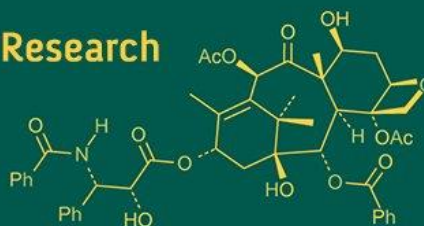


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(5): 712-716
www.biochemjournal.com
Received: 05-02-2026
Accepted: 07-03-2026

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Effect of iron and zinc on growth and yield of foxtail millet (*Setaria italica* L.)

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i5Si.8451>

Abstract

The field experiment was conducted during *kharif* 2025 at Crop Research Fram, Naini Agricultural Institute, Department of Agronomy, SHUATS, Prayagraj (U.P). The experiment was laid out in randomized Block Design with ten Treatments which are replicated thrice on the basis of one year experimentation. The Treatment consist of two factors with three different levels of Iron (5kg/ha, 10 kg/ha, 15kg/ha and three different levels of Zinc (15kg/ha, 20 kg/ha and Control 20-20-10 kg N-P-K /ha. The result showed that Significantly Maximum Plant height (91.60cm), Plant dry weight (9.40g), No of tillers per running row meter (18.03), Panicles/ m² (89.33), Grain yield (2463.33kg/ha) was recorded in treatment with the application of [Iron (10kg/ha + Zinc (25kg/ha)]. Similarly, maximum gross returns (INR 149564.80/ha), net return (INR109983.80/ha) and benefit cost ratio (2.78) was obtained in the treatment with the application of [Iron 10kg/ha +Zinc 25kg/ha) as compared to other treatments.

Keywords: Foxtail millet, iron, zinc, growth, yield and economics

Introduction

Foxtail millet, (*Setaria italica*) is an annual grass belongs to Poaceae family. It is diploid in nature (2n = 18) a self-pollinating and short duration crop. It is one of the ancient crops cultivated in Europe and Asia, almost 8700 years ago (Ingale *et al.* 2022), It has an erect leafy stem (60-75cm) tall, C4 cereal and grow at any altitudes from sea level 2000m above sea levels (Yeshamalla *et al.* 2023). In India it grown as rain fed crop. It is also called as Italian millet, Hungarian millet and German millet. It is commonly known in India as Kangni, Kang, Navane, Tenai. Foxtail millet is abiotic stress-tolerant, particularly to drought and salinity, making it an excellent model for bio fuel crops. Foxtail millet grains are coarse, only 79% of the grain is digestible. The remaining non-digestible portion of the grain consist of some anti- nutritional ingredients and comparatively high fiber content (Swamy 2023), (Ravi *et al.* 2010). The composition of Foxtail millet grain per 100g edible portion is as fallows water 12g, energy 1470kj (351 kcal), protein 11.2 g fat 4.0 g, carbohydrates 63.2g, crude fiber 6.7g, Ca 31mg, Fe 2.8 mg, thiamine 0.6mg, riboflavin 0.1mg and niacin 3.2 mg. It is used as energy source and gained attention in health foods and nutraceutical industries due to gluten free nature, high dietary fiber and obesity (Mohanan *et al.* 2025). Among millet it is the second most widely cultivated and ranks second in the total world production of millets and it continues to have a important place in the world agriculture providing food for millions of people in arid and semi- arid regions (Academic, 2023). The essential amino acids are tryptophan, lysine, methionine, phenylalanine, threonine, valine, leucine and isoleucine. In India it is cultivated on about 0.8 lakh ha area with 0.6 lakh tone production in Andhra Pradesh, Karnataka, Rajasthan, Maharashtra, Tamil Nadu and North eastern states with productivity of 762 kg/ha. (K. Hari Prasanna 2023) [2, 10, 11, 16, 23, 30, 35].

