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Effect of Micronutrients on Growth and Yield of Sorghum (*Sorghum bicolor* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted during *Zaid* season 2022 at experimental field of Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj and Uttar Pradesh, India. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH7.3), low in organic carbon (0.48%), available nitrogen (230 kg/ha), available phosphorus (13.60 kg/ha) and available potassium (215.4 kg/ha). The treatments consist of Zinc soil application (2.5,5 kg/ha) and Zinc foliar application (0.3, 0.6%) along Boron (0.3%) and Iron (0.3%) along with control. The experiment was layout in Randomized Block Design with ten treatments each replicated thrice. Higher plant height (185.19cm), maximum plant dry weight (92.86 g) and the yield attributes namely test weight (15.50g), grains/earhead (1297.67), grain yield (3.03t/ha), stover yield (4.16t/ha) was with treatment 9 [Zinc 2.5ka/ha + Zinc 0.3% + B 0.3% + Fe 0.3%].

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1. INTRODUCTION

"Sorghum [*Sorghum bicolor* L.] is the king of millets and third important crop in the country after rice and wheat. Sorghum is grown extensively in almost all the countries in Africa, America, Brazil, China, Russia and Peru and grown substantially by marginal farmers. Sorghum ranks 5th among the world cereal food crops after Rice, Wheat, Maize and Barley. In India, it is most popularly known as "Jowar". It is widely grown especially in tropical and sub-tropical regions of India. 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" [1]. "Because of its wide adaptation, rapid growth, high green and dry fodder yields with high ratoonability, and drought tolerance, sorghum has great potential to supplement fodder resources in India" Belum et al. [2]. **"**It contains 10-12% protein, 70% carbohydrate, 3% fats, vitamins and mineral salts which are essential for vigorous growth of human life. It is being considered more stable and adaptable crop compared to maize. The sorghum area in Asia decreased from 23 million ha to 11 million ha between the early 1970s and 2007. However, production increased from 19 million t in the early 1970s to 21 million t in the late 1970s, but decreased thereafter to 11 million t in 2006. Yield has increased from 800 kg ha-1 in the early 1970s to 1,000 kg ha-1 in 2006" Belum et al. [2].

"Zinc 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" [3].

"Iron deficiency is a common nutritional disorder in many crop plants, resulting in poor yields and reduced nutritional quality. In plants, iron is involved in chlorophyll synthesis, and it is essential for the maintenance of chloroplast structure and function. The visual symptoms of inadequate iron nutrition in higher plants are interveinal chlorosis of young leaves and stunted root growth" Rout and Sahoo [4].

"Boron plays an important role in the plant growth as an essential micronutrient, it helps sugars and nutrients transfer from leaves to reproduction system that supports in the development of organs, increase in pollination as well as development of seed. The strengthening of cell wall, cell division, development of seed and sugar transport are related to boron (B) nutrition. However, boron requirements for optimum plant nutrition are relatively low in comparison with those of the primary nutrients contributing to the maximum forage yields" [5].

2. MATERIALS AND METHODS

In order to study the two micronutrients with foliar spray, Iron and Silicon were taken. The experiment was conducted at during *Zaid* 2022, April, at Crop Research Farm, Naini Agricultural Institute, SHUATS, Prayagraj. The experimental site of the study is geographically located at 25.28^{o}N latitude, 81.54^{o}E longitude and 98 m altitude above the mean sea level (MSL). The soil of the experimental field constituting a part of central Gangetic alluvium is neutral and deep. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH7.3), low in organic carbon (0.48%), available nitrogen (230 kg/ha), available phosphorus (13.60 kg/ha) and available potassium (215.4 kg/ha). Pre-sowing soil samples were taken from a depth of 15 cm with the help of an auger. The composite samples were used for the chemical and mechanical analysis. The treatments consist of three micronutrients Zinc at (0.3, 0.6%), Boron (0.3, 0.6%) and Iron at (0.3, 0.6%) applied as foliar also zinc in soil application (2.5, 5.0 Kg/ha). The experiment was laid out in randomized block design with ten treatments each replicated thrice and control i.e., recommended N, P and K (80:40:40 kg/ha). For sowing high yielding variety NJT-5 was selected.

S. No	Treatment combinations
1.	Zn 0.6% + B 0.3%
2.	Zn 0.6% + Fe 0.3%
3.	Zn 0.6% + B 0.3% + Fe 0.3%
4.	Zn 5Kg/ha + B 0.3%
5.	Zn 5Kg/ha + Fe 0.3%
6.	Zn 5Kg/ha + B 0.3% + Fe 0.3%
7.	Zn 2.5kg/ha + Zn 0.3% + B 0.3%
8.	Zn 2.5kg/ha + Zn 0.3% + Fe 0.3%
9.	Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%
10.	Control (RDF 80:40:40 NPK Kg/ha)

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Table 1 Pertaining the details of effect of iron and silicon on growth attributes of sorghum.

