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Effect of zinc and iron on growth and yield of sorghum (*Sorghum bicolor* L.)

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Abstract
The field experiment was conducted during *Kharif* season of 2020 at Sri Aurobindo Institute of Rural Development Krishi Vigyan Kendra, Gaddipally, Garidepally, Suryapet, Telangana. The soil of the experimental field is sandy loam in texture, nearly neutral in soil reaction (pH 7.4), the available N, P, K fertilizer is applied along with micronutrients of Zinc and Iron. The treatment ofRDF + 0.5% $ZnSO_4$ Foliar spray at 25 and 45 DAS, *viz*. whose effect is observed on Sorghum (var. PSV-56). The experiment was laid out in Randomized Block Design with nine treatments replicated thrice. The treatment with RDF + 0.5% $ZnSO_4$ foliar spray at 25 and 45 DAS found significantly higher in Plant height (164.53 cm), dry weight (44.67 g/plant), crop growth rate (23.00 g/m^2/plant), more number of effective tillers/plant and ears/plant were as compared to other treatments. Maximum number of grains/ear (844.38) and Grain yield (4433.33 kh/ha) were found significantly higher with the application of treatment RDF + 0.5% $ZnSO_4$ foliar spray at 25 and 45 DAS and Test weight (32.6g) were found significantly higher with the application of treatment RDF + 0.5% $ZnSO_4$ foliar spray at 45 DAS as compared to other treatments. Maximum Gross return (Rs.112086.00/ha), Net return (Rs.75703.40/ha) and B: C ratio (2.08) were recorded in treatment with application of treatment RDF + 0.5% $ZnSO_4$ foliar spray at 25 and 45 DAS.

Keywords: $ZnSO_4$, $FeSO_4$, foliar spray, RDF

Introduction
Sorghum is one of the most important tropical crop grown in India and best adopted in the region of low rainfall. It contains 10-12% protein, 70% carbohydrate, 3% fats, vitamins and mineral salts which are essential for vigorous growth of human life. It is grown on an area of about 45 m. ha in the world with a production of about 61m.t, while in India it occupies an area of about 12.8 m ha with a total production of about 12.5 m.t. Average productivity of sorghum in India is only 977 kg per ha which is well below the world average of 1500 kg per ha.

Micronutrients are important for maintaining soil health and also increasing productivity of crops. These are needed in very small amounts. The soil must supply micronutrients for desired growth and development of plants. Increased removal of micronutrients as a consequence of adoption of HYVs and intensive cropping together with shift towards high analysis NPK fertilizers has caused decline in the level of micronutrients in the soil to below normal at which productivity of crops cannot be sustained.

Zn is essential for several enzyme systems that regulate various metabolic activities in plants. It is involved in auxin production which is growth regulating substances in plants. Zinc is also vital for the oxidation processes in plant cells and helps in the transformation of carbohydrates and regulates sugar in plants. (Tandon 1995) [6]. It is important in the synthesis of tryptophan, a component of some proteins and a compound needed for the production of growth hormones like indole acetic acid. Reduced growth hormone production in Zn-deficient plants causes the shortening of internodes and smaller than normal leaves (Tisdale *et al*. 2003) [7].

Materials and Methods
Experimental site and plant material
The experiment was carried out during *Kharif* season of 2020 at Sri Aurobindo Institute of Rural Development Krishi Vigyan Kendra, Gaddipally, Garidepally, Suryapet, Telangana. The KVK is situated at 79 36'47" N latitude, 17 8'22" E longitude (Google, 2020) and 331 m altitude above the mean sea level. This area is situated in the village outskirts of gaddipally. Total land in kvk was 25.9 ha but under crops it was 19.6 ha.

Soil of the experimental site was sandy loam with pH 7.4 and organic carbon status 0.51%. The area was ploughed and harrowed before sowing. Recommended dose of fertilizer was applied before sowing to each plot at 80:40:40 NPK kg/ha.

