RESEARCH ARTICLE

Effect of Zinc Fortification on Growth attributes, Yield Attributes and Soil Available Nutrients of Babycorn

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ABSTRACT

A field experiment was conducted to determine the effect of zinc fortification on growth attributes, yield attributes and soil-available nutrients of babycorn. The treatments comprised of T_1: control, T_2: $ZnSO_4$ at 25 kg ha^{-1} as soil application, T_3: $ZnSO_4$ at 37.5 kg ha^{-1} as soil application, T_4: Foliar spray at 0.5% on 20 and 40 DAS, T_5: Foliar spray at 1.0% on 20 and 40 DAS, T_6: T_2+T_4, T_7: T_2+ T_5, T_8: T_3+ T_4, T_9: T_3+ T_5. Growth parameters *viz.,* plant population, leaf area index, days to first tasseling, days to first cob initiation and days to first harvest were significantly influenced by combined application of $ZnSO_4$ to soil @ 37.5 kg ha^{-1} with foliar spray @ 1.0% on 20 DAS and 40 DAS. Dry matter production of babycorn was significantly higher in soil application of $ZnSO_4$ @ 37.5 kg ha^{-1} with foliar spray at 0.5% on 20 and 40 DAS. Increased yield attributes such as number of cobs/plant, cob and corn length, cob and corn weight, cob and corn girth were observed higher with combined application of $ZnSO_4$ @ 37.5 kg ha^{-1} to soil with foliar spray @ 0.5% at 20 and 40 DAS. Soil available nutrient status of NPK was not significantly influenced by Zn fertilization. However, higher availability of zinc nutrient after harvest of the crop was obtained with application of $ZnSO_4$ @ 37.5 kg ha^{-1} in soil with foliar spray of 0.5% at 20 and 40 DAS.

Keywords: *Zinc fortification; Babycorn; Days to first harvest; Cob weight; Available Zinc.*

INTRODUCTION

Babycorn is typically a maize ear produced from regular corn plants which are harvested earlier, particularly when the silks have a size of 1-3 cm (Thavaprakaash *et al.,* 2005). Babycorn is the safest vegetable to eat as it is almost free from pesticide residue effects due to wrapping of young cob with husk (Kawatra and Sehgal, 2007). It has a high nutritive value and its nutritional quality is superior to some of the high-priced vegetables such as tomato, cucumber, cabbage and cauliflower (Yodpet, 1979). Thavaprakaash *et al.* (2005) reported that 100 g of babycorn contained moisture (89.1 g), fat (0.2 g), carbohydrate (8.2 mg), protein (1.9 g), calcium (28.0 mg), phosphorus (86.0 mg), ash (0.06 g) and ascorbic acid (11.0 mg). It is a best source of several minerals (phosphorus, potassium, iron and calcium), vitamins (Vitamin A, B and C) and rich in fibrous protein which helps for easy digestion.

Zinc (Zn) is one of the eight trace elements, required in minimum amounts for healthy growth and development of plants and humans. When zinc supply is insufficient, it directly affects many of the physiological functions in plant. Zinc deficiency in plants reduces the crop quality and causes Zn deficiency in our diet (Bagci *et al.,* 2007). In Asia, about 2.50 billion people are suffered highly from zinc deficiencies between the age group of 0 and 5 years (Caballero, 2002). As per the World Health Organization, the human daily dietary should have zinc intake of 5 mg day $^{-1}$ for infants,10 mg day $^{-1}$ for children, 12 mg day $^{-1}$ for women, 15 mg day $^{-1}$ for pregnant women, 16 mg day $^{-1}$ for lactating women and 15 mg day $^{-1}$ for men besides iron intake of considerable amounts (Anonymous, 2000). Intake of zinc less than the quantity specified by WHO may lead to slow down the physiological processes (Salgueiro *et al.,* 2000).