Iron is a micronutrient which is important in many physiological and biochemical pathways in plants. It activates many metabolic pathways and is prosthetic group constitute of many enzymes such as porphyrin, ferrochrome, cytochromes and some pigments and assist in nitrate and sulphate reduction and energy production within the plant. It involved in the synthesis of chlorophyll in plants and is required for the maintenance of chloroplast structure and function. (Vineetha *et al.* 2024) [33]. Iron in chloroplast reflects the presence of cytochromes which is performing various photosynthesis reduction process, enhance

growth and yield by increasing plant height, tiller number and dry matter production. Application of micro nutrients fertilizers through soil application is the most efficient and economical method of getting these nutrients into the crops. (rajaie *et al.* 2009)^[21].

Zinc is a micronutrient required by humans, animals and plants. It plays a crucial role in various biological process. It is a component of RNA polymerase, which is necessary for protein synthesis. It affects nitrogen metabolism through its interaction with protease, and it is involved in the synthesis of glutamic acid, ribose and protein through its interaction with glutamate dehydrogenase (Shi *et al.* 2023)^[27]. It plays a crucial role in plant resistance against diseases, various biochemical processes, including photosynthesis, respiration, protein metabolism and hormone synthesis. Enhancing the zinc content and bioavailability of grain is of immense importance in addressing zinc deficiency in human beings and fulfilling the zinc requirement for optimal human health. Zinc is essential for plant functions, production of auxins, an essential growth hormone, it is necessary for Strach formation, proper development, chlorophyll and carbohydrates.

Materials and methods

The experiment was carried out during Kharif season 2025 at crop research farm, Naini Agricultural Institute, Sam Higginbottom university of agriculture, technology and sciences, Prayagraj, which is located at 25° 24' 42" n latitude, 81° 50' 56" e longitude and 98m altitude above the mean sea level. This area is situated on the right side of the river Yamuna by the side of Allahabad Rewa Road about 5km away from Allahabad city. The soil was sandy loam texture, slightly alkaline in nature (pH 6.8). The experiment was conducted in randomized block design with 10 treatments each replicated thrice. The plot size of each treatment was 3m *3m. The factors are Iron (5kg/ha, 10kg/ha,15kg/ha) and Ascorbic acid (15kg/ha, 20kg/ha, 25 kg/ha). The treatment combinations are T1- Iron 5kg/ha + Zinc 15 kg/ha, T2- Iron 5kg/ha + Zinc 20kg/ha, T3- Iron 5kg/ha + Zinc 25 kg/ha, T4- Iron 10kg/ha + Zinc 15kg/ha, T5- Iron 10 kg/ha+ Zinc 20kg/ha, T6- Iron 10kg/ha + Zinc 25kg/ha, T7- Iron 15kg/ha +Zinc 15kg/ha, T8- Iron 15kg/ha + Zinc 20kg/ha, T9- Iron 15kg/ha + 25kg/ha, T10- Control N-P-K 20-20-10 kg/ha. The Foxtail millet was sown on 20th July 2025. Harvesting was done by taking 1m² area from each plot, and from it some plants were randomly selected for recording growth and yield parameters. The observations were recorded for plant height (cm), Plant dry weight (g), No of tillers per running row meter by scale in each row, no of seeds per ear or head by taking 5 effective tillers among the one-meter square area. Panicles/plant was calculated from the effective plants, Test weight (g) Grain yield Kg/ha and Stover yield kg/ha and Harvest index (%). The data was subjected to statically analysis by analysis of variance method. Economics was calculated viz., cost of cultivation, gross return, net return, benefit cost ratio were calculated.