The seeds of sorghum (*Sorghum bicolor* L.) variety "PSV-56" were sown in eight rows per plot, with spacing of 45 cm between rows. After germination, the plants were thinned to obtain optimum plant population. Two inter-culturing and hand weeding were carried out. The micronutrients were used as soil application and as foliar sprayed at time intervals as following treatments

Treatments

The experiment comprised of total 9 treatments *viz*. T1(Absolute control), T2 (RDF + 20kg Zinc as soil application), T3 (RDF + 0.5% $ZnSO_4$ Foliar spray at 25DAS), T4 (RDF + 0.5% $ZnSO_4$Foliar spray at 45DAS), T5 (RDF + 0.5% $ZnSO_4$ Foliar spray at 25 and 45 DAS), T6 (RDF + 10 kgs Iron (Soil application), T7 (RDF + 0.5% $FeSO_4$ Foliar spray at 20DAS), T8 (RDF + 0.5% $FeSO_4$ Foliar spray at 40DAS), T9 (RDF + 0.5% $FeSO_4$ Foliar spray at 20 and 40DAS).

Experimental design and layout

The experiment was laid out thrice in Randomized Block Design (R.B.D.) in with the plot size of (a) Gross cultivated area: 366.12 m2 (b) Net cultivated area: 243 m. The row spacing and seed rate were 45 cm x 15 cm and 6 Kg\ha respectively. The fertilizer 80:40:40 NPK kg/ ha was applied.

Observations

The plants were harvested at physiological maturity and yield components, such as plant height (cm), number of tillers, number of ears, 1000 seed weight were recorded on five randomly selected plants in each plot. Seed yield was determined by harvesting the plants for meter square.

Seed yield (kg/ha)

At the maturity, the sesame crop in each plot was harvested and threshed, and yield ha−1 was calculated by the following formula

Seed yield plot/kg Seed yield kg/ha = (Seed yield plot/kg / Plot size m^2) X 10000

Results and Discussion

Effect of Zinc and Iron on growth parameters

Plant height

At harvest, there was non-significant difference between the treatments and maximum plant height (164.53 cm) was observed the applications of RDF + 0.5% $ZnSO_4$ Foliar spray at 25 and 45 DAS followed by treatment with RDF + 10 kgs Iron (Soil application).

Plant height increased with application of zinc fertilizer. Since zinc is involved in the biosynthesis of Indole 3-acetic acid, a growth hormone, involved in stem elongation, hence the increase in the plant height. Earlier Patel *et al.*, (2007) [5] also reported a significant increase in the plant height with soil application of zinc over its foliar application and control. Similar results were also observed by Azam *et al.*, 2010 [1] and Bhoya *et al.*, 2014.

Plant dry weight

At harvest, the maximum and significant plant dry weight (44.67 g) was observed in treatment with the applications of RDF + 0.5% $ZnSO_4$ Foliar spray at 25 and 45 DAS. Whereas treatment with application of RDF + 0.5% $ZnSO_4$ Foliar spray at 45DAS and RDF + 0.5% $FeSO_4$ Foliar spray at 20 and 40DAS were statistically at par with the applications of RDF + 0.5% $ZnSO_4$ Foliar spray at 25 and 45 DAS as compared to other treatments.

Higher dry matter production due to zinc application may also be attributed to higher plant height, more leaf area index and additive effect of significant increase in green forage and dry fodder yield. Earlier Marschner (1995) [3] and Patel *et al.*, (2007) [5] have also reported significant increase in dry matter yield with zinc application over its foliar application.

Effect of Zinc and Iron on yield and yield attributes

Number of effective tillers per plant

The maximum and significant Number of effective tillers per plant (1.61) was observed in treatment with the applications of RDF + 0.5% $ZnSO_4$ Foliar spray at 25 and 45 DAS, whereas the treatment with application of RDF + 0.5% $ZnSO_4$ Foliar spray at 45DAS and RDF + 0.5% $FeSO_4$ Foliar spray at 20 and 40DAS were satistically at par with highest treatment as compared to other treatments.

