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Effect of Zinc on Growth, Plant Yield, NPK Uptake and Economics

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Abstract

The experiment was conducted at agricultural farm of Palli Siksha Bhavana, Visva-Bharati at Sriniketan of Birbhum district, West Bengal during *pre-rabi* season of 2015 to study the effect of zinc on growth and productivity of baby corn. The soil at experimental site was analysed sandy loam in texture with low in available N, medium in available P_2O_5 and K_2O and slightly acidic (p^H: 4.78) in nature. The experiment was carried out in RBD with 8 treatments. Each treatment was replicated thrice and the different treatments viz. absolute control, soil application of Zn @ 6 kg ha^{-1}, soil application of Zn @ 10 kg ha^{-1}, seed treatment @ 0.6% Zn, seed treatment @ 1.2% Zn, one foliar spray @ 0.05% Zn at 25 DAS, soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn, seed treatment @ 0.6% Zn+one foliar spray of 0.05% Zn at 25 DAS. At tasseling stage, growth attributes like highest number (9.3) of leaves, maximum (3220 cm^2, 4.0) leaf area and LAI, respectively, highest (26.4 g m^{-2} day^{-1}) CGR and maximum (47.2 days) LAD were resulted with soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS. On the other hand, at tasseling stage, highest (11.3 g m^{-2} day^{-1}) NAR were produced by seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS. However, soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) recorded highest (59.06 kg ha^{-1}) N uptake, maximum (11.8 kg ha^{-1}) P uptake and highest (32.51 kg ha^{-1}) K uptake which was significantly higher than all other treatments.Moreover highest net return (₹ 165442 ha^{-1}) as well as B:Cratio were found with the soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS.

Keywords: Baby corn, zinc, methods of application, plant yield

1. Introduction

Baby corn, a novel utilization of maize, is used as a vegetable in many Asian countries. It is used as an ingredient in the preparation of many food items. It refers to whole, entirely edible corn of immature cob harvested just before fertilization at the silk emergence stage (Galinant, 1985). It is dehusked young ear of the female inflorescence of maize plant, harvested at silk emergence before fertilization (Pandey et al., 2000; Kapoor, 2002). Thavaprakash et al. (2005) and Das et al. (2008) reported that 100 g of baby corn contained 89.1 g moisture, 0.2 g fat, 1.9 g protein, 8.2 mg carbohydrate, 0.06 g ash, 28.0 mg calcium, 86.0 mg phosphorus, and 11.0 mg of ascorbic acid. Its nutritive value is similar to those of non-leguminous vegetables such as cauliflower, tomato, cucumber and cabbage. In addition to high nutritional value as human food, another benefit of baby corn consists of utilizing husk, silk and stover as green herbage for feeding ruminants and swine (Aekatasanawan, 2001). It starts the reproductive phase after 45 days and ends its life cycle within 60–70 days after sowing normally in the *kharif* season (Singh et al., 2010). Growing maize for baby corn purpose adds diversification and value addition to maize cultivation.. The dehusked young ears of baby corn can be eaten as vegetable, whose delicate sweet flavor and crispiness are much in demand. Importantly, it is free from pesticides and it is very much suitable to organic farming. So day by day in India, the demand of baby corn consumption increasing.Baby corn is highly remunerative and farmers can get a high return of his investment in a short period by cultivating this crop (Ali and Awan, 2009). Zinc is an essential element for plants, animals and human beings.It is startling to find in the 21st century that an estimated 2 billion people on the planet are zinc deficient. Zinc deficiency is more prevalent in developing countries of the world (Gibbson, 2006). About two- thirds of all global deaths in children are associated with micronutrient nutritional deficiencies and sub-optimal growth and mortality are some of the severe symptoms associated with Zn deficiency (Welch, 2002). As well documented by plant physiologists, zinc exerts a great influence on basic plant life processes, such as (i) nitrogen metabolism – uptake of nitrogen and protein quality; (ii) photosynthesis – chlorophyll synthesis, carbon anhydrase activity; (iii) resistance to abiotic and biotic stresses – protection against oxidative damage (Alloway, 2004; Cakmak, 2008). The present study was performed because previously only limited information had been available on the performance of zinc fertilizers on growth, plant yield, NPK uptake and economics of baby corn.