Result and discussion

Plant height (cm): The effect of iron and zinc on increasing plant height at 60 DAS was found to be significant difference among treatments. The maximum plant height was recorded in 6th treatment with the application of Iron 10kg/ha +Zinc 25kg/ha. 1st treatment (87.66cm), 2nd treatment (88.60cm), 7th treatment (86.86cm) and 8th

treatment (87.66cm) were found statistically at par with 6th treatment (91.60cm). The result indicates that iron with 10kg/ha is combined with 25kg of zinc, significantly enhances foxtail millet height. Iron plays a role in starch formation and protein synthesis as well as maintenance and synthesis of chlorophyll in plants. Iron helps in the proliferation of roots and thereby increasing the uptake of the plants nutrients from the soil supplying to the aerial parts of the plant and ultimately enhancing the vegetative growth of the plant. And also, the availability of iron to plant stimulated the metabolic and enzymatic activities and helps in the increase in the growth of the plant. Vaja *et al.* (2020), Yadav *et al.* (2013) and Rao *et al.* (2019). Soil application of Zinc increases the availability and absorption of zinc helps to improving cell division and cell elongation and also increases in the rate of photosynthesis and chlorophyll formation leads to the increase in internode length. Similar results are in support with Shalini *et al.* (2020), Mehendi *et al.* (2012) and Maurya *et al.* (2012)^[13, 15, 24, 25, 32, 34].

Plant dry weight (g): The data related to the plant dry weight is placed in table1. At 60 DAS, there is significant difference among the treatments. Maximum plant dry weight was recorded with the application of Iron 10kg/ha and Zinc 25 kg/ha, 2nd treatment (8.26), 3rd treatment(7.24), and 4th treatment were found statistically at par with 6th treatment (9.40). The soil application of iron and zinc plays a role in nutrient uptake, chlorophyll synthesis and metabolic activities that enhance the cell division and plant growth. Iron distribution within the plant xylem and phloem, promoting dry matter accumulation by improving photosynthetic activities. Involvement of zinc in auxin metabolism results in improvement in overall biomass. (Nadim *et al.* (2012), (Ghulam Abbas, 2012), (Bandiwaddar, 2015), (Patil, 1975)^[4, 18, 20].

No of Tillers per running meter row: The data reveal that there was significant difference among the treatments at 60 DAS, Maximum no of tillers running row meter was recorded with the application of iron 10kg/ha, zinc 25kg/ha, 4th treatment (16.73) was found statistically at par with 6th treatment (18.03). The role of iron is stimulating vegetative growth, chlorophyll formation and improving photosynthesis efficiency and tiller formation. Increasing iron resulted in greater tiller number per running row meter. Abbas *et al.* (2015) and Shrivastava *et al.* (2018). The role of zinc in biosynthesis of indole acetic acid and initiation of primordial for reproductive parts and partitioning of photosynthates towards them (Pratap *et al.* 2008)^[1, 7, 21, 28].

Yield attributes and yield

Panicles/m²: The data reveals that there was a significant difference among different treatments at harvest on panicles /m², significantly maximum number of panicles /m² was recorded in the treatment with application of iron 10kg/ha and zinc 25kg/ha, 3rd treatment (78.66) was statistically at par with 6th treatment (89.33). Iron and zinc play a part in photosynthesis, assimilation and translocation of photosynthates from source to sink due to increased translocation of photosynthates towards reproductive system helps in panicles improvement. Debroy *et al.* (2013), Olusengun *et al.* (2014), Mosanna and Ebrahim (2015) and Tejaswi *et al.* (2022)^[5, 17, 19, 31].

Test weight (g): The data reveals that there was no significant difference among the treatments and higher test weight was recorded with the application of iron 10kg/ha and zinc 25kg/ha (3.19). Zinc maintains cell membrane stability, ensuring better nutrient uptake and grain filling, indirectly contributing the higher test weight. Han *et al.* (2023).

Grain yield (kg/ha): The data shows the significant difference among the treatments. Maximum grain yield was recorded in the 6th treatment with the application of iron 10 kg/ha and zinc 25kg/ha. 8th treatment (2166.66) and 9th Treatment was statistically at par with 6th treatment (2463.33). Iron plays a major role in the biosynthesis of IAA and initiation of primordial reproductive parts portioning of photosynthetic toward them which promotes the yield. Zinc role as a catalyst in the sunthesis of tryptophan and growth and development of plant, ascribes to the increase in grain yield. Similar results was also observed in Rao *et al.* (2019), Sharma *et al.* (2012) and Singh *et al.* (2016) [24, 26, 29].

