**Effect of Zinc Fertilization on Physiological Parameters, Nutrient Uptake and Economics of Babycorn**

**Abstract**

The field experiment was conducted during late *Kharif* (September-November) of the year 2018 at Eastern Block farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore to find out the effect of agronomic bio-fortification with zinc on physiological parameters, nutrient uptake and economics of babycorn under irrigated condition. The field experiment was laid in randomized complete block design with three replications. The treatments comprised of T1: No zinc (control), T2: Zinc Sulphate (ZnSO4)at 25 kg/ha as soil application, T3: ZnSO4 at 37.5 kg/ha as soil application, T4: Foliar spray of ZnSO4 at 0.5% on 20 and 40 DAS, T5: Foliar spray of ZnSO4 at 1.0% on 20 and 40 DAS, T6: ZnSO4 at 25 kg/haas soil application + foliar spray at 0.5% on 20 and 40 DAS, T7: ZnSO4 at 25 kg/ha as soil application + foliar spray at 1.0% on 20 and 40 DAS, T8: ZnSO4 at 37.5 kg/ha as soil application + foliar spray at 0.5% on 20 and 40 DAS, T9: ZnSO4 at 37.5 kg/ha as soil application + foliar spray at 1.0% on 20 and 40 DAS. Babycorn hybrid G-5414 was used for the experimentation with adopted plant spacing of 45 cm x 25 cm. The results showed that combined application of zinc sulphate @ 37.5 kg/ha with 1.0% foliar spray at 20 and 40 DAS recorded significantly higher Crop Growth Rate (CGR) (31.07, 30.83) g/cm2/day, Relative Crop Growth Rate (RGR) (110.25, 31.67) mg/g/day and Net Assimilation Rate (NGR) (9.65, 4.54)mg/cm2/day was recorded at 25-45 DAS interval respectively, and NPK uptake was recorded higher in (T8) and total zinc content was higher in (T9) at harvest stage and higher benefit: cost ratio was obtained with soil application of zinc sulphate @ 37.5 kg/ha with 0.5% foliar spray at 20 and 40 DAS.

**Key words:** Babycorn; G 5414; Crop growth rate; Total zinc uptake and Green cob yield

**Introduction**

Maize is third most important cereal crop, next to rice and wheat. The novelty of maize is cultivating it predominantly for vegetable purpose as “babycorn”. Babycorn is typically a maize ear *(Zea mays* L.) produced from regular corn plants which are harvested earlier, particularly when the silks have the size of 1- 3 cm (Thavaprakaash *et al.,* 2005). Worldwide, Thailand is the leading producer and exporter of babycorn. India is emerging as the potential producer of babycorn due to high demand with less cost of production. The average production of babycorn in India is about 7.5-8.7 tonnes/ha (Mohinder *et al.,* 2017).

Zinc (Zn) is one of the most eight trace/oligo elements, required in minimum amounts but in critical concentrations for healthy growth and development of plants, humans and animals. In human, Zn occupies an essential role in normal healthy growth and development, to regulate the immune system, sensory functions, reproductive health and neuro behavioral development (Hershfinkel *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). Among the field crops, maize is the highly susceptible to zinc and it can be used for as an indicator plant of zinc deficiency. 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. World Health Organisation, Anonymous (2000) has estimated that bio-fortification of iron and zinc could help in curing two billion people suffering from iron and zinc deficiency-induced disorders. Agronomic zinc biofortification in babycorn has a great scope in alleviating zinc related deficiencies by human consumption of Zn rich babycorn. Hence, the present study was framed to study the agronomic bio-fortification with zinc on yield and economics of babycorn.

**Material and methods**

The field experiment was conducted during late *Kharif* (September-November) of the year 2018 at Eastern Block farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore in sandy clay loam textured soil. The farm is located in the Western Agro Climatic Zone of Tamil Nadu at 110 N latitude, 770 E longitude and at an altitude of 426.7 m above MSL. The soil of experimental field was slightly alkaline in nature (8.74), medium in organic carbon (0.53%), low available nitrogen (202 kg/ha), medium in available phosphorus (20 kg/ha), high in available potassium (757 kg/ha). The experiment was laid in Randomized Complete Block Design with nine treatments and three replications.The treatments comprised of T1: No zinc (control), T2: ZnSO4 at 25 kg/ha as soil application, T3: ZnSO4 at 37.5 kg/ha as soil application, T4: Foliar spray of ZnSO4 at 0.5% on 20 and 40 DAS, T5: Foliar spray of ZnSO4 at 1.0% on 20 and 40 DAS, T6: ZnSO4 at 25 kg/haas soil application + foliar spray at 0.5% on 20 and 40 DAS, T7: ZnSO4 at 25 kg/ha as soil application + foliar spray at 1.0% on 20 and 40 DAS, T8: ZnSO4 at 37.5 kg/ha as soil application + foliar spray at 0.5% on 20 and 40 DAS, T9: ZnSO4 at 37.5 kg/ha as soil application + foliar spray at 1.0% on 20 and 40 DAS.

