<u>Original Research Article</u>

Effect of Iron and Boron on Growth and Yield of Foxtail millet

ABSTRACT

The field experiment was conducted during *Zaid* season 2023 at experimental field of Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.8), low in organic carbon (0.62%), available nitrogen (225 kg/ha), available phosphorus (38.2 kg/ha) and available potassium (240.7 kg/ha). The experiment was laid down in Randomized Block Design with ten treatments which are replicated thrice. The experiment consists of Iron and Boron. The treatment combinations are T_1: Iron 0.25% + Boron 0.25%, T_2: Iron 0.25% + Boron 0.50%, T_3: Iron 0.25% + Boron 0.75%, T_4: Iron 0.50% + Boron 0.25%, T_5: Iron 0.50% + Boron 0.50%, T_6: Iron 0.50% + Boron 0.75%, T_7: Iron 0.75% + Boron 0.25%, T_8: Iron 0.75% + Boron 0.50%, T_9: Iron 0.75% + Boron 0.75%, T_{10}: Control (RDF 50:30:20 NPK kg/ha). Results revealed that significant and higher plant height (84.43 cm), maximum number of tillers/hill (8.60), higher plant dry weight (14.41 g), higher panicle length (15.33 cm), number of grains/ panicle (1263.00), test weight (4.34 g), grain yield (1.99 t/ha), straw yield (3.39 t/ha), maximum gross return (INR 66480.00), net return (INR 43186.40) and B:C ratio (1.85) were recorded in treatment 9 [Iron 0.75% + Boron 0.75%].

Keywords: *Foxtail millet, Zaid, Iron, Boron, Growth, Yield, Economics.*

Introduction

Foxtail millet is one of the world's oldest cultivated crops, widely grown in Asia and Africa's arid and semi-arid regions, as well as in some other economically developed countries where it is more commonly used as bird feed. This article provides a thorough examination of the physicochemical and health-functional properties of foxtail millet, as well as the processing techniques used to improve these properties and create more palatable food products. Foxtail millet has high protein, fiber, mineral, and phytochemical content. Anti-nutrients in this millet, such as phytic acid and tannin, can be reduced to negligible levels by using appropriate processing methods. **Swaroop and Debbarma 2022.** Millet is also said to have hypolipidemic, low-glycemic index, and antioxidant properties. According to this review, foxtail millet, like most millet varieties, is under-utilized as a food source. It is, however, receiving increased research and commercial attention, because its cultivation is not overly demanding in terms of agricultural inputs, and it can grow in difficult terrains. It is reasonable to believe that foxtail millet has the potential to improve nutritional and food security. Foxtail millet has an excellent nutritional profile and is miles ahead of rice and wheat in terms of protein, fiber, minerals, and vitamins. It has good nutritive value as it is rich in proteins (12.3 g), carbohydrates (60.9 g), fat (4.3 g), crude fiber (8.0 g), calcium (3.1 g), vitamins and thiamin (50 mg) per 100g. The grain is a good source of Beta carotene, which is the precursor of Vitamin A **(Murugan and Nirmala, 2006).** Worldwide production of millets is 89.17 m.m.tons. from an area of 74.00 m.ha in 2076. In India area under the cultivation of small millets is 0.459m.ha, production is 0.33m.tons and its productivity is 809 kg/ha, Foxtail millet predominates all millets in terms of productivity, yielding about2166 kg/ha **(GOI, 2021-22).**

Iron is a micronutrient that is required by almost all living organisms because it is involved in metabolic processes such as DNA synthesis, respiration, and photosynthesis. Iron also activates many metabolic pathways and is a prosthetic group constituent of many enzymes. The primary causes of iron chlorosis are an imbalance between the solubility of iron in soil and the plant's demand for iron. Although abundant in most well-aerated soils, iron has low biological activity because it forms highly insoluble ferric compounds at neutral pH levels. Iron is important in many physiological and biochemical pathways in plants. It is required for a wide range of biological functions because it is a component of many vital enzymes, such as cytochromes of the electron transport chain. Iron is involved in the synthesis of chlorophyll in plants and is required for the maintenance of chloroplast structure and function **Grace *et al.*, 2023.**

Boron is a trace element that can be applied in soil as well as foliar. It is many times observed that foliar applied boron causes increased in yield more than soil applied boron because boron is required more at reproductive stage and foliar applied is instantly present for plant in compared to soil applied boron. Boron is very important in plant metabolism through acting activity of certain enzymes, cell division, carbohydrate transport, and calcium and potassium uptake and protein synthesis; ultimately it may enhance in pod and seed formation. Boron ranks third place among micronutrients in its concentration in seed and stem as well as its total amount after zinc. Boron is an essential micronutrient for plants, but the range between deficient and toxic B concentration is smaller than for any other nutrient element. Plant responds directly to the activity of B soil solution and only indirectly to B adsorbed on the soil constituents. Soil factors affecting availability of B to plants are viz, pH, texture, moisture, temperature, organic matter, and clay mineralogy **Movalia*et al.*, 2020**. Boron is necessary in the synthesis of one of the bases for RNA formation and in cellular activities and promote root growth. It is essential for pollen germination and growth of the pollen tube and formation of flowers, and for development of seed. Bom has been associated with lignin synthesis, activities of certain enzymes, seed and cell wall formation, and sugar transport. It helps in absorption and utilization of calcium in plants.