Maize is highly susceptible to zinc and it occupy the third rank in zinc demand after rice and wheat (Meena *et al.,* 2013). Bio-fortification works for twin objective of increasing the concentration of the micronutrients in the grains and simultaneously improving the bioavailability of micronutrients in the grains to alleviate the micronutrient deficiency in human beings and also plants. Agronomic zinc bio-fortification in babycorn has a great scope in alleviating zinc related deficiencies in the crop as well as in human beings by consumption of Zn enriched babycorn.

Materials and Methods

A field experiment was conducted at Eastern Block Farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during late *Kharif* (September- November) of 2019. The farm is located in the Western Agro Climatic Zone of Tamil Nadu at 11^{0} N latitude, 77^{0} E longitude and at an altitude of 426.7 m above the MSL. The experiment was laid out in Randomised Bock Design (RBD) with three

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replications. Babycorn hybrid G-5414 was used for the experimentation and adopted plant spacing of 45 cm x 25 cm. The treatments comprised of T_1: No zinc (control), T_2: $ZnSO_4$ at 25 kg ha^{-1} as soil application, T_3: $ZnSO_4$ at 37.5 kg ha^{-1} as soil application, T_4: Foliar spray at 0.5% on 20 and 40 DAS, T_5: Foliar spray at 1.0% on 20 and 40 DAS, T_6: T_2+T_4, T_7: T_2+ T_5, T_8: T_3+ T_4, T_9: T_3+ T_5.

The blanket recommendation of fertilizer *viz.,* nitrogen (150 kg ha^{-1}), phosphorus (60 kg ha^{-1}) and potassium (40 kg ha^{-1}) were applied in the form of urea, single super phosphate and muriate of potash, respectively. N and K were applied in two equal splits *i.e.* one at the time of sowing and another at 25 days after sowing (DAS). Full dose of P was applied as basal. As per the treatment schedule, recommended quantity of zinc sulphate was applied as basal and foliar spray of zinc sulphate @ 0.5% and 1% was given at 20 and 40 DAS based on the treatments. De-tasseling, a most important practice in babycorn cultivation was done immediately after the emergence of the tassel before anthesis mainly to avoid pollination and fertilization. Detasseling was done manually by holding the tassels firmly with hand and giving an upward jerk for getting good quality babycorn. Totally five picking were harvested and every picking the observation on yield attributes were calculated.

Growth attributes of babycorn

Plant Population

From the net plot area, the total germinated plants were counted and calculated for area of one hectare at 15 DAS and expressed as numbers/ha.

Leaf Area Meter

Leaf area index (LAI) is the ratio of leaf area to the ground area occupied by the plant. It is a dimensionless term. The length and breadth of the third fully opened leaf from top were recorded for all the five selected plants in each treatment plot at 25 and 45 DAS and at harvest. Leaf area index was calculated using the following formula given by (Williams, 1946).

$$LAI = \frac{L \text{ x } B \text{ x } N \text{ x } 0.796}{\text{Plant spacing}}$$

Where,

L - Mean leaf length (cm), B - Mean leaf breadth (cm), N - Mean number of leaves per plant and 0.796 – Constant.

Drymatter production

Each time (25 DAS, 45 DAS and harvest), five tagged plants were selected from the sampling rows of treatment plots and uprooted without damaging the root, made free from soil by thorough washing with water and shade dried. After that, the samples were oven dried at 70 ± 2^{0}C till a constant weight was obtained. The weight was taken using an electronic balance, and the drymatter was expressed in kg ha^{-1}.

Days to emergence of first tassel and first cob initiation and days to first harvest

During the period of experimentation, tassel and cob emergence and days to harvest period were observed in all the treatment plots on every alternate day and the days on which the first tassel and cob appeared in each plot were recorded and computed as days to first tasseling and first cob initiation and days to first harvest and expressed as days.

Yield attributes of babycorn

Number of cobs per plant

From the five tagged plants in each treatment plot, the total number of cobs harvested in each picking were counted, expressed as average number of cobs per plant.