During the cropping period, total rainfall of 324.4mm was received over 31 rainy days. All the treatments equally received the blanket recommended dosage of NPK (150:60:40 kg/ha), 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.,* as basal and top dressing on 25 days after sowing (DAS) while the entire dose of P was applied as basal. The quantity of zinc sulphate @ 25 kg/ha and 37.5 kg/ha was applied as basal and foliar application of zinc sulphate @ 0.5% and 1.0% given at 20 and 40 DAS as per the treatments. The plant samples collected at various growth stages (25 DAS, 45 DAS and at harvest) were shade dried followed by oven dried and ground into fine powder using willey mill and used for chemical analysis of total N, P, K and Zn as given below.

The uptake of nutrients (NPK and Zn) was worked out using the following formula.

|  |  |  |
| --- | --- | --- |
| Nutrient uptake (kg/ha) |  = | Percentage of nutrient x Total drymatter production (kg/ha) |
| 100 |

 Total cost of cultivation, gross return, net return and benefit cost ratio were worked out for various zinc fertilization treatments. In these observations were statistically analysed by (Gomez and Gomez 2010)

**Results and discussion**

**Effect of zinc fertilization on physiological parameters of babycorn**

Crop growth rate is an important factor to decide LAI and dry matter accumulation per unit area of land. Crop growth rate (CGR) had a significant influence by zinc fertilization. Soil application of zinc sulphate @ 37.5 kg/ha with 0.5% foliar spray at 20 DAS and 40 DAS recorded the highest CGR at all stages. Increase in CGR might be due to nitrogen metabolism, which in turn influenced by zinc as both the nutrients are synergistic to each other. Hammad *et al.* (2011) also opined that zinc nutrition increased the nitrogen uptake that led to higher CGR.

Relative Growth Rate (RGR) is mainly used to assess the amount of growing substance per unit dry weight of plant per unit time. Soil application of zinc sulphate @ 37.5 kg/ha with 0.5% foliar spray at 20 DAS and 40 DAS recorded higher RGR value which was comparable with other treatments of zinc fertilization over control. The results were in controversy with Sharma *et al.* (2017) reported increasing zinc concentration failed to show any variation on relative crop growth rate between 25 to 50 DAS and 50 to 70 DAS.

Perusal of the results from the experiment indicated that zinc fertilization had a significant effect on NAR. Soil application of zinc sulphate @ 37.5 kg/ha with 0.5% foliar spray at 20 and 40 DAS recorded higher NAR with an increment of 14.7% and 28.2% between 25 DAS and 45 DAS and between 45 DAS and harvest stages, respectively. The experimental results are in accordance with the findings of Palai *et al.* (2017) who reported that higher rate of zinc applied as seed priming and foliar spray @ 2% gave maximum NAR.

**Table 1. Effect of zinc fertilization on CGR, RGR and NAR at different growth stages of babycorn**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **CGR****g/cm2/day** | **RGR****mg/g/day** | **NAR****mg/cm2/day** |
| **25-45****DAS** | **45 DAS - H** | **25-45****DAS** | **45 DAS - H** | **25-45****DAS** | **45 DAS - H** |
| T1: Control (No Zinc) | 23.35 | 20.66 | 105.86 | 29.42 | 8.41 | 3.54 |
| T2: ZnSO4 @ 25 kg/ha as soil application | 25.28 | 23.93 | 106.69 | 30.33 | 8.38 | 3.77 |
| T3: ZnSO4 @ 37.5 kg/ha as soil application | 26.48 | 25.13 | 108.09 | 30.48 | 8.52 | 3.84 |
| T4: Foliar spray of ZnSO4 @ 0.5 % on 20 and 40 DAS | 27.27 | 26.25 | 108.24 | 30.82 | 8.67 | 3.97 |
| T5: Foliar spray of ZnSO4 @ 1.0 % on 20 and 40 DAS | 27.11 | 25.73 | 108.24 | 30.49 | 8.70 | 3.92 |
| T6: T2 + T4 | 28.07 | 27.35 | 108.35 | 31.10 | 8.72 | 4.04 |
| T7: T2 + T5 | 28.66 | 28.20 | 108.48 | 31.34 | 9.07 | 4.24 |
| T8:T3 + T4 | 31.07 | 30.83 | 110.25 | 31.67 | 9.65 | 4.54 |
| T9: T3 + T5 | 29.68 | 29.25 | 109.15 | 31.42 | 9.30 | 4.35 |
| **SEd** | 0.97 | 1.52 | 3.25 | 0.81 | 0.37 | 0.25 |
| **CD (P=0.05)** | 2.06 | 3.21 | NS | 1.72 | 0.78 | 0.54 |

