.57	1.93
S.E. ±	1.01	0.19	0.03
C.D. at 5%	NS	NS	0.11
P levels (kg ha^{-1}) – Sub plot			
P_1 - 50	133.95	20.15	1.84
P_2 - 75	135.71	21.05	1.85
P_3 - 100	137.4	21.74	1.86
S.E. ±	1.13	0.24	0.04
C.D. at 5%	3.29	0.69	NS
Interaction			
N x Z			
S.E. ±	1.52	0.34	0.06
C.D. 5%	NS	NS	NS
N x P			
S.E. ±	1.96	0.41	0.07
C.D. 5%	NS	NS	NS
Z x P			
S.E. ±	1.6	0.34	0.06
C.D. 5%	NS	NS	NS
N x Z x P			
S.E. ±	2.77	0.58	0.1
C.D. 5%	NS	NS	NS
General mean	134.8	21.19	1.85
Initial content	186.42	17.18	1.42

Table 4: Spindle yield ha^{-1} as influenced by N x Z interaction in maize

Treatment	Spindle yield kg ha^{-1} Z_1	Z_2
N_1	1024.6	1159.9
N_2	1393.1	1515.3
N_3	1573.8	1711.4
S.E. ±	40.2	
C.D. 5%	126.5	

levels of Nitrogen. Available Nitrogen was highest and significant with application of 150 kg N ha^{-1} compared to other Nitrogen levels. Phosphorus content in soil was shown high up to 75 kg ha^{-1}. Available Zinc in soil was not affected significantly by Nitrogen levels. Paramasivan *et al.* (2011) also showed the similar kind of findings in relation with the post harvest status of soil with that of Nitrogen, Phosphorus, Potassium and Zinc.

Available Nitrogen, Phosphorus and Zinc status of soil increased with increasing dose and higher available Nitrogen, Phosphorus and Zinc was found with 35 kg $ZnSO_4$. But the Nitrogen and Phosphorus was found to be non-significant. Higher Nitrogen availability at higher doses and responsiveness of crop increased meristematic activities in different plant parts which also required more Phosphorus for fulfilling their energy and tissues requirement. It is inferred from the above that increase in available status of soil was due to increase in fertilizer dose with declining response at higher levels. These results are in conformity with the work done by Stalin *et al.*, (2011). Soil application of Zinc enhanced the nutrient availability in deficit soil and showed more response to the soil applied Zinc (Tetarwal *et al.*, 2011).

Increase in the level of fertility level of Nitrogen, Phosphorus and Zinc might assured the availability of these nutrients to the crop plants in adequate amount and remained in soil in substantial quantity after fulfilling the crop improvement that improved the soil fertility. It was confirmed by the findings of Saha and Mondal (2006).

Interaction effect

The interaction effect between Nitrogen and Zinc fertility levels was significant on maize spindle yield (Table 4). 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) also reported that interaction effect was significant among the fertility levels. This increase in yield was probably due to effective utilization of applied nutrients, increased sink capacity and nutrient uptake by the crop. The yield potential of maize is mainly governed by the growth and yield components. Since Nitrogen is the major structural constitute of cells, as Nitrogen level increased the rate of vegetative and reproductive growth also increased in plants due to increase in assimilating surface of plants as well as total photosynthesis. In physiological terms, the grain yield of maize is largely governed by source (Photosynthesis) and sinks (grain) relationship which is directly related to Nitrogen. These resulted in more interactive effect significant fertility levels of Nitrogen and Zinc. The positive response of hybrid maize up to 250 kg Nitrogen ha^{-1} was recorded by Srikanth *et al.* (2009).

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