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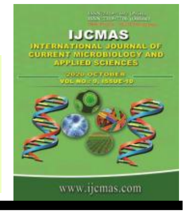

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Effect of Zinc and Iron Fortification on Growth and Yield of Summer Pearl Millet (*Pennisetum glaucum* (L.) R. Br. Emend. Stuntz)

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A B S T R A C T

A field experiment was conducted on medium black calcareous clayey soil at Junagadh (Gujarat) during summer season of 2019 to study the effect of zinc and iron fortification on growth and yield of summer pearl millet (*Pennisetum glaucum* (L.) R. Br. Emend. Stuntz). The experimental results revealed that significantly higher values of growth parameters *viz.*, Number of total tillers/plan tand yield attributes *viz*., Number of effective tillers/plant, Ear head length, Ear head girth and 1000-grain weight along with higher seed yield and stover yield were recorded with increasing foliar spray of iron and zinc. However, higher net return and B:C ratio were also realized with the application of $FeSO_4$ @ 1.0% 25 & 50 DAS and $ZnSO_4$ @ 0.5% at 25 & 50 DAS.

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br. Emend. Stuntz] is the most widely grown type of millet. It has been grown in Africa and South Asia since prehistoric times. In Asia, important pearl millet growing countries are India, China, Nigeria, Pakistan, Sudan, Egypt, Arabia and Russia. Pearl millet belongs to Gramineae family. It is one of the most important food grain cereal crops of India and ranks fourth in area after rice, wheat and sorghum. It is one of the major cereal crop grown in the arid and semi-arid regions of the world. India is the largest single producer of the crop, both in terms of area 6.93 million hectares and production 8.61 million tonnes and productivity of 1243 kg/ha (Directorate of Millets Development, 2020) during summer season.

Major pearl millet growing states in India are Rajasthan (52.34%), Maharashtra (14.6%) and Gujarat (9.9%). Banaskatha, Junagadh, Jamnagar, Rajkot, Mehsana, Kheda, Amerali and Kutch are the major pearl millet growing districts of Gujarat. The area under summer pearl millet was 2.26 lakh hectares with an annual production of 6.17 lakh tonnes and productivity of 2721 kg/ha in Gujarat state during 2019-2020 (Anon., 2020).

Zinc plays significant role in various enzymatic and physiological activities of plant. Zinc is an essential micro nutrient required for growth and development of the higher plants (Kochian, 1993 and Marschner, 1995) and is involved in membrane integrity, enzyme activation and gene expression (Kim *et al*., 2002).

Iron plays a role in the formation of plant chlorophyll. Iron-containing plant haemoglobins are another promising target for altering Fe content in plant-based foods. Plant haemoglobin is similar to the human haemoglobin, with Fe binding capacity and is most commonly found in nodulating legumes (nitrogen fixing plants) (Kundu *et al*., 2003).

Bio fortification is the process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding or modern biotechnology. Bio fortification differs from conventional fortification in that bio fortification aims to increase nutrient levels in crops during plant growth rather than through manual means during processing of the crops. Agronomic approaches such as application of Zn and Fe-containing fertilizers appear to be rapid and simple solution to address the Zn and Fe deficiency in crop and human health. Agronomic fortification with foliar application of micronutrients particularly zinc and iron not only increase the yield but also nutrient quality of pearl millet for obtaining good economic return and also nutritional security. So, enrichment of pearl millet with zinc and iron fortification is one of the option to improve the quality.

Materials and Methods

The field experiment was conducted during the year 2019 at Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh (Gujarat), which is situated in South Saurashtra Agro-climatic region of Gujarat state and enjoys a typically subtropical climate characterized by fairly cold and dry winter, hot and dry summer as well as warm and moderately humid monsoon. Which is situated at 21.5^0 N latitude and 70.5^0 E longitudes with an altitude of 60 m above the mean sea level. The soil was clayey in texture and slightly alkaline in reaction with pH 7.9 and EC 0.33 dS/m. The soil of the experimental site was medium in available nitrogen (277 kg/ha), available phosphorus (27.02 kg/ha), available potassium (279.55 kg/ha), medium in available zinc (0.65 ppm) and medium in available iron (5.53 ppm). The soil was free from any kind of salinity or sodicity hazards.