Materials and Methods

The experiment was conducted during *Zaid* season 2023 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P,). 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 soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.8), low in organic carbon (0.62%), available nitrogen (225 kg/ha), available phosphorus (38.2 kg/ha) and available potassium (240.7 kg/ha). The treatments consist of foliar application ion Iron (0.25, 0.50, 0.75 %) and foliar application of Boron (0.25, 0.50, 0.75 %) along with control. The experiment was layout in Randomized Block Design with ten treatments each replicated thrice. The data recorded on different aspects of crop viz., growth parameters, yield attributes and yield were subjected to statistical analysis by variance method **Gomez and Gomez, (1984)**and economics is also calculated.

RESULTS AND DISCUSSIONS

Growth parameters

Plant height (cm)

At 80 DAS, [Table 1] higher plant height (84.43 cm) was recorded in treatment 9 (0.75 % Iron + 0.75 % Boron). However. Treatment 8 (83.50 cm) (0.75 % Iron + 0.50 % Boron) was found to be statically at par with treatment 9.

This might be due to iron 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. Similar results are obtained by **Vaja, RP. *et al.* 2022.** Boron enhances the differentiation of tissue cell division and nitrogen absorption from the soil. Similar result was found by **Singh *et al.* 2014.**

Plant dry weight (g)

At 80 DAS, [Table 1] maximum plant dry weight (14.41 g) was recorded in treatment 9 (0.75 % Iron + 0.75 % Boron). However. Treatment 8 (14.29 g) (0.75 % Iron + 0.50 % Boron) was found to be statically at par with treatment 9.

This might be due to iron application which has many important functions in plant growth and development, such as involvement in the biosynthesis of chlorophyll, respiration, chloroplast development and improves the performance of photosystems, which resulted in higher dry weight. Similar results are obtained by **Srihari *et al.* 2023.** Application of boron aids in the synthesis of chlorophyll, photosynthetic process, enzyme activation and grain formation, as well as carbohydrate metabolism, which leads to nutrient uptake and finally results in an increase in growth and finally resulting in increased dry weight. Similar results are obtained by **Naiknaware*et al.* 2015.**

Tillers/hill

At 80 DAS, [Table 1] more tillers/hill (8.60) was recorded in treatment 9 (0.75 % Iron + 0.75 % Boron). However. Treatment 8 (8.40) (0.75 % Iron + 0.50 % Boron) was found to be statically at par with treatment 9.

This might be due to iron application which is a structural component of porphyrin molecules, cytochromes, hemes, hematian, ferrichrome and leghemogloben. These substances are involved in oxidation-reduction reactions in respiration and photosynthesis. Similar results are obtained by **Choudhary *et al.* 2015.** The application of Boron which resulted in the increase in growth attributes, may be due to the translocation of plant nutrients due to foliar application of it to growing plant parts and more photosynthesis which in turn may have promoted more tiller per plant. Similar results are obtained by **Kader *etal*. 2013**

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

At 60-80DAS, [Table 1] higher crop growth rate (7.315 g/m^2/day) was recorded in treatment 9 (0.75 % Iron + 0.75 % Boron). However. Treatment 8 (7.199 g/m^2/day) (0.75 % Iron + 0.75 % Boron) was found to be statically at par with treatment 9.

Yield attributes and yield

Panicle length (cm)

At Harvest, [Table 2] significantly higher panicle length (15.33 cm) was recorded in treatment 9 (0.75 % Iron + 0.75 % Boron). However. Treatment 8 (15.10 cm) (0.75 % Iron + 0.50 % Boron) was found to be statically at par with treatment 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 like panice length. Similar results are obtained by **Maharana and Singh 2021**. Boron is important for root and shoot growth, sugar translocation and protein synthesis as well as increase translocation of photosynthates which characters and ultimately resulted in increased yiels attributes like panicle length. These results agree with the findings of **Sreelatha *et al.* 2004.**

Grains/panicle

At Harvest, [Table 2] significantly more grains/panicle (1263.00) was recorded in treatment 9 (0.75 % Iron + 0.75 % Boron). However. Treatment 8 (1231.33) (0.75 % Iron + 0.50 % Boron) was found to be statically at par with treatment 9.

Boron, required for cell differentiation, development and growth of pollen grains. It acts as a greater role in translocation of photosynthates, resulting in increased pollination and seed setting and plant metabolism. Similar results are obtained by **Movalia*et al.* 2020.**

Grain yield (t/ha)

At harvest, [Table 2] significantly higher grain yield (1.99 t/ha) was recorded in treatment 9 (0.75 % Iron + 0.75 % Boron). However. Treatment 8 (1.94 t/ha) (0.75 % Iron + 0.50 % Boron) was found to be statically at par with treatment 9.

