Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 434-437
Received: 03-03-2019
Accepted: 06-04-2019

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Agronomic bio-fortification with zinc on growth and yield of babycorn under irrigated condition

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Abstract
A field experiment was conducted at Department of Agronomy Farm, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, to study the effect of agronomic bio-fortification with zinc on growth and yield of babycorn under irrigated condition. The treatments comprised of T_1: No zinc (control), T_2: $ZnSO_4$ at 25 kg/ha as soil application, T_3: $ZnSO_4$ at 37.5 kg/ha as soil application, T_4: Foliar spray of $ZnSO_4$ at 0.5% on 20 and 40 DAS, T_5: Foliar spray of $ZnSO_4$ 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 result of this experiment showed that combined application of zinc sulphate at 37.5 kg/ha with 0.5% foliar spray at 20 and 40 DAS recorded significantly higher plant height (211.6 cm), drymatter production (12758 kg/ha), chlorophyll SPAD value (53.56), took lesser number of days to tasseling (47.88 days) and cob initiation (48.73 days), green cob yield (18637 kg/ha) and green fodder yield (31592 kg/ha) compared to other treatments. However, it was statically on par with combined soil application of zinc sulphate (25 kg/ha or 37.5 kg/ha) with foliar spray (0.5% or 1.0%) at 20 and 40 DAS (T_9, T_7 and T_6).

Keywords: Babycorn, biofortification, zinc sulphate, SPAD values, green cob yield

Introduction
Maize is popularly called as “Queen of cereals” as well as “miracle crop” because it has a greater yield potential. 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) [19]. Babycorn is one of the safest vegetables to eat, because it has almost been free from the residual effects of pesticides due to wrapping of young cob with husk and well protected from insects and diseases (Kawatra and Sehgal, 2007) [11]. 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) [14].
In the world, about 50% of cereal growing areas have low phyto-available Zn content (Graham and Welch, 1996) [8]. Zinc deficiency not only reduces the crop production but it cause deficiency to Zn in our diet (Bagei *et al*., 2007) [2]. In Asia, about 2.50 billion people were estimated to be suffered highly from zinc deficiencies, specifically between the age group of 0 to 5 years (Cababallero, 2002) [4]. Zinc is important for the normal healthy growth of higher plants, animals and humans. Unavailability of critical zinc concentrations results in physiological stress as a results of irregular function of several enzyme systems and other metabolites. Among the field crops, maize is highly susceptible to zinc deficiency and it can be used as an indicator plant for zinc deficiency. Maize occupies the third rank in demand for zinc next to rice and wheat, respectively (Meena *et al.*, 2013) [13].
Though babycorn is popular worldwide, suitable agro-techniques to increase the production along with nutritional security is the present day need. Though babycorn is short duration crop, being an exhaustive nutrient feeder, requires considerable amount of macro and micro nutrients for sustaining higher productivity. Biofortification is the process by which the necessary daily micronutrients are delivered directly to staple crops (Bouis, 2005) [3]. The fundamental of agronomic zinc biofortification is keeping adequate quantity of available zinc in the soil solution (by soil application) and in the leaf tissues (by foliar application) which maintains sufficient level of zinc in the plant by encouraging root uptake. 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 growth and yield of babycorn.

Materials and Methods

The field study was conducted during *Kharif* season (September to November) of 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 11^0 N latitude, 77^0 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). During the cropping period, total rainfall of 324.4 mm was received over 31 rainy days. Babycorn hybrid G-5414 was used for the experimentation and adopted plant spacing of 45 cm x 25 cm. The experiment was laid in Randomized Complete Block Design with nine treatments and three replications. The treatments comprised of T_1: No zinc (control), T_2: $ZnSO_4$ at 25 kg/ha as soil application, T_3: $ZnSO_4$ at 37.5 kg/ha as soil application, T_4: Foliar spray of $ZnSO_4$ at 0.5% on 20 and 40 DAS, T_5: Foliar spray of $ZnSO_4$ 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.