## Effect of zinc fertilization on nutrients uptake of babycorn

Nutrient uptake is the function of nutrient concentration in plants and drymatter yield. Among the different levels of application of zinc sulphate tested, combined application of zinc sulphate of 37.5 kg/ha in soil with foliar spray of 0.5% on 20 DAS and 40 DAS recorded a profound influence on N uptake during respective growth stages. The N uptake was consistently increased with enhanced Zn doses. The uptake and accumulation of N in plants was enhanced by zinc fortification. This might be due to the synergistic effect of Zn on N and also due to better foraging capacity of roots led to better growth and development. The results of the study were in accordance with the findings of Shivay and Prasad (2014).

The P uptake had not been significantly influenced by zinc fertilization at all growth stages. The similar result was accordance with increased zinc uptake may depress root phosphorus uptake and may also involve in transportation of zinc from root to shoot through the xylem and this may be hinder translocation of P from root to shoot. These conclusions are supported in the literature (Zhu *et al.*, 2001; Keram *et al.*, 2012).

Potassium is third most important element next to N and P. K is essential needed for the plant to enhance the biomass production and make the plant to drought tolerant and disease resistant to improve the yield and quality. The K uptake had been significantly influenced by zinc fertilization at all growth stages. Application of zinc sulphate @ 37.5 kg/ha with foliar spray of either 0.5% or 1.0 % at 20 DAS and 40 DAS recorded higher K uptake during respective growth stages . Higher availability of K was noted probably due to synergistic effect between Zn and K. The results are in conformity with the findings of Meena *et al.* (2013) in maize crop.

Zinc is an important micronutrient required for normal healthy growth and development of plant. Zinc fertilization had significantly influenced the zinc uptake in babycorn. Application of zinc sulphate in soil @ 37.5 kg/ha with foliar spray of either 0.5% or 1.0% at 20 DAS and 40 DAS recorded higher Zn uptake during the respective growth stages. External application of zinc through soil and foliar application had enhanced the zinc concentration in the plants. This might be due to that higher micronutrient concentration in plants was improved by micronutrient concentration in the soil that facilitated greater absorption coupled with foliar spray which resulted in better translocation of the nutrient from source to sink. Similar results were confirmed with Kumar *et al.* (2015), Nayak and Panda (2000) and Habib (2009).

**Table 2. Effect of zinc fertilization on plant N, P, K and Zn status (kg/ha) at different stages of babycorn**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Total Nitrogen uptake (kg/ha)** | **Total Phosphorus uptake (kg/ha)** | **Total Potassium uptake (kg/ha)** | **Total Zinc uptake****(g/ha)** |
| **25 DAS** | **45 DAS** | **Harvest** | **25 DAS** | **45 DAS** | **Harvest** | **25 DAS** | **45 DAS** | **Harvest** | **25 DAS** | **45 DAS** | **Harvest** |
| T1 | 17.8 | 95.7 | 124.1 | 0.92 | 10.3 | 12.47 | 6.6 | 66.3 | 95.1 | 35.4 | 209.5 | 286.8 |
| T2 | 18.5 | 101.7 | 162.2 | 0.99 | 12.6 | 16.10 | 7.1 | 73.6 | 111.7 | 41.9 | 260.1 | 335.3 |
| T3 | 20.2 | 117.5 | 167.6 | 1.07 | 12.5 | 16.04 | 7.3 | 86.6 | 111.5 | 42.7 | 234.9 | 385.8 |
| T4 | 21.0 | 130.1 | 176.2 | 1.08 | 12.6 | 16.83 | 7.7 | 99.6 | 121.9 | 57.0 | 240.4 | 422.8 |
| T5 | 21.7 | 129.2 | 180.4 | 1.10 | 12.9 | 16.48 | 7.8 | 94.2 | 129.6 | 54.9 | 320.5 | 439.0 |
| T6 | 22.3 | 131.3 | 187.3 | 1.12 | 13.8 | 22.07 | 7.8 | 94.4 | 141.4 | 58.5 | 370.0 | 504.0 |
| T7 | 23.2 | 137.9 | 192.9 | 1.29 | 14.3 | 25.29 | 8.8 | 107.8 | 151.0 | 58.7 | 384.6 | 507.1 |
| T8 | 24.0 | 147.4 | 207.3 | 1.33 | 14.8 | 25.59 | 9.4 | 115.0 | 158.0 | 63.5 | 430.0 | 544.5 |
| T9 | 24.0 | 141.4 | 195.1 | 1.35 | 14.9 | 25.44 | 9.3 | 114.8 | 158.3 | 63.6 | 428.6 | 567.3 |
| **SEd** | 1.25 | 8.10 | 11.34 | 0.07 | 1.06 | 1.25 | 0.48 | 6.16 | 7.2 | 3.0 | 10.2 | 32.0 |
| **CD (P=0.05)** | 2.65 | 17.17 | 24.04 | 0.14 | 2.26 | 2.66 | 1.03 | 13.05 | 15.3 | 6.4 | 21.7 | 67.8 |