The experiment was conducted with three foliar spray of $FeSO_4$ *viz*., F_1: Control (No spray), F_2: $FeSO_4$ @ 1.0% at 25 DAS, F_3: $FeSO_4$ @ 1.0% at 25 & 50 DAS and Foliar spray of $ZnSO_4$*viz*., Z_1: Control (No spray), Z_2: $ZnSO_4$ @ 0.5% at 25 DAS, Z_3: $ZnSO_4$ @ 0.5% at 25 & 50 DAS in factorial randomized block design replicated three times. The crop was sown at 45 x 10 cm^2 spacing on 20th February and recommended dose of fertilizer was 120-60-0 N-P-K kg/ha and all other recommended practices were adopted according to as per needed of crop requirement. The crop was harvested at physiological maturity on May 17, 2019. The growth and yield attributes were recorded from the five tagged plants in each plot. Seed and stover yield were recorded from the net plot area and converted into kilogram per hectare base.

The expenses incurred for all the cultivation operations from preparatory tillage to harvesting including the cost of inputs *viz*., seeds, manures, fertilizers, irrigation, etc. applied to each treatment was calculated on the basis of prevailing local charges. The gross realization in terms of rupees per hectare was worked out taking into consideration the seed and stover yields from each treatment and local market prices. Net return of each treatment was calculated by deducting the total cost of cultivation from the gross returns. The benefit:cost ratio (B:C) was calculated by dividing gross return with cost of cultivation.

Statistical analysis of the individual data of various characters studied in the experiment was carried out using standard statistical procedures as described by Panse and Sukhatme (1985). Standard error of mean, critical difference (C.D.) at 5 per cent level of probability and coefficient of variance were worked out for the interpretation of the results.

Results and Discussion

Effect of iron

It is apparent from data in Table 1 indicated that the increasing foliar spray of iron significantly increased the number of total tillers per plant as well as number of effective tillers per plant, earhead length, earhead girth and 1000-grain weight. Seed and stover yields also increased significantly up to $FeSO_4$ @ 1.0% at 25 & 50 DAS. Application of $FeSO_4$ @ 1.0% at 25 & 50 DAS registering highest grain yield (4430 kg/ha) and stover yield (8019 kg/ha). This might be due to iron role in starch formation and protein synthesis as well as maintenance and synthesis of chlorophyll in plants.

Table.1 Growth attributes, yield attributes and yield as influenced by different iron and zinc applications

Treatments	Number of total tillers/plant	Number of effective tillers/plant	Earhead Length (cm)	Earhead Girth (cm)	1000-grain weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
Foliar spray of iron							
F_1: Control (No spray)	4.49	2.87	20.24	7.16	8.27	3707	6803
F_2: $FeSO_4$ @ 1.0% at 25 DAS	6.00	4.02	23.84	8.77	9.77	4004	7526
F_3: $FeSO_4$ @ 1.0% at 25 & 50 DAS	6.38	4.13	24.60	8.99	10.56	4430	8019
S.Em.±	0.16	0.09	0.62	0.23	0.27	158	289
C.D. at 5%	0.47	0.28	1.86	0.69	0.80	475	866
Foliar spray of zinc							
Z_1: Control (No spray)	5.09	3.27	21.38	7.58	8.95	3649	6771
Z_2: $ZnSO_4$ @ 0.5% at 25 DAS	5.71	3.80	23.10	8.51	9.46	4031	7493
Z_3: $ZnSO_4$ @ 0.5% at 25 & 50 DAS	6.07	3.96	24.19	8.83	10.20	4462	8084
S.Em.±	0.16	0.09	0.62	0.23	0.27	158	289
C.D. at 5%	0.47	0.28	1.86	0.69	0.80	475	866
Interaction (Fe × Zn)							
S.Em.±	0.27	0.16	1.07	0.40	0.46	274	500.83
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
C.V.%	8.31	7.69	8.13	8.31	8.36	11.75	11.64

