Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(5): 989-992
Received: 07-07-2017
Accepted: 09-08-2017

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Effect of zinc fertilization on yield and economics of baby corn (*Zea mays* L.)

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Abstract
A field experiment was conducted at Rajendranagar, Hyderabad during the *kharif* season 2016, to study the effect of zinc fertilization on yield and economics of baby corn. The experiment was laid out in a randomized block design consisting of twelve treatments and replicated thrice. In the present experiment soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS recorded significantly higher number of cobs per plant, corn and cob weight, corn and cob length, corn and cob girth and also corn yield, cob yield, husk yield and green fodder yield. Gross returns, net returns and B:C ratio were recorded highest with soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS. Each increment of zinc application correspondingly improved yield and yield attributes as well as gross returns, net returns and B:C ratio of baby corn.

Keywords: zinc fertilization, *Zea mays* L, *kharif* season

Introduction
Baby corn is an important crop of Thailand, Taiwan and India; recently, baby corn has gained popularity in Delhi, Uttar Pradesh, Haryana, Maharashtra, Telangana, Karnataka, Andhra Pradesh, Rajasthan and Meghalaya states of India. Today, Thailand and China are the world leaders in baby corn production. Attention is now being paid to explore its potential in India for earning foreign exchange besides higher economic returns to the farmers. Recently cultivation of baby corn has started and gaining popularity in peri-urban areas due its export potential besides huge employment generation. Baby corn is the dehusked young cobs of harvested within 2-3 days of silk emergence and are consumed as vegetable due to its sweet flavour. The earliness facilitates crop diversification, increase overall cropping intensity in a year and increases profitability.

According to the recent survey, zinc deficiency in human nutrition is the most wide spread nutritional disorder, next to iron, vitamin ‘A’ and iodine. Nearly, 49% of the global population does not meet their daily-recommended intake of 15 mg day-1 of zinc for an adult and is one of the leading risk factors associated with diseases such as diarrhoea and retarded growth contributing to the death of 8,00,000 people each year. One third of the world population is reported at the risk of malnutrition due to inadequate dietary intake of zinc (Cakmak, 2009) [5]. About 50% of Indian soils are deficient in zinc causing low level of zinc and yield losses in fodder crops and affecting the health of the livestock (Singh, 2011) [14]. Widespread deficiencies of zinc have been reported right through East Asia, to the tune of 50-70 % in India and Pakistan. The regions with Zn deficient soils are also the regions where Zn deficiency in human beings is widespread, for example in India, Pakistan, China, Iran and Turkey (Cakmak *et al.*, 1999; Alloway, 2004; Hotz and Brown, 2004) [4, 1, 6].

Micronutrients can increase grain yield up to 50%, as well as increase macronutrients use efficiency. Among the micronutrients, zinc is an essential nutrient for the standard and healthy growth and development of plants. Zinc deficiency is one of the most widespread micronutrient deficiencies in plants and causes severe reductions in crop production.

Zinc plays an important role in various plant metabolism processes such as, development of cell wall, respiration, carbohydrate metabolism and gene regulation. Zinc fertilization are used to increase micronutrient in edible parts to reduce the micro nutrient deficiency in human populations. Zinc fertilization is essential for keeping sufficient amount of available zinc in soil solution (by soil application of zinc) and in leaf tissue (by foliar application of zinc) which contributes to the maintenance of adequate root zinc uptake.

Material and methods
The present experiment was conducted at College Farm, College of Agriculture,

Rajendranagar, Hyderabad, Telangana State, during *kharif* season, 2016. The experiment was laid out in a randomized block design consisting of twelve treatments and replicated thrice. The treatments of zinc fertilization are, T_1: Control (No zinc), T_2: Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS, T_3: Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS, T_4: Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS, T_5: Soil application of $ZnSO_4$ @ 12.5 kg ha^{-1}, T_6: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS, T7: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS, T8: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS, T9: Soil application of $ZnSO_4$ @ 25 kg ha^{-1}, T10: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS, T11: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS, T12: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS.