Cob length

Cobs of five tagged plants from each treatment were harvested and cob length was measured from base to tip of the cob and mean length of these cobs (average of five pickings) were obtained and expressed in cm.

Cob girth

From the representative plant samples, the girth of cobs from each treatment was measured at three points *viz.,* bottom, middle and top of the cob and mean girth of these cobs was computed and expressed in cm.

Cob weight

From the representative plant samples, the weight of green cobs from each treatment was measured and mean weight of these cobs (average of five pickings) were arrived and expressed in g/cob.

Corn length

From the representative plants, the length of the babycorn was measured from the base of the dehusked babycorn to the tip of the dehusked babycorn and the mean length of the husked corn in five pickings were recorded and expressed in cm.

Corn girth

From the representative plants, the girth of corn was measured at bottom, middle and top of babycorn and mean girth of the dehusked corn was calculated and expressed in cm.

Corn weight

From the selected five plants, green cobs weight without husk was taken and the mean was calculated as weight of corn and expressed in g/corn.

Soil Available Nutrients

From each treatment plot of the experimental area, a composite soil sample had been drawn at 0 to 15 cm depth to analyse initial and post harvest soil samples and shade dried for 2-3 days, sieved through 2 mm sieve and analyzed. The values of available nutrients (N, P, K and Zn) in soil were expressed in kg ha^{-1}.

All the data were statistically analysed as per the procedure of Gomez and Gomez (2010)

RESULTS AND DISCUSSION

Effect of zinc fortification on growth attributes of babycorn

Nutrient supply is one of the major important factors to create assured higher productivity of babycorn. Besides the response of maize and its sub types, including babycorn to increasing doses of primary nutrients, the demand for micronutrients especially zinc and iron also increases considerably. Among the two, zinc is important for normal healthy growth of higher plants, animals and humans. It is required in small amount, but in critical concentrations and if the availability is insufficient, plants and animals will highly suffer from many of the physiological stresses brought about by the irregular function of several enzyme systems and other metabolic functions in which zinc occupy a major part. Currently millions of hectare of crop plants are affected by zinc deficiency and approximately one third of the human population suffer from an inadequate intake of zinc. Low zinc content in grains and straw results in poor zinc nutrition of human beings and animals, which has received considerable attention (Cakmak, 2008).

The different levels of zinc fertilization exhibited significant impact on LAI of the crop at various stages (Table 1). The highest value of LAI was recorded with application of zinc sulphate in soil @ 37. 5 kg ha^{-1} with either 0.5 % or 1.0 % foliar spray on 20 DAS and 40 DAS with an increase of 15.9% over the control (no zinc) at 45 DAS. Leaf area index (LAI) is the key factor to determine the light interception, photosynthetic activity, transpiration rate and drymatter accumulation. Presence of more number of green leaves with larger leaf area decided leaf area index which might be due to the reason that zinc involved in cell division and cell elongation led to increased chlorophyll content with highest photosynthetic efficiency. Tekale *et al.* (2009) reported that the highest leaf area obtained was due to the influence of zinc nitrogen metabolism, uptake of nitrogen and protein quality, photosynthesis-chlorophyll synthesis, carbon anhydrase activity, resistance to abiotic and biotic stresses protection against oxidative damage. Similar findings were reported by Meena *et al.* (2013), Kumar and Bohra (2014), Manea *et al.* (2015) and Kumar *et al.* (2016).