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 observation on plant height, drymatter production and green fodder yield were taken based on the standard procedure. The chlorophyll content of babycorn leaves was estimated with SPAD meter and mentioned in SPAD values. The number of days counted from date of sowing to the stage when 50 per cent of the plants have projected tassels out, in each treatment was recorded and expressed as days to first tasseling and days to first cob initiation. From five picking, the total green cobs from the plants were harvested and pooled and the weight of fresh green cobs was taken and expressed as kilogram per hectare. In these observations were statistically analysed by (Gomez and Gomez 2010) [9].

Results and Discussion

Growth parameters of babycorn *viz.*, plant height, drymatter production (at harvest stage), chlorophyll content, days to tasseling, days to cob initiation, of babycorn were significantly influenced by zinc fertilization (Table 1).

Table 1: Effect of zinc fertilization on growth of babycorn

Treatment details	Plant height (cm)	Chlorophyll value (SPAD)	Days to tasseling	Days to cob initiation	Drymatter production (kg/ha)
T_1: No Zinc	143.4	40.22	55.20	57.70	9317
T_2: Znso$_4$ @ 25 kg/ha as soil application	177.6	46.84	54.94	57.40	11042
T_3: Znso$_4$ @ 37.5 kg/ha as soil application	180.5	49.14	50.53	52.05	11188
T_4: Foliar spray of Znso$_4$ 0.5% on 20 and 40 DAS	181.8	50.07	50.84	52.29	11254
T_5: Foliar spray of Znso$_4$ 1% on 20 and 40 DAS	183.7	49.34	52.14	52.64	11353
T_6: T_2 + T_4	192.1	50.47	52.75	54.15	11773
T_7: T_2 + T_5	195.9	51.25	50.33	54.86	11969
T_8: T_3 + T_4	211.6	53.56	47.88	48.73	12758
T_9: T_3 + T_5	209.9	51.93	49.88	51.53	12676
SEd	9.773	0.946	1.289	1.015	614
CD(P=0.05)l	20.72	2.005	2.734	2.152	1300

Plant height: Soil application of zinc sulphate @ 37.5 kg/ha with 0.5% foliar spray at 20 and 40 DAS recorded significantly higher plant height (211.6 cm) over others. It was statistically on par with soil application of 37.5 kg/ha zinc sulphate with 1.0% of foliar spray at 20 and 40 DAS recorded the plant height (209.9 cm) and also soil application of 25 kg/ha zinc sulphate with 1.0% of foliar spray at 20 and 40 DAS recorded plant height (195.9 cm). The lowest plant height of 143.4 cm was recorded in control (without zinc fertilizer application). The favourable influence of the micronutrient on the growth of babycorn might be due to rapid cell division and cell elongation with balanced nutrient (NPK) supply. Chand *et al.*, (2017) [5] at Rajendranagar, Hyderabad observed that application of zinc sulphate 25 kg/ha + foliar spray of 0.2% recorded the taller plant height than other treatments. Similar results reported with the findings of Kumar and Bohra (2014) [12] and Mohsin *et al*. (2014) [15].

Chlorophyll content: The growth trend of babycorn in terms of plant height was maintained in cholorophyll content also among the treatments tested in the study. Application of zinc sulphate @ 37.5 kg/ha with 0.5% foliar spray at 20 and 40 DAS has recorded higher values of chlorophyll content (53.56) which was statistically on par with soil application of $ZnSO_4$ at 37.5 kg/ha with 1% of foliar spray at 20 and 40 DAS (51.93). Lower SPAD values (40.22) were recorded in the treatment of without zinc fertilizer application. This might be due to chlorophyll content in leaves is due to zinc content which plays a cofactor for protein synthesis and biosynthesis of pigment development, the light colour of leaves reflects low concentration of zinc in leaves. The similar finding was confirmed with the findings of Durgude *et al.* (2014) [6] and Samreen *et al.* (2013) [18].

Days to first tassel and cob initiation: Application of zinc sulphate @ 37.5 kg/ha with 0.5% foliar spray at 20 and 40 DAS recorded lesser number of days for tasseling (47.88 days) and cob initiation (48.73 days), compared to other treatments under testing. This was on par with soil application of the micronutrient @ 37.5 kg/ha with 1% of foliar spray at 20 and 40 DAS registering 49.88 days and 51.53 days, for tasseling and cob initiation, respectively. The treatment without zinc fertilizer application took more days for tasseling and cob initiation. This might be due to the influence of zinc on photosynthates accumulation which decided the days to tasseling and cob initiation.