A short duration baby corn variety, VL-1 was used by adopting a spacing of 40 cm x 20 cm. The recommended dose of 150:60:50 NPK kg ha^{-1} was applied to all treatments using urea, SSP and MOP respectively. The experimental soil was sandy clay loam in texture, slightly alkaline in reaction. The fertility status of the experimental soil was low in organic carbon available nitrogen as well as low in available zinc content, medium in available phosphorus and high in potassium. The minimum and maximum temperatures ranged from 22.3 ˚C and 29.6 ˚C in the crop growing period. The crop received three irrigation during crop growing period.

Five random plants were sampled from each plot to record number of cobs per plant, cob weight, cob length and cob girth. These yield parameters were measured before and after removing the husk. Observations on corn yield, cob yield, husk yield and green fodder yield were recorded as per the standard procedure. The economics of treatments were calculated using existing market prices. The input and output costs were compared treatment-wise and different parameters, *viz*., net returns and the B: C ratio were calculated. Data were statistically analyzed as suggested by Panse and Sukhatme (1978) [10].

Result and discussion

The yield attributes *viz*., number of cobs per plant, cob and corn weight, cob and corn length, cob and corn girth were significantly influenced by different zinc fertilization treatments (Table. 1). Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS recorded significantly higher yield attributes i.e. number of cobs per plant (3.46), cob weight (35.09 g cob^{-1}), corn weight (8.37 g cob^{-1}), cob length (19.03 cm), corn length (7.88 cm), cob girth (7.10 cm) and corn girth (4.13 cm) over control (no zinc). The increase in yield attributes due to application of zinc was caused by higher chlorophyll contents, and this had apparently a positive effect on photosynthetic activity, synthesis of metabolites and growth-regulating substances, oxidation and metabolic activities and ultimately better growth and development of crop, which led to increase in yield attributes of baby corn. The results were in conformity with Meena *et al.* (2013) [8], Rakesh kumar and Bohra (2014) [11] and Shivay and Prasad (2014) [12].

Similarly, significantly higher corn yield (1630 kg ha^{-1}) and cob yield (6550 kg ha^{-1}) was found with soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS over control (no zinc) but remained on par with soil application of $ZnSO_4$ @ 25 kg ha^{-1}, soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS (Table. 2). Zinc treatment either by soil or foliar application led to an increase in the cob yield by 10.0% to 35.5% and in the corn yield by 0.4% to 31.4% over control (no zinc). Yield is an ultimate end product of many yield contributing components, physiological and morphological processes taking place in plants during growth and development (Mona, 2015) [9]. Zinc fertilization has beneficial effect on physiological process, plant metabolism and plant growth, which leads to higher yield. Increase in cob and corn yield with application of zinc was also reported by Rakesh kumar and Bohra (2014) [11].

Higher husk yield (4920 kg ha^{-1}) and green fodder yield (27.76 t ha^{-1}) was recorded with soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS but remained on par with soil application of $ZnSO_4$ @ 25 kg ha^{-1}, soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS (Table. 2). Lower husk yield (3571 kg ha^{-1}) and green fodder yield (22.38 t ha^{-1}) was recorded with control (no zinc). Zinc treatment either by soil or foliar application led to an increase in the husk yield by 13.2% to 37.1% and in the green fodder yield by 3.1% to 24.0% over control (no zinc). Increase in green fodder yield might be due to the enhanced translocation of photosynthates with applied zinc, which resulted in higher production of green fodder in the respective levels of nutrient. Similar results of significantly higher fodder yield with Zn application was also reported by Mahdi *et al.* (2012) [7], Balwinder kumar *et al.* (2013) [2] and Mona (2015) [9].

However, highest cost of cultivation ₹ 46546/- recorded with soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS and least cost of cultivation of ₹ 40182/- was observed with control due no zinc application in treatment (Table 3.). Higher gross return (₹ 139886/-), net returns (₹ 93340/-) and benefit cost ratio (3.00) were recorded with soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS among all treatments. Lower gross return (₹ 106057/-), net returns (₹ 65875/-) and benefit cost ratio (2.64) was observed with control (no zinc) treatment. Increase in gross returns, net returns and benefit cost ratio due to higher baby corn yield and green fodder yield with soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS over control (no zinc). These results are positively corroborate with findings of Bindhani *et al.* (2007) [3], Singh *et al.* (2010) [13] and Rakesh kumar and Bohra (2014) [11].