Number of ears/plant

There was non-significant difference between the treatments and maximum Number of ears/plant (1.57) was observed with application of RDF + 0.5% $ZnSO_4$ Foliar spray at 25 and 45 DAS.

Number of grains/ear

The maximum and significant Number of grains/ear (844.38) was observed in treatment with the applications of RDF + 0.5% $ZnSO_4$ Foliar spray at 25 and 45 DAS, whereas the treatment with application of RDF + 0.5% $ZnSO_4$ Foliar spray at 45DAS and RDF + 0.5% $FeSO_4$ Foliar spray at 20 and 40DAS were satistically at par with highest treatment as compared to other treatments.

Test weight

There was non-significant difference between the treatments and maximum test weight (32.6 g) was observed with application of RDF + 0.5% $ZnSO_4$ Foliar spray at 45 DAS.

Grain yield

The maximum and significant Grain yield (4433.33 kg/ha) was observed in treatment with the applications of RDF + 0.5% $ZnSO_4$ Foliar spray at 25 and 45 DAS, whereas the treatment with application of RDF + 0.5% $ZnSO_4$ Foliar spray at 45DAS and RDF + 0.5% $FeSO_4$ Foliar spray at 20 and 40DAS were satistically at par with highest treatment as compared to other treatments.

Stover yield

The maximum and significant Stover yield (7054.44 kg/ha) was observed in treatment with the applications of RDF + 0.5% $ZnSO_4$ Foliar spray at 25 and 45 DAS, whereas the treatment with application of RDF + 0.5% $ZnSO_4$ Foliar spray at 45DAS and RDF + 0.5% $FeSO_4$ Foliar spray at 20 and 40DAS were satistically at par with highest treatment as compared to other treatments.

The increase in grain and straw yield due to Zn fertilization may be ascribed to the fact that zinc plays an important role in biosynthesis of the IAA and initiation of primordial for reproductive parts and a result of favourable effect on the metabolic reactions within the plants. Enhancement of enzymatic activity by zinc application which in turn might have stimulated the translocation of assimilates efficiently toward sink that resulted in increased yield (Malve *et al.*, 2014) [4].

Table 1: Effect of Zinc and Iron on growth attributes of Sorghum

S. No.	Treatment combination	Plant height (cm)	Plant dry weight (g/plant)	Crop growth rate (g/m²/day)	Relative growth rate (g/g/day)
1.	Control (80-40-40 kg N-P-K/ha)	157.09	63.27	19.58	0.026
2.	RDF + 20 kg Zinc (soil application)	155.16	64.17	20.86	0.027
3.	RDF + 0.5% ZnSO4 foliar spray at 25 DAS	155.2	66.85	21.11	0.026
4.	RDF + 0.5% ZnSO4 foliar spray at 45 DAS	155.79	68.65	21.88	0.027
5.	RDF + 0.5% ZnSO4 foliar spray at 25 and 45 DAS	164.53	71.26	23.60	0.027
6.	RDF + 10 kgs Iron (soil application)	163.70	64.10	19.94	0.026
7.	RDF + 0.5% FeSO4 foliar spray at 20 DAS	162.28	65.94	20.72	0.026
8.	RDF + 0.5% FeSO4 foliar spray at 40 DAS	159.7	66.80	21.08	0.026
9.	RDF + 0.5% FeSO4 foliar spray at 20 and 40 AS	157.97	68.56	21.85	0.027
	SEm(±)	2.48	1.19	0.55	0.001
	CD	-	3.55	1.63	-