RDF (120:60:00 kg $N:P_2O_5:K_2O$/ha) was applied to all the treatments

Table.2 Economics of pearl millet as influenced by different iron and zinc applications

Treatments	Gross return (₹ /ha)	Cost of cultivation (₹ /ha)	Net return (₹ /ha)	B:C ratio
Foliar spray of iron				
F_1: Control (No spray)	80348	26134	54214	3.07
F_2: $FeSO_4$ @ 1.0% at 25 DAS	87137	27158	59979	3.20
F_3: $FeSO_4$ @ 1.0% at 25 & 50 DAS	95786	28183	67603	3.40
Foliar spray of zinc				
Z_1: Control (No spray)	79237	26347	52890	3.00
Z_2: $ZnSO_4$ @ 0.5% at 25 DAS	87548	27158	60390	3.22
Z_3: $ZnSO_4$ @ 0.5% at 25 & 50 DAS	96486	27969	68517	3.45

The increased in the availability of iron to plant might have stimulated the metabolic and enzymatic activities thereby increasing the growth of the crop. Similar findings were also reported by Yadav *et al*., (2013). Iron provides potential for many of the enzymatic transformations. Several of these enzymes are involved in chlorophyll synthesis, grain formation and dry matter production, which ultimately lead to final yield characters such as number of effective tillers per plant. These findings are in confirmation to the earlier reported by Gupta *et al.,* (2002) and Abbas *et al.,* (2009). There was considerable increase in net return and B:C ratio due to iron application. Increasing foliar spray of iron significantly increased the net returns up to $FeSO_4$ @ 1.0% at 25 & 50 DAS (₹ 67603/ha) with B:C ratio 3.40. This might be due to significant increase in yield with increased supply of available iron and correction in hidden deficiency of iron in plant or better nutrition of the crop with the foliar application of this nutrient. It gave maximum recovery from application of iron with less expenditure. Similar result was also reported by Yadav *et al*., (2013).

Effect of zinc

The perusal of data presented in Table 1 revealed that the increasing foliar spray of zinc significantly increased the number of total tillers per plant as well as number of effective tillers per plant, earhead length, earhead girth and 1000-grain weight. Seed and stover yields are increased significantly up to $ZnSO_4$ @ 0.5% at 25 & 50 DAS. Application of $ZnSO_4$ @ 0.5% at 25 & 50 DAS registering highest grain yield (4462 kg/ha) and stover yield (8084 kg/ha). Zn plays important role in synthesis of various enzymes like carbonic anhydrase, glutamic acid dehydrogenase, lactic acid dehydrogenase and some peptidases. It is also considered to be precursor for auxin synthesis involved in nitrogen metabolism and several oxidation-reduction reactions, stability of RNA and starch formation thus its adequate supply results higher dry matter production, ultimately growth and development of plants (Dadhich and Gupta, 2003). Parallel results were also established by Abbas *et al*., (2016). The increased in the yield attributes might also be due to role of zinc in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordia for reproductive parts and partitioning of photosynthates towards them (Wear and Hagler, 1968), which might have been resulted in better flowering and fruiting. This finding is in conformation to the earlier reports of Singaravel *et al*., (2001).

Successive increase in zinc rates up to 0.5% at 25 & 50 DAS significantly increased net returns (₹ 68517/ha) and B:C ratio 3.45. This could be primarily due to higher grain and stover yields (Table 2) with comparatively less additional cost of zinc compared to additional yield under this treatment. The result is in conformity with the work of Gill and Walia (2013)

On the basis of the results of the present one year field study, it can be concluded that higher production and net returns from summer pearl millet (GHB-732) can be secured by application of $FeSO_4$ @ 1.0% and $ZnSO_4$ @ 0.5% at 25 & 50 DAS.

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