3.2 Plant Height (cm)

At 100 DAS, Higher plant height (185.19 cm) was recorded significantly in the treatment no.9 [Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%]. However, treatment no.8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] was found to be statistically at par with treatment no. 9.

“Increase in plant height, due iron plays a critical role in metabolic process such as DNA synthesis, respiration, photosynthesis and it also involves in synthesis of chlorophyll” [6]. “More availability and absorption of Zn from soil solution which results in fastens the auxin metabolism, synthesis of cytochrome and stabilization of ribosomal fractions, faster the cell division and cell elongation”. (Shalini et al. 2022). “Boron application also improved plant height might be due to active involvement of B in meristematic growth of plant” [7].

3.3 Dry Weight (g)

At 100 DAS, Maximum plant dry weight (92.86g) was recorded significantly in the treatment no.9 [Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%]. However, treatment no.8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] was found to be statistically at far with treatment no. 9.

“Spray of iron along with younger seedlings resulted in higher dry matter production before physiological maturity of the crop” [8]. “Zn accumulates dry matter at faster rate per unit leaf area per unit time which results in reducing the death of tillers and senescence of leaves at different days after sowing of the wheat crop” (Shalini et al. 2022).

3.4 Crop Growth Rate (g/m^2/day)

During 80-100DAS, Highest crop growth rate (3.03mg/m^2/day) was recorded non-significantly in the treatment no.9 [Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%].

3.5 Relative Growth Rate (g/g/day)

During 80-100DAS, Highest relative growth rate (4.16g/g/day) was recorded non-significantly in the treatment no.9 [Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%].

3.6 Yield Attributes

Table. 2 Pertaining the details of effect of iron and silicon on yield attributes and yield of sorghum.

3.7 Grains/ Earhead

At harvest, the data recorded more grains/earhead (1297.67) in treatment no.9 [Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%]. However, treatment no.8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] was statistically at par with treatment no.9.

“Zinc plays a significant role in enzyme activation, chlorophyll biosynthesis, pollen tube formation and pollen viability, starch utilization ensuing in greater seed set” [9]. “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 increase in yield characters” [6].

3.8 Grain Yield (t/ha)

At harvest, the data recorded higher grain yield (3.03 t/ha) in treatment no.9 [Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%]. However, treatment no.8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] (2.93 t/ha) was statistically at par with treatment no.9.

Zinc's role as a "catalyst" in the synthesis of tryptophan, as well as the. growth and development of the plant, may be ascribed to the increase in grain yield [10]. “Iron plays a major role in biosynthesis of IAA and especially due to its role in initiation of primordial reproductive part and portioning of photosynthetic towards them which promotes the yield” [6]. “Boron enhances chlorophyll content in leaf and there by bio mass and phosynthates production is increased, which are effectively transferred towards the roots for its development and to provide required energy for nutrient uptake this uptake results in higher biological yields” [11].

3.9 Stover Yield (t/ha)

At harvest, the data recorded higher stover yield (4.16 t/ha) in treatment no.9 [Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%]. However, treatment no.7 [Zn 2.5kg/ha + Zn 0.3% + B 0.3%], treatment no.8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] was statistically at par with treatment no.9. Increase in straw yield with increasing dose of

zinc and boron application % (soil + foliar) might be due to increased photosynthetic efficiency and carbohydrate metabolism resulting in superior vegetative growth and yield attributes (Singh et al. 2015) [12,13].

3.10 Harvest Index (%)

At harvest, the data recorded maximum harvest index (42.13 %) in treatment no.9 [Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%]. However, treatment no.8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] was statistically at par with treatment no.9.

"Iron plays a role in starch formation and protein synthesis as well as maintenance and synthesis of chlorophyll in plants. The increased in the availability of iron to plant might have stimulated the metabolic and enzymatic activities thereby increasing the growth of the crop" Maharana and Singh [6].

Table 1. Effect of micronutrients on Growth parameters of sorghum

S.No.	Treatment combinations	Plant height (cm)	Dry weight (g)	Crop Growth Rate	Relative Growth Rate
1.	Zn 0.6% + B 0.3%	175.06	79.65	5.87	0.0051
2.	Zn 0.6% + Fe 0.3%	176.45	81.05	6.39	0.0055
3.	Zn 0.6% + B 0.3% + Fe 0.3%	177.79	82.66	6.53	0.0055
4.	Zn 5Kg/ha + B 0.3%	178.72	84.10	6.69	0.0055
5.	Zn 5Kg/ha + Fe 0.3%	179.45	85.96	6.77	0.0055
6.	Zn 5Kg/ha + B 0.3% + Fe 0.3%	181.11	87.76	7.22	0.0057
7.	Zn 2.5kg/ha + Zn 0.3% + B 0.3%	183.05	89.14	6.81	0.0053
8.	Zn 2.5kg/ha + Zn 0.3% + Fe 0.3%	184.25	91.82	6.99	0.0053
9.	Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%	185.19	92.86	7.71	0.0058
10.	Control (RDF 80:40:40 NPK Kg/ha)	173.40	79.26	6.01	0.0053
	F test	S	S	NS	NS
	SEm (±)	0.35	0.35	0.36	0.0962
	CD (p = 0.05)	1.03	1.05	-	-