Table 1: Number of cobs plant^{-1}, cob and corn weight, cob and corn length and cob and corn girth as influenced by zinc fertilization.

Treatments	Number of cobs plant^{-1}	Cob weight (g cob^{-1})	Corn weight (g cob^{-1})	Cob length (cm)	Corn length (cm)	Cob girth (cm)	Corn girth (cm)
T_1: Control (No zinc)	2.83	28.72	6.92	16.87	7.03	6.45	3.70
T_2: Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS	2.89	29.28	7.32	17.35	7.36	6.82	3.87
T_3: Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS	2.90	31.95	7.46	17.63	7.30	6.80	3.92
T_4: Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS	3.00	32.93	7.56	18.34	7.59	6.73	3.93
T_5: Soil application of $ZnSO_4$ @ 12.5 kg ha^{-1}	3.23	31.92	7.64	17.55	7.68	7.00	3.94
T_6: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS	3.29	32.99	7.61	17.92	7.69	6.83	3.94
T7: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS	3.30	30.73	7.75	17.56	7.52	6.95	3.94
T8: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS	3.39	33.09	7.88	18.76	7.68	6.92	3.99
T9: Soil application of $ZnSO_4$ @ 25 kg ha^{-1}	3.45	31.80	8.06	17.93	7.77	6.85	4.00
T10: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS	3.44	34.81	8.35	18.47	7.70	7.07	4.06
T11: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS	3.46	33.68	8.36	18.21	7.56	6.90	4.09
T12: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS	3.46	35.09	8.73	19.03	7.88	7.10	4.13
SEm ±	0.21	1.20	0.34	0.34	0.13	0.13	0.08
CD (P=0.05)	0.61	3.51	0.98	1.01	0.39	0.39	0.24

Table 2: Corn yield, cob yield, husk yield and green fodder yield as influenced by zinc fertilization.

Treatments	Cob yield (kg ha^{-1})	Corn yield (kg ha^{-1})	Husk yield (kg ha^{-1})	Green fodder yield (t ha^{-1})
T_1: Control (No zinc)	4832	1261	3572	22.38
T_2: Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS	5395	1349	4046	23.10
T_3: Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS	5313	1240	4073	23.33
T_4: Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS	5423	1245	4178	23.66
T_5: Soil application of $ZnSO_4$ @ 12.5 kg ha^{-1}	5645	1351	4294	24.57
T_6: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS	5744	1326	4418	24.73
T7: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS	5785	1459	4327	25.81
T8: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS	5894	1404	4491	25.92
T9: Soil application of $ZnSO_4$ @ 25 kg ha^{-1}	6163	1522	4481	27.06
T10: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS	6250	1500	4751	26.48
T11: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS	6311	1566	4744	27.48
T12: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS	6550	1630	4920	27.76
SEm ±	135	44.54	71.6	0.70
CD (P=0.05)	391	130	210	2.04

Table 3: Economics of baby corn as influenced by zinc fertilization

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1: Control (No zinc)	40182	106057	65875	2.64
T_2: Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS	41619	115564	73945	2.78
T_3: Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS	41542	114700	73158	2.76
T_4: Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS	42227	116841	74614	2.77
T_5: Soil application of $ZnSO_4$ @ 12.5 kg ha^{-1}	42942	121531	78590	2.83
T_6: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS	43579	123257	79678	2.83
T7: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS	43845	125493	81647	2.86
T8: T_5 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS	44489	127300	82811	2.86
T9: Soil application of $ZnSO_4$ @ 25 kg ha^{-1}	44677	130636	85959	2.92
T10: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS	45395	133471	88076	2.94
T11: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 40 DAS	45676	135879	90203	2.97
T12: T9 + Foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS	46546	139886	93340	3.00
SEm ±	-	3599.09	3230.83	-
CD (P=0.05)	-	10555.77	9475.71	-

Conclusion

It is concluded that among different zinc fertilization treatments studied in baby corn, soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar spray of $ZnSO_4$ @ 0.2% at 25 DAS and at 40 DAS recorded significantly higher yield attributes, cob yield, corn yield, husk yield and green fodder yield over control (no zinc) and also found economically viable with higher net returns and benefit cost ratio.

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