2. Materials and Methods

The experiment was conducted at agricultural farm of Palli Siksha Bhavana, Visva-Bharati at Sriniketan of Birbhumdistrict, West Bengal during *pre-rabi* season of 2015 (From September 2015 to November 2015) in red and lateritic soil on a sandy loam soil. The farm was situated at 23°39' N latitude and 87°42' E longitude with an average altitude of 58.90 m above mean sea level. The experiment was conducted in a randomized block design and the treatments were absolute control, soil application of Zn @ 6 kg ha^{-1}, soil application of Zn @ 10 kg ha^{-1}, seed treatment @ 0.6% Zn, seed treatment @ 1.2% Zn, one foliar spray @ 0.05% Zn at 25 DAS, soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS, seed treatment @ 0.6% Zn+one foliar spray of 0.05% Zn at 25 DAS. Source of zinc was zinc sulphate monohydrate (33% Zn).

The experimental plot was applied with fertilizer 150 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} after field preparation as basal application. Seed treatment with Zn @ 0.6% and 1.2% was done and kept overnight before sowing. The maize variety, Navaneet were sown with a seed rate of 40 kg ha^{-1} with uniform row to row spacing of 40 cm and plant to plant spacing of 20 cm for baby corn purpose. Gap filling and thinning were done at 14 DAS and once manual weeding operation and one foliar spray of 0.05% Zn was done at 25 DAS. Detasseling is a major operation in baby corn and it was done on a daily basis since start of tassel emergence (first detasseling was done at 50 DAS) till tassels from all the plants are removed.

Leaf number of baby corn counted and leaf area of baby corn was measured at knee high and tasseling stage using leaf area meter and expressed in cm^2. The CGR, NAR and LAD of baby corn plant were calculated during seedling to knee-high stage and knee-high to tasseling stage. Baby corns were found by dehusking the young cobs. Individual plant yield components like No. of young cob plant^{-1}, weight of young cob (g plant^{-1}), fresh weight of baby corn (g plant^{-1}), weight of green husk (g plant^{-1}) and Fresh weight of whole plant fodder at harvest(g plant^{-1}) were calculated from randomly selected plants. Yield attributes like average no. of cobs, fresh weight of cobs and baby corn yield per ha basis were calculated by adding each harvest. Total fodder yield was calculated at final harvest. Plant samples were analyzed for total N using Kjeldahl digestion unit (Prasad et al., 2006), P analysis by using spectrophotometer and K by Flame photometer.

2.1. Statistical analysis

The analysis of variance method (Panse and Sukhatme, 1967) was followed to statistically analyse the various data. The significance of different source of variations was tested by "Error Mean Square Method" of Fisher Snedecor's 'F' test at probability level of 0.05. In the tables of result and discussion chapter, the standard error of Mean (SEm±) and the value of critical difference (C.D.) to compare the differences between means have been provided.

3. Results and Discussion

3.1. Growth characters

At tasseling stage,highest number (9.3) of leaves (Table 1) was found with the soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn (T_7) which was significantly higher with all the treatments except seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8). From Table 1 it is revealed that at tasseling stage, leaf area was significantly highest (3220 cm^2) at tasseling stage with soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) and remained at par with seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8), one foliar spray @ 0.05% Zn at 25 DAS (T_6), soil application of Zn @ 10 kg ha^{-1} (T_3), soil application of Zn @ 6 kg ha^{-1} (T_2). So, obviously significant with seed treatment @ 0.6% Zn (T_4), seed treatment @ 1.2% Zn (T_5) and control (T_1). At tasseling stage, leaf surface area, LAI (4.0) was also significantly improved under soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) (Table 1). This treatment was only statistically at par withseed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8), one foliar spray @ 0.05% Zn at 25 DAS (T_6), soil application of Zn @ 10 kg ha^{-1} (T_3) and soil application of Zn @ 6 kg ha^{-1} (T_2). During knee-high to tasseling stage, CGR recorded was highest (26.4 g m^{-2} day^{-1}) (Table 1) with soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) and remained at par with one foliar spray @ 0.05 % Zn at 25 DAS (T_6), seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8). From Table 1 during knee-high to tasseling stage, seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8) was recorded highest (11.3 g m^{-2} day^{-1}) NAR and remained at par with one foliar spray @ 0.05 % Zn at 25 DAS (T_6), soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7)andseed treatment @ 1.2% Zn (T_5).During knee-high to tasseling stage, soil application of Zn @ 6 kg ha^{-1} + one foliar spray @ 0.05% Zn at 25 DAS (T_7)recorded highest (47.2 days) (Table 1) LAD at par with soil application of Zn @ 10 kg ha^{-1} (T_3), one foliar spray @ 0.05 % Zn at 25 DAS (T_6), soil application of Zn @ 6 kg ha^{-1} (0.13) (T_2) and seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8). Highest leaf area at tasseling stage might be attributed to highest leaf numbers. These result also followed the trend as studied by Mohsin et al. (2014) where they quoted that combined treatment of seed priming and foliar spray @ 2% gave maximum LAI (6.10) of Pioneer 30-Y-87 variety. These result pursued the study of Mohsin et al. (2014) that, higher rate of Zn both as seed priming and foliar spray @ 2% gave maximum CGR (28.75 g m^{-2} day^{-1}) of Pioneer 30-Y-87 variety. These values also followed the result of Kumar and Bohra (2014) that the highest CGR (6.5 g day^{-1}) obtained with soil application of Zn @ 10 kg ha^{-1}. These findings were in coincidence with the study of Mohsin et al. (2014), where higher rate of Zn both as seed priming and foliar spray @ 2% gave maximum NAR (8.06 g m^{-2} day^{-1}) of Pioneer 30-Y-87 variety.