Table 2. Effect of micronutrients on post-harvest observations of sorghum

S.No.	Treatment combinations	Grains/ earhead	Test weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1.	Zn 0.6% + B 0.3%	1143.00	12.50	2.13	3.72	36.31
2.	Zn 0.6% + Fe 0.3%	1185.00	12.88	2.25	3.74	37.58
3.	Zn 0.6% + B 0.3% + Fe 0.3%	1199.00	12.53	2.35	3.87	37.77
4.	Zn 5Kg/ha + B 0.3%	1219.00	13.60	2.48	3.95	38.57
5.	Zn 5Kg/ha + Fe 0.3%	1237.33	14.33	2.66	4.04	39.72
6.	Zn 5Kg/ha + B 0.3% + Fe 0.3%	1251.00	14.70	2.76	4.06	40.46
7.	Zn 2.5kg/ha + Zn 0.3% + B 0.3%	1267.00	13.35	2.84	4.10	40.91
8.	Zn 2.5kg/ha + Zn 0.3% + Fe 0.3%	1281.00	15.27	2.93	4.09	41.65
9.	Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%	1297.67	15.50	3.03	4.16	42.13
10.	Control (RDF 80:40:40 NPK Kg/ha)	1043.33	12.77	1.93	3.65	34.54
	F test	S	NS	S	S	S
	SEm (±)	8.60	0.76	0.03	0.02	0.31
	CD (p = 0.05)	26.44	-	0.10	0.07	0.93

4. CONCLUSION

From the observations, it was concluded that with the combination of Zn 2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3% in treatment no. 9 significantly recorded higher in all the growth and yield attributes and can be recommended to farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Akhila M, Navya P, P, Dawson J. Effect of zinc and iron on growth and yield of sorghum (*Sorghum bicolor* L.). J Pharmacogn Phytochem. 2021;10(2): 1292-5.
2. Belum VSR, Ramesh S, Reddy PS. Sorghum breeding research at ICRISAT – goals, strategies, methods and accomplishments. Sorghum research reports; 2004.
3. Tandon HLS. Sulphur fertilizers in Indian Agriculture. A guide book. Pun. Festi. Dev. And Consultation Organization New Delhi; 1995.
4. Rout GR, Sahoo S. Role of iron in plant growth and metabolism. Rev Agric Sci. 2015;3:1-24.
   DOI: 10.7831/ras.3.1
5. Ismail AM. Response of maize and sorghum to excess Boron and salinity. Biol Plant. 2003;46(2):313-6.
   DOI:10.1023/B:BIOP.0000022274.72111.12
6. Maharana S, Singh S. Effect of iron and zinc on growth and yield of pearl millet [*Pennisetum glaucum* (L.)]. The Pharm Innov J. 2021;10(10):546-50.ISSN (E):2277-7695.
7. Reddy BN, Umesha C, Pole S. Reddy BN, Umesha C, kiran PS, Reddy D. Effect of zinc and Boron Levels on Growth, Yield and Economics of Rice (*Oryza sativa* L.) var. Shiats Dhan-1. Int J Curr Microbiol App Sci. 2020;9(12):826-32.
   DOI: 10.20546/ijcmas.2020.912.099
8. Singh AK, Singh V. Effect of foliar application of iron, zinc and age of seedlings on growth and yield of Rice (*Oryza sativa* L.). Int J Curr Microbiol Appl Sci. 2018;7(8). ISSN: 2319-7706:1062-8.
   DOI: 10.20546/ijcmas.2018.708.120
9. Gudela DS, Debbarma V. Effect of zinc and bio-fertilizers on growth and yield of wheat (*Triticum aestivum* L.). Int J Plant Soil Sci. 2022;34(22):1624-32.
10. Reddy VSN, Singh R, Chaudu LD. Effect of phosphorus and zinc on growth and yield of pearl millet (*Pennisetum glaucum* L.). The Pharm Innov J. 2022;11(4):542-5.
11. Aluri MK, Umesha C, Gorla VR. Effect of phosphorus and boron Levels on growth and yield of chickpea (*Cicer arietinum* L.). Int J Plant Soil Sci. 2022;34(21):266-71.
12. Shalini, Ahamad A, Singh A, Kumar A. Effect of zinc fortification on growth, yield and economics of wheat (*Triticum aestivum* L.) under irrigated condition of Punjab. Int J Chem Stud. 2020;8(3) 2700:266.
13. Belum VSR, Kumar AA, Reddy PS. Recent advances in sorghum improvement research at ICRISAT. Kasetsart J (Natl Sci). 2010;44:499-506.

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