Drymatter production: Application of zinc sulphate 37.5 kg/ha with 0.5% foliar spray at 20 and 40 DAS recorded significantly higher drymatter production (12758 kg/ha) among the treatments tested over others. It was statistically on par with soil application of $ZnSO_4$ @ 37.5 kg/ha with 1% of foliar spray at 20 and 40 DAS that registered 12676 kg/ha and also soil application of 25 kg/ha Zinc sulphate with 1.0% of foliar spray at 20 and 40 DAS recorded (12676 kg/ha). The favourable increase in drymatter of babycorn might be due to zinc involvement in auxin synthesis which played a major role in photosynthetic activity of the crop (as in other C_4 plants) reported that soil application of zn @ 6 kg/ha + one foliar spray @ 0.05% zn at 25 DAS was significantly higher than all treatments. The present study is in accordance with the findings of Palai *et al.*, (2018) [17].

The profound increase in these growth parameters was probably due to the involvement of zinc in auxin metabolism, which led to higher hormonal activity and growth performance at critical crop growth stages.

Yield

Green cob yield

Green cob yield was positively influenced by zinc fertilization (Table 2). Soil application of zinc sulphate 37.5 kg/ha along with 0.5% foliar spray at 20 and 40 DAS recorded higher green cob yield (18637 kg/ha) than others and was on par with application of 37.5 kg zinc sulphate with 1% foliar spray at 20 DAS and 40 DAS (18516 kg/ha). The lowest green cob yield (13578 kg/ha) was recorded in control treatment (without zinc application). The favourable influence on the yield of babycorn might be due to reason of auxin and starch synthesis influenced by zinc fertilizer, applied both in soil as well as foliar spray. Favourable crop growth such as more plant height, drymatter production and chlorophyll content also enhanced the yield attributes and increased the yield ultimately. Similar results were reported by Chand *et al*. (2017) [5] and Aravinth *et al.* (2011) [1].

Table 2: Effect of zinc fertilization on green cob yield and green fodder yield of babycorn

Treatment details	Green cob yield (kg/ha)	Green fodder yield (kg/ha)
T_1: No Zinc	13578	19603
T_2: $Znso_4$ @ 25 kg/ha as soil application	16115	25615
T_3: $Znso_4$ @ 37.5 kg/ha as soil application	16328	26121
T_4: Foliar spray of $Znso_4$ 0.5% on 20 and 40 DAS	16425	26351
T_5: Foliar spray of $Znso_4$ 1% on 20 and 40 DAS	16571	26695
T_6: $T_2 + T_4$	17189	28160
T_7: $T_2 + T_5$	17476	28842
T_8: $T_3 + T_4$	18637	31592
T_9: $T_3 + T_5$	18516	31306
SEd	865	1082
CD (P=0.05)	1834	2294

Green fodder yield

The similar trend of green cob yield was maintained in green fodder yield also. Wherein, the combined application of zinc sulphate 37.5 kg/ha with 0.5% foliar spray at 20 and 40 DAS showed its significant superiority in producing higher green fodder yield (31592 kg/ha) than other treatments. It was on par with by zinc sulphate application in soil @ 37.5 kg/ha with 1% foliar spray at 20 and 40 DAS of zinc sulphate. Green fodder yield was increased due to the enhanced translocation of photosynthates, which resulted in higher production of green fodder with respective levels of zinc as soil and foliar application. Similar results of higher fodder yield with Zn application was also reported by Kumar *et al.*, (2013) [10] and Mona (2015) [16].

Conclusion

From this study, it could be concluded that among the different treatments of zinc fertilization, soil application of $ZnSO_4$ (37.5 kg/ha or 25 kg/ha) with foliar spray of (0.5% or 1.0%) at 20 DAS and 40 DAS recorded higher growth parameters, green cob yield and green fodder yield of babycorn. Increased the plant height and drymatter production as evidenced in the present study also influenced favourably on the green fodder yield.

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