Effect of Micronutrients on growth and yield of Sorghum (*Sorghum bicolor* L.)

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. Highest Plant height (185.19cm), ~~maximum~~ plant dry weight (92.86g/plant) and the yield attributes namely test weight (15.50g), grains/earhead (1297.67), grain yield (3.03Kg/ha), stover yield (4.16Kg/ha) was with treatment 9 [Zinc 2.5ka/ha +Zinc 0.3% +B 0.3% + Fe 0.3%].

Keywords:*Sorghum, Iron, Boron, Zinc,growth, yield.*

Comment [A1]: Consider treatment 8 also for recommendation

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. **(Akhila, M. *et al.* (2021).** 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.

Zincis a vital micronutrient required for the plant growth. Zinc plays an important role in many biochemical reactions within the plant. It is important in synthesis of protein, tryptophan and indole-acetic acid. Zinc acts as a structural component of several enzymes in plants and an inadequate supply could result in serious physiological disturbances.

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. Iron plays an important role in respiration, photosynthesis and the production of healthy green leaves. Iron (Fe) is an important nutrient for humans and plants. It is very important for plant growth and its deficiencies hindered plant growth and production.

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 **(Ismail, 2003).**

Materials and Methods:

In order to study the two micronutrients with foliar spray, Iron and Silicon were

Comment [A2]: Identified problem in the experimental location for which present experiment was done is not mentioned
Objective of present experiment is missing

Comment [A3]: Add at least 15-20 more references

Comment [A4]: Climate details of experimental site, variety used, cultural practice (very short), observations taken and methods, formulas used and details about statistical analysis needed to be attached.

taken. The experiment was conducted at during *Zaid* 2022, at Crop Research Farm, Naini Agricultural Institute, SHUATS, Prayagraj. The experimental site of the study is geographically located at 25.28°N latitude, 81.54°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. 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).

Results and Discussions:

Growth parameters

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

Plant height (cm)

At 100 DAS, ~~Higher~~Maximumand significant effect on plant height (185.19 cm) was recorded ~~significantly~~ in the treatment ~~no.~~number 9 [Zn2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%]. However,treatment ~~no.~~number 8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] was found to be statistically at par with treatment ~~no.~~number 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 **(Maharana and Singh, 2021**).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. **(Reddy *et al.*, 2020).**

Dry weight (g)

At 100 DAS, ~~Maximum~~ plant dry weight (92.86g) was recorded significantly in the treatment ~~no.~~number 9 [Zn2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%].However, treatment ~~no.~~number 8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] was found to be statistically at far with treatment ~~no.~~number 9.

Spray of iron along with younger seedlings resulted in ~~higher~~maximum dry matter production before physiological maturity of the crop. **(Singh~~,A, K.~~ and Singh~~, V.,~~ 2018)**. Zn accumulates dry matter at faster rate per unit leaf area per unit time which

Comment [A5]: Mention month of experiment

Comment [A9]: Mention numerical magnitude

Comment [A6]: Soil NPK and micronutrient status needed to be attached for having proper idea of the experimental site

Comment [A7]: From here treatment details is not clear if there is 6 treatments or combinations were used, better exhibit in chart form

Comment [A8]: Justify the basis of selecting these doses, (some references can be attached in support of these doses)

Comment [A10]: Add numerical value

results in reducing the death of tillers and senescence of leaves at different days after sowing of the wheat crop. **(Shalini *et al.*,2022).**

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.~~number 9 [Zn2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%]

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.~~number 9 [Zn2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%].

Yield attributes:

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

Grains/earhead

At harvest, the data recorded more grains/earhead (1297.67) in treatment ~~no.~~number 9 [Zn2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%].However, treatment ~~no.~~number8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] was statistically at par with treatment ~~no.~~number 9.

Zinc plays a significant role in enzyme activation, chlorophyll biosynthesis, pollen tube formation and pollen viability, starch utilization ensuing in greater seed set. (Gudela and Debbarma, 2022).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. **(Maharana and Singh, 2021).**

Grain yield (t/ha)

At harvest, the data recorded ~~higher~~maximum grain yield (3.03 t/ha) in treatment ~~no.~~number 9 [Zn2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%]. However, treatment ~~no.~~number 8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] (2.93 t/ha) was statistically at par with treatment ~~no.~~number 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.**(Reddy *et al.* (2022).**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. **(Maharana and Singh, 2021).**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

Comment [A11]: Exhibit numerical value provide required energy for nutrient uptake this uptake results in ~~higher~~maximum biological yields.**(Aluri*et al.* 2022**).

Stover yield (t/ha)

At harvest, the data recorded ~~higher~~maximum stover yield (4.16 t/ha) in treatment ~~no.~~number 9 [Zn2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%]. However, treatment ~~no.~~number 7 [Zn 2.5kg/ha + Zn 0.3% + B 0.3%], treatment ~~no.~~number 8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] was statistically at par with treatment ~~no.~~number 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).**

Harvest index (%)

At harvest, the data recorded ~~maximum~~ harvest index (42.13 %) in treatment ~~no.~~number 9 [Zn2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%]. However, treatment ~~no.~~number 8 [Zn 2.5Kg/ha + Zn 0.3% + Fe 0.3%] was statistically at par with treatment ~~no.~~number 9.

CONCLUSION

From the observations, it was concluded that with the combination of Zn2.5kg/ha + Zn 0.3% + B 0.3% + Fe 0.3%~~in treatment no. 9 significantly recorded higher~~exhibited significantly enhanced performance for ~~in~~ all the growth and yield attributes and can be recommended to farmers.

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Comment [A12]: Exhibit numerical value

Comment [A13]: Consider treatment 8 also as performance is statistically at per

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Table 1: Effect of micronutrients on Growth parameters of sorghum:

S.~~No.~~ 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. Number.	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