The drymatter production is a direct index to assess the vigour and final yield of the crop. Yield of crop has a positive relationship with DMP, which influences the translocation of assimilates from source to sink. In the present investigation, application of zinc sulphate to soil @ 37.5 kg ha^{-1} with foliar spray @ 0.5% at 20 and 40 DAS resulted in accumulation of higher DMP at the rate of 20.5%, 31.5% and 39.3% over control at 25 DAS, 45 DAS and at harvest, respectively (Table 1). However, it was comparable with other zinc fertilization treatments wherein, zinc sulphate was applied both in soil (25 kg ha^{-1} or 37.5 kg ha^{-1}) along with foliar spray @ 0.5% or 1.0% on 20 and 40 DAS. Plant height, number of leaves and LAI are the direct parameters which influence the DMP. All these parameters are better in Zn fertilization, which ultimately enhanced the DMP of babycorn. The increase in DMP might be due to the involvement of zinc in the synthesis of tryptophan in plants, a precursor for the production of growth regulators like auxin, indole acetic acid and cytokinin for cell division, cell elongation and root growth and ultimately increased DMP. Sharafi *et al.* (2002) reported that zinc fertilization enhanced the growth and nutrient uptake by the crop with consequent increase in vegetative growth and finally promoted the DMP.

The results of the present field experiment indicated that days to first tasseling, days to first cob initiation and days to first harvest were significantly influenced by zinc fertilization (Fig 1). Application of zinc sulphate to soil @ 37. 5 kg ha^{-1} with 1.0% foliar spray on 20 DAS and 40 DAS took lesser days to initiate tassel and cob than others. This might be due to higher levels of Zn nutrition, which accelerated the cob development and silk emergence, thereby reducing the number of days to tasseling and initiation of babycorn. The results are duly supported by the findings of Kumar (2013).

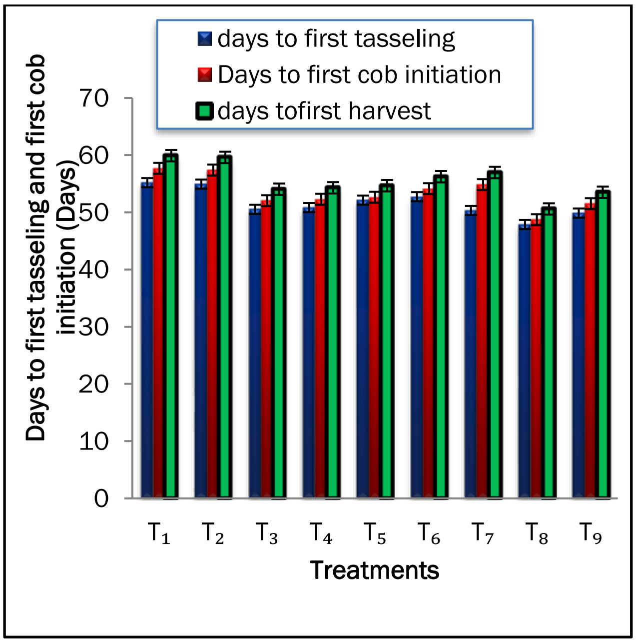


Fig 1.Effect of zinc fertilization on days to first tasseling (days), days to first cob initiation (days) and days to first harvest (days) of babycorn

Table 1.Effect of zinc fertilization on growth and yield attributes of babycorn

Treatments	Plant population (Nos ha $^{-1}$)	LAI	DMP	Number of cobs per plant (Number plant $^{-1}$)
T_1: Control (No Zinc)	86805	4.70	12741	3.1
T_2: $ZnSO_4$ @ 25 kg ha $^{-1}$ as soil application	87097	5.12	11979	3.5
T_3: $ZnSO_4$ @ 37.5 kg ha $^{-1}$ as soil application	87541	5.28	11556	3.6
T_4: Foliar spray of $ZnSO_4$ @ 0.5 % on 20 and 40 DAS	86941	5.35	13844	3.6
T_5: Foliar spray of $ZnSO_4$ @ 1.0 % on 20 and 40 DAS	87638	5.30	12452	3.6
T_6: T_2 and T_4	87464	5.38	12044	3.7
T_7: T_2 and T_5	87652	5.43	11131	3.8
T_8: T_3 and T_4	87668	5.49	13013	4.0
T_9: T_3 and T_5	87678	5.50	12178	4.0
SEd	4753	0.06	660	0.2
CD (P=0.05)	NS	0.13	1399	0.5