Iron plays a major role in the biosynthesis of IAA and especially due to its role in the initiation of primordial reproductive parts portioning of photosynthetic towards them which promotes the yield. Similar result was also observed by **Rao*et al.* 2019.** Boron involves in physiological processes and plant Growth and adequate nutrition is a critical for increases yield and quality of crops. Similar result was reported by **Banoth *et al.* 2022.**

Straw yield (t/ha)

At harvest, [Table 2] significantly higher straw yield (3.39 t/ha) was recorded in treatment 9 (0.75 % Iron + 0.75 % Boron). However. Treatment 8 (3.31 t/ha) (0.75 % Iron + 0.50 % Boron) was found to be statically at par with treatment 9.

This might be due to favourable effect of iron on the proliferation of roots and thereby increasing the uptake of the plants nutrients from the soil supplying in to the aerial parts of the plant and ultimately enhancing the vegetative growth of the plant. Similar results are obtained by **Rao, S. G. B. *et al.* 2019.**

Economics

Higher Gross returns (66,480.00 INR/ha), Net returns (43,186.00 INR/ha) and Benefit cost ratio (1.85) was found to be highest in treatment 9 (Iron 0.75% + Boron 0.75%). [Table 3].

Conclusion

Based on above findings, it is concluded that the application of 0.75% Iron along with 0.75% Boron in foxtail millet, performed better in growth and yield and also proven profitable.

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Table 1: Effect of Iron and Boron on Growth attributes of Foxtail Millet

S. No.	Treatments	Plant Height (cm)	Dry Weight (g)	Tillers/hill	CGR (60-80 DAS)
1.	Iron 0.25% + Boron 0.25%	80.40	13.28	6.47	5.411
2.	Iron 0.25% + Boron 0.50%	82.60	13.40	6.53	5.857
3.	Iron 0.25% + Boron 0.75%	81.07	13.53	7.00	5.697
4.	Iron 0.50% + Boron 0.25%	81.47	13.60	7.33	6.077
5.	Iron 0.50% + Boron 0.50%	82.13	13.73	7.47	6.880
6.	Iron 0.50% + Boron 0.75%	82.37	13.88	7.73	6.858
7.	Iron 0.75% + Boron 0.25%	83.07	14.10	8.20	6.907
8.	Iron 0.75% + Boron 0.50%	83.50	14.29	8.40	7.199
9.	Iron 0.75% + Boron 0.75%	84.43	14.41	8.60	7.315
10.	Control (RDF 50:30:20 NPK kg/ha)	80.30	13.16	6.13	5.868
	F-test	S	S	S	S
	SEm(±)	0.35	0.05	0.08	2.367
	CD (p = 0.05)	1.03	0.15	0.23	3.945

Table 2: Effect of Iron and Boron on Yield and Yield Attributes of Foxtail Millet

S. No.	Treatments	Yield Attributes and Yield			
		Panicle length (cm)	Grains/panicle (no.)	Grain yield (t/ha)	Straw yield (t/ha)
1.	Iron 0.25% + Boron 0.25%	13.47	1108.67	1.63	2.63
2.	Iron 0.25% + Boron 0.50%	13.53	1124.33	1.67	2.74
3.	Iron 0.25% + Boron 0.75%	13.73	1131.67	1.71	2.89
4.	Iron 0.50% + Boron 0.25%	13.87	1144.67	1.76	2.98
5.	Iron 0.50% + Boron 0.50%	14.27	1176.00	1.81	3.04
6.	Iron 0.50% + Boron 0.75%	14.53	1200.00	1.84	3.11
7.	Iron 0.75% + Boron 0.25%	14.73	1215.00	1.89	3.2
8.	Iron 0.75% + Boron 0.50%	15.10	1231.33	1.94	3.31
9.	Iron 0.75% + Boron 0.75%	15.33	1263.00	1.99	3.39
10.	Control (RDF 50:30:20 NPK kg/ha)	13.40	1087.33	1.59	2.58
	F-Test	S	S	S	S
	SEm (±)	0.09	10.77	0.03	0.04
	CD (p = 0.05)	0.27	31.99	0.09	0.11

Table 3:Effect of Iron and Boron on Economics of Foxtail Millet

S. No.	Treatments	Economics		
		Gross return(INR/ha)	Net returns(INR/ha)	B C ratio(B:C)
1.	Iron 0.25% + Boron 0.25%	54160.00	31426.00	1.38
2.	Iron 0.25% + Boron 0.50%	55580.00	32566.00	1.41
3.	Iron 0.25% + Boron 0.75%	57080.00	33786.00	1.45
4.	Iron 0.50% + Boron 0.25%	58760.00	36026.00	1.58
5.	Iron 0.50% + Boron 0.50%	60380.00	37366.00	1.62
6.	Iron 0.50% + Boron 0.75%	61420.00	38126.00	1.63
7.	Iron 0.75% + Boron 0.25%	63100.00	40366.00	1.77
8.	Iron 0.75% + Boron 0.50%	64820.00	41806.00	1.81
9.	Iron 0.75% + Boron 0.75%	66480.00	43186.00	1.85
10.	Control (RDF 50:30:20 NPK kg/ha)	52860.00	30406.00	1.35