Table 2: Effect of Zinc and Iron on yield and yield attributes of Sorghum

S. No	Treatments	No. of effective tillers/plant	No. of ears/plant	No. of grains/ear	Test weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)
1	Control	1.427	1.363	768.07	31.13	3720.6	6116.93
2	RDF + 20 kg Zn (Soil application)	1.469	1.404	767.19	31.37	3616.66	6336.53
3	RDF + 0.5 % $ZnSO_4$ Foliar spray at 25 DAS	1.441	1.402	802.29	30.43	3610	6061.33
4	RDF + 0.5 % $ZnSO_4$ Foliar spray at 45 DAS	1.567	1.494	819.47	32.26	4243.33	6544.66
5	RDF + 0.5 % $ZnSO_4$ Foliar spray at 25 DAS and 45 DAS	1.611	1.575	844.38	30.62	4433.33	7054.66
6	RDF + 10 kg Iron (Soil application)	1.489	1.381	776.02	31.08	3391.63	6475.69
7	RDF + 0.5 % $FeSO_4$ Foliar spray at 20 DAS	1.474	1.486	793.61	30.22	3230.79	6234.58
8	RDF + 0.5 % $FeSO_4$ Foliar spray at 40 DAS	1.493	1.464	802.17	32.16	3562.2	6274.66
9	RDF + 0.5 % $FeSO_4$ Foliar spray at 20 DAS and 40 DAS	1.526	1.526	818.63	30.09	4123.33	6784.66
	Sem (+)	0.03	0.05	11.74	0.51	119.07	116.13
	CD (0.05%	0.10	-	34.88	-	353.77	345.04

Table 3: Effect of Zinc and Iron on economics of Sorghum

S. No	Treatments	Total cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
1	Control	35682.70	94459.10	58776.50	1.65
2	RDF + 20 kg Zn (Soil application)	36722.70	92601.40	55878.70	1.52
3	RDF + 0.5 % $ZnSO_4$ Foliar spray at 25 DAS	36032.70	91903.70	55871.00	1.55
4	RDF + 0.5 % $ZnSO_4$ Foliar spray at 45 DAS	36032.70	106867.00	70834.40	1.97
5	RDF + 0.5 % $ZnSO_4$ Foliar spray at 25 DAS and 45 DAS	36382.70	112086.00	75703.40	2.08
6	RDF + 10 kg Iron (Soil application)	36102.70	87906.50	51803.90	1.43
7	RDF + 0.5 % $FeSO_4$ Foliar spray at 20 DAS	36222.70	83869.70	47647.00	1.32
8	RDF + 0.5 % $FeSO_4$ Foliar spray at 40 DAS	36222.70	91274.00	55051.30	1.52
9	RDF + 0.5 % $FeSO_4$ Foliar spray at 20 DAS and 40 DAS	36762.70	104695.00	67932.40	1.85

Summary

The present investigation titled, "Effect of Zinc and Iron on growth and yield of Sorghum (*Sorghum bicolor* L.)" was conducted at Sri Aurobindo Institute of Rural Development Krishi Vigyan Kendra, Gaddipally, Garidepally, Suryapet, Telangana. During *Kharif* season of 2020. The experiment was laid out in Randomized block design with nine treatments replicated thrice. The important findings of the experiment have been summarized and concluded here under this chapter.

1. The results revealed that increase in growth attributes of Sorghum *viz*., Plant height, Plant dry weight, Crop growth rate, more Number of Effective tillers per plant and number of ears per plant, recorded maximum plant height (164.53 cm), dry weight (44.67 g/plant), crop growth rate (23.00 g/m^2/plant), more number of effective tillers/plant and ears/plant were found significantly higher with application of treatment No.5 RDF + 0.5% $ZnSO_4$ foliar spray at 25 and 45 DAS as compared to other treatments. Maximum number of grains/ear (844.38) and Grain yield (4433.33 kg/ha) were found significantly higher with the application of treatment RDF + 0.5% $ZnSO_4$ foliar spray at 25 and 45 as compared to other treatments.
2. Maximum Gross return (Rs.112086.00/ha), Net return (Rs.75703.40/ha) and B: C ratio (2.08) were recorded in treatment with application of treatment No.5 RDF + 0.5% $ZnSO_4$ foliar spray at 25 and 45 DAS.

Conclusion

On the basis of one *Kharif* season experimentation it was concluded that the application of treatment No.5 RDF + 0.5% $ZnSO_4$ foliar spray at 25 and 45 DAS was found more productive (Rs.4433.33 kg/ha) but BC ratio of 2.08. The conclusions drawn are based on one season data only which requires further confirmation for recommendation.

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