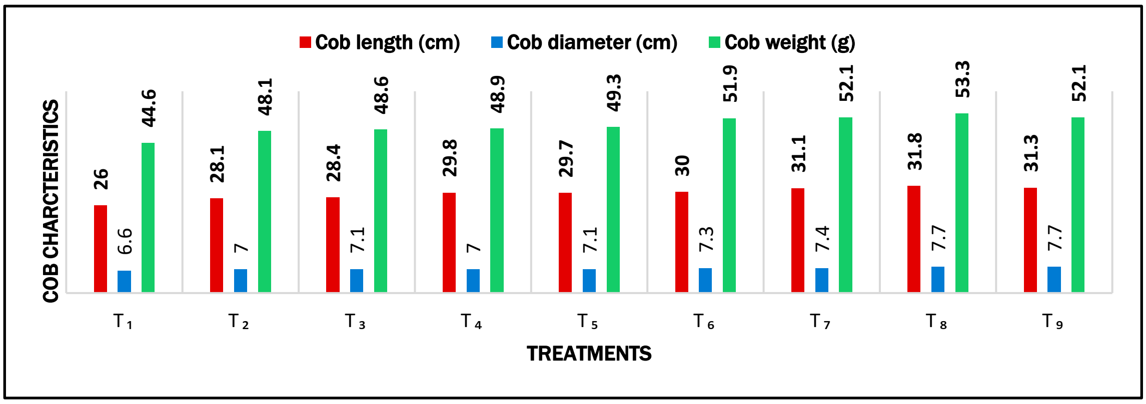


Fig. 2. Effect of zinc fertilization on cob characteristics of babycorn

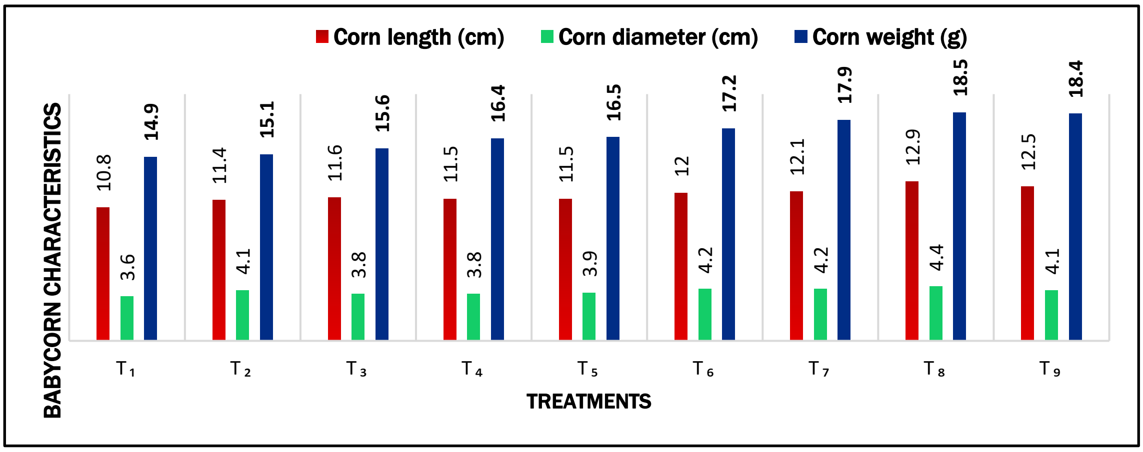


Fig. 3 Effect of zinc fertilization on Babycorn characteristics of babycorn

Effect of zinc fortification on yield attributes of babycorn

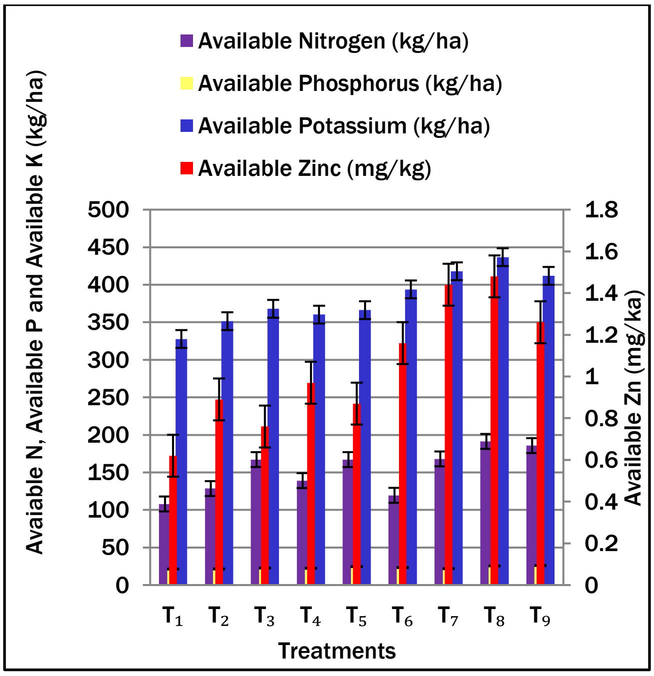
The data on yield attributes *viz.,* cob length, corn length, cob girth, corn girth, cob weight and corn weight of the crop were recorded at harvest and are furnished in the (Fig 2 & 3) and number of cobs per plant are furnished in the (Table 1)

The yield attributes of babycorn had been significantly affected by zinc fertilization. The number of cobs per plant ranged from 3.1 to 4.0 irrespective of the treatments imposed. Among the treatments, application of zinc sulphate through soil @ 37.5 kg ha^{-1} with foliar spray @ (0.5% and 1.0%) at 20 and 40 DAS (T_8 and T_9) recorded the maximum cob number (4.0 Nos.) per plant. It was observed that all the treatments that were supplied with zinc nutrition (T_9, T_8, T_7, T_6, T_5, T_4, T_3 and T_2) were statistically on par with each other, but significantly superior over control (T_1) which recorded the lowest number of cobs (3.1 Nos.) per plant.

Soil application of zinc sulphate @ 37.5 kg ha^{-1} with foliar spray of 0.5% on 20 and 40 DAS resulted in producing positive improvement in yield attributes *viz.,* number of cobs per plant, cob length, cob girth, cob weight, corn length, corn girth and corn weight over the control. The per cent increase of 22.3 per cent in cob length, 16.6 per cent in cob girth, 19.5 per cent in cob weight, 19.4 per cent in corn length, 22.2 per cent in corn girth and 24.1 per cent in corn weight. The favourable influence on