3.2. Yield components

Number of young cob $plant^{-1}$ was obtained highest (2.0) with soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) that was statistically significant over all treatments except seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8) (Table 1). Almost similar trend of previous parameter was recorded where soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) was found to produce highest (90 g $plant^{-1}$) weight which was significantly higher than all treatments (Table 1). The 2nd highest (74.62 g $plant^{-1}$), seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8) was also proved significantly better than all treatments except soil application of Zn @ 10 kg ha^{-1} (T_3). Soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) was recorded the highest (13.34 g $plant^{-1}$) (Table 1) fresh weight of baby corn which was significantly higher with rest of the treatments except seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8). Seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8) was also found significant with soil application of Zn @ 10 kg ha^{-1} (T_3) and soil application of Zn @ 6 kg ha^{-1} + one foliar spray @ 0.05% Zn at 25 DAS (T_7). However, the highest weight of green husk (68.63 g $plant^{-1}$) was obtained with soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) and lowest (38.63 g $plant^{-1}$) by control (T_1) but non-significant. The data showed non-significant effect of zinc treatment on $plant^{-1}$ fresh weight of whole plant fodder.However, seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8) was recorded highest (190.2 4) fresh weight of whole plant fodder than the other treatments (Table 1). Kumar and Bohra (2014) found the highest leaf no. (14.0) at soil application of Zn @ 10 kg ha^{-1}. The yield component findings were almost in proximity of the findings by Kumar and Bohra (2014). These findings ensued the result of Potarzycki and Grzebisz (2009) that plants fertilized with 1.0 kg Zn ha^{-1} significantly increased both total N uptake and grain yield.

Table 1: Effect of treatments on growth and yield components of baby corn

Treatment	LNTS	LA	LAI	CGR	NAR	LAD	NYCP	WYC	FWBC	WH	FWWPFH
T_1	7.3	2176	2.7	15.0	8.2	37.0	1.55	50.80	8.10	38.63	165.27
T_2	7.5	2750	3.4	19.0	8.5	45.0	1.61	64.40	10.31	54.15	178.95
T_3	7.9	2800	3.5	20.6	9.0	47.0	1.72	68.83	11.82	59.92	190.13
T_4	7.0	2361	3.0	17.4	8.9	40.0	1.50	59.48	9.27	55.31	168.13
T_5	7.7	2274	2.8	17.7	9.4	37.7	1.66	62.80	9.95	51.42	165.90
T_6	8.3	2929	3.7	25.5	11.2	45.1	1.66	66.45	10.69	65.38	174.18
T_7	9.3	3220	4.0	26.4	10.9	47.2	2.00	90.00	13.34	68.63	183.47
T_8	8.7	3090	3.9	25.3	11.3	44.6	1.94	74.62	12.32	59.08	190.22
SEm±	0.3	170	0.2	1.2	0.7	2.3	0.06	2.45	0.38	6.38	10.43
CD (*p*=0.05)	0.9	517	0.6	3.7	2.2	6.9	0.19	7.42	1.16	NS	NS
CV%	6.6	11	10.9	10.1	12.8	9.1	6.21	6.31	6.19	19.53	10.21