## Effect of zinc fertilization on economics of babycorn

The economic analysis of different treatments revealed large variations in cost of cultivation, gross return, net return and benefit cost ratio in babycorn.

Among the treatments, higher cultivation cost 78612/ha was incurred with soil application of zinc sulphate at 37.5 kg/ha with foliar spray of 1.0% on 20 DAS and 40 DAS (T9) than other treatments. Lowest cultivation cost of 75667/ha was incurred with no zinc fertilization treatment (control).

The maximum value of gross return 417732/ha was obtained with soil application of zinc sulphate at 37.5 kg/ha and foliar spray of 1.0 % on 20 DAS and 40 DAS (T9). The lowest gross return 338532/ha was attained in control (T1).

With regard to net return, soil application of zinc sulphate @ 37.5 kg/ha and foliar spray of 0.5 % at 20 DAS and 40 DAS (T8) recorded the highest net return of339422/ha followed by soil application of zinc sulphate at 37.5 kg/ha with foliar spray of 1.0% on 20 DAS and 40 DAS (T9) recording339120/ha. The lowest net return260165/ha was obtained in control (no zinc) treatment.

The benefit cost ratio was the highest (5.33) with soil application of zinc sulphate @ 37.5 kg/ha along with foliar spray of 0.5% at 20 DAS and 40 DAS (T8) . The second highest benefit cost ratio value of 5.31 was attained with soil application of zinc sulphate @ 37.5 kg/ha with foliar spray of 1.0% at 20 DAS and 40 DAS (T9). The lowest benefit cost ratio (4.44) was obtained in control (T1). Economic efficiency and viability of crop production are dependent on higher crop productivity with lesser cost of cultivation which could result in better economic parameters like higher net return and B: C ratio. In general, during the course of experimentation, cost of cultivation was higher with application of zinc sulphate with each successive increased levels (either through soil application or as foliar spray) compared to no zinc application due to increased variable costs *viz.*, cost of the input and application charges.

On consideration of the economics of babycorn as influenced by zinc fertilization it revealed that application of zinc sulphate in soil @ 37.5 kg/ha with foliar spray @ 1.0 % at 20 and 40 DAS incurred higher cost of cultivation and attained higher gross return and benefit cost ratio of 5.31. Maximum net return and benefit cost ratio of 5.33 was attained with application of zinc sulphate in soil @ 37.5 kg/ha with foliar spray @ 0.5 % at 20 and 40 DAS. This was attributed to the production of higher green cob and green fodder yields over other treatments. It is obvious because of favourable effect of zinc application on production of higher babycorn and green fodder yield as well as remunerative returns in spite of higher cost of cultivation. Similar results were also reported by Kumar and Bohra (2014), in babycorn. The results were also confirmed with Palai *et al.* (2018).

**Table 3. Economics of baby corn as influenced by zinc fertilization**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Total Cost of cultivation****(/ha)** | **Gross****return****(/ha)** | **Net return****(/ha)** | **B: C****Ratio** |
| T1: Control (No Zinc) | 75667 | 335832 | 260165 | 4.44 |
| T2: ZnSO4 @ 25 kg/ha as soil application | 77217 | 373530 | 296313 | 4.84 |
| T3: ZnSO4 @ 37.5 kg/ha as soil application | 77992 | 378802 | 300810 | 4.86 |
| T4: Foliar spray of ZnSO4 @ 0.5 % on 20 and 40 DAS | 75977 | 381270 | 305293 | 5.02 |
| T5: Foliar spray of ZnSO4 @ 1.0 % on 20 and 40 DAS | 76287 | 384810 | 308523 | 5.04 |
| T6: T2 + T4 | 77527 | 400100 | 322573 | 5.16 |
| T7: T2 + T5 | 77837 | 407204 | 329367 | 5.23 |
| T8:T3 + T4 | 78302 | 417724 | 339422 | 5.33 |
| T9: T3 + T5 | 78612 | 417732 | 339120 | 5.31 |

 (\*Data not statistically analysed)

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