yield parameters might be due to better enhancement of plant growth characters by maintaining sufficient quantity of zinc in soil as well as in plant, it ultimately betters growth and development of crop by increased photosynthetic activity and metabolic activities, which led to increase in yield attributes of babycorn. It was confirmed by Kumar and Bohra (2014), Khasragi and Yarnia (2014) and Arabhanvi and Hulihalli (2018).

Effect of zinc fertilization on soil available N, P, K and Zn of babycorn

Soil available status of P and K nutrients were not influenced by zinc fertilizer application after harvest of the crop. However, it had a profound influence on available zinc status in the soil (Fig 4). Soil available nitrogen significantly influenced by zinc fertilization because of synergistic effect on nitrogen and zinc. It was evident that higher values of soil available zinc were observed with application of zinc sulphate in soil @ 37.5 kg ha^{-1} with foliar spray of either 0.5% or 1.0 % at 20 and 40 DAS when compared to other levels of zinc fertilization and no zinc application. This might be due to that higher quantity of zinc sulphate applied in soil could have maintained optimum concentration of zinc in soil solution that accounted for the increased availability of zinc. The results were in conformity with the findings of Durgude *et al.* (2014) and Singh *et al.* (2017).



CONCLUSION

From the present study, it could be concluded that, application of zinc sulphate to soil @ 37.5 kg ha^{-1} with foliar spray @ 0.5% at 20 and 40 DAS, could be a successful practice for achieving higher productivity, profitability with bio-fortification of babycorn under irrigated condition.

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