T_1: Absolute control; T_2: Soil application of Zn @ 6 kg ha^{-1}; T_3: Soil application of Zn @ 10 kg ha^{-1}; T_4: Seed treatment @ 0.6% Zn; T_5: Seed treatment @ 1.2% Zn; T_6: One foliar spray @ 0.05% Zn at 25 DAS; T_7: Soil application of Zn @ 6 kg ha^{-1}+One foliar spray @ 0.05% Zn; T_8: Seed treatment @ 0.6% Zn+one foliar spray of 0.05% Zn at 25 DAS; LNTS: Leaf number at tasseling stage; LA: Leaf area (cm^2) at tasseling stage; LAI: LAI at tasseling stage; CGR: CGR (g m^{-2} day^{-1}) during knee high to tasseling stage; NAR: NAR (g m^{-2} day^{-1}) During knee high to tasseling stage; LAD: LAD (days) during knee high to tasseling stage; NYCP: No. of young cob $plant^{-1}$; WYC: Weight of young cob (g $plant^{-1}$); FWBC: Fresh weight of baby corn (g $plant^{-1}$); WH: Weight of husk (g $plant^{-1}$); FWWPFH: Fresh weight of whole plant fodder at harvest (g $plant^{-1}$)

3.3. NPK uptake by baby corn

From Table 2 it is revealed that soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) recorded highest (59.06 kg ha^{-1}) N uptake which was highly significant at par with seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8). Seed treatment @ 0.6% Zn + one foliar spray @ 0.05% Zn at 25 DAS (T_8) was showing second highest (52.04 kg ha^{-1}) uptake of N which was significant over all treatments except soil application of Zn @ 10 kg ha^{-1} (T_3) and soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7). Soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) recorded highest (11.8 kg ha^{-1}) P uptake (Table 2) which was significantly higher over all treatment. Seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8) showed the second highest (9.83 kg ha^{-1}) and soil application of Zn @ 10 kg ha^{-1} (T_3) showed the third highest (8.78 kg ha^{-1}) P uptake. This might be due to the healthier plant uptake more nutrient. Soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) recorded highest (32.51 kg ha^{-1}) K uptake (Table 2) which was significantly higher over all the treatment. Seed treatment @ 0.6% Zn+one foliar spray @ 0.05% Zn at 25 DAS (T_8) was showing second highest (27.52 kg ha^{-1}) K uptake value which was also significant over rest of the treatments except soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7). This highest plant P uptake with soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) might be due to the healthier plant uptake more nutrient. The high uptake of K might be due to higher percentage of nutrient along with highest yield by soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7).

3.4. Economics

From Table 2, it was resulted that the highest net return (₹ 165442 ha^{-1}) was found from soil application of Zn @ 6 kg ha^{-1} +one foliar spray @ 0.05% Zn at 25 DAS (T_7) which is ₹ 85057 higher than the net return found from seed treatment @ 0.6% Zn (T_4), which treatment had the lowest cost of cultivation among all. The B:Cratio was highest (4.46) in soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) and lowest (2.29) in control (T_1) (Table 2).

Table 2: Effect of treatments on total nutrient uptake and economics of baby corn

Treatment	Total N uptake (kg ha^{-1})	Total P uptake (kg ha^{-1})	Total K uptake (kg ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
T_1	20.05	5.01	10.59	63909	2.29
T_2	30.41	7.55	19.53	94514	2.92
T_3	45.19	8.78	22.40	107834	3.18
T_4	23.99	5.98	13.18	80385	2.78
T_5	28.27	7.30	15.46	87700	3.03
T_6	37.01	8.00	20.75	108287	3.49
T_7	59.06	11.80	32.51	165442	4.46
T_8	52.04	9.83	27.52	132428	3.95
SEm±	2.35	0.63	1.21		
CD (p=0.05)	7.13	1.90	3.67		
CV%	11.01	13.53	10.35		

Baby corn market price=₹ 100 kg^{-1}, Fodder price=₹ 1500 t^{-1}

4. Conclusion

Soil application of Zn @ 6 kg ha^{-1}+one foliar spray @ 0.05% Zn at 25 DAS (T_7) proved best in influencing growth and yield attributes, yield, NPK uptake of baby corn. This treatment however, resulted highest net return (₹ 165442 ha^{-1}) and B:C ratio (4.46) of baby corn.

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