Stover yield (kg/ha): The data reveals that there was significant difference among the treatments and maximum stover yield was recorded in the 8th treatment with the

application of iron 15kg/ha and Zinc 20 kg/ha (3590kg/ha), 4th treatment (3190) and 6th Treatment (3530) were found to be statistically at par with 8th treatment. Iron helps in the photosynthetic efficiency, vegetative biomass accumulation and improved iron nutrition stimulates enzymatic acitivity and root growth, leading to greater dry matter production and higher stover yield. Grace *et al.* (2023), Adsul *et al.* (2011). Zinc enhances the stover yield by promoting better vegetative growth and chlorophyll synthesis and improves plant vigour, resulting in higher biomass accumulation. Similar trends was observed by Kharadi *et al.* (2020) and Shrivastava *et al.* (2018) [3, 8, 12, 28].

Economic Analysis: The maximum benefit cost ratio (2.78) was recorded in Iron 10kg/ha nd Zinc 25kg/ha and minimum (1.52) was recorded in treatment with the application of iron 5kg/ha and zinc 25kg/ha. The economi returns of foxtail millet due to their positive influence on grain yield, stover yield and overall biomass production. Higher micronutrients doses improved upatake efficiency and photosynthetic activity, which translated into increased marketable yield and higher gross returns, similar findings are with Durgude *et al.* (2013) and Meena *et al.* (2013) [6, 14].

Table 1: Effect of iron and zinc on Growth and Growth Attributes of foxtail millet.

S. No	Treatments	Growth and growth Attributes at 60DAS		
		Plant height(cm)	Plant Dry weight (g)	No of tillers per running meter row
1.	Iron 5kg/ha + Zinc 15 kg/ha	87.66	5.40	13.30
2.	Iron 5kg/ha + Zinc 20 kg/ha	88.60	8.26	16.10
3.	Iron 5kg/ha + Zinc 25 kg/ha	82.46	7.24	16.70
4.	Iron 10kg/ha + Zinc 15 kg/ha	85.86	6.61	16.73
5.	Iron 10kg/ha + Zinc 20 kg/ha	83.86	6.41	14.80
6.	Iron 10kg/ha + Zinc 25 kg/ha	91.60	9.40	18.03
7.	Iron 15kg/ha + Zinc 15 kg/ha	86.86	3.99	14.10
8.	Iron 15kg/ha + Zinc 20 kg/ha	87.66	5.97	15.91
9.	Iron 15kg/ha + Zinc 25 kg/ha	83.73	5.39	16.33
10.	N- P- K 20-20-10 kg/ha (Control)	84.66	5.72	14.33
	F-Test	S	S	S
	S Em±	1.71	0.95	0.58
	CD (p=0.05)	5.09	2.84	1.73

Table 2: Effect of iron and zinc on yield attributes, yield and economics of foxtail millet.

S. No	Treatments	Yield attributes				
		Panicles / m ²	Test weight (g)	Grain Yield (kg/ha)	Stover Yield (kg/ha)	B:C ratio
1.	Iron 5kg/ha + Zinc 15 kg/ha	68.01	3.02	1596.66	2970	1.71
2.	Iron 5kg/ha + Zinc 20 kg/ha	74.33	2.35	1723.33	3060	1.81
3.	Iron 5kg/ha + Zinc 25 kg/ha	78.66	2.48	1606.66	2590	1.52
4.	Iron 10kg/ha + Zinc 15 kg/ha	79.33	2.63	1570.00	3190	1.61
5.	Iron 10kg/ha + Zinc 20 kg/ha	64.02	2.70	1603.33	3030	1.57
6.	Iron 10kg/ha + Zinc 25 kg/ha	89.33	3.19	2463.33	3530	2.78
7.	Iron 15kg/ha + Zinc 15 kg/ha	66.00	2.52	1739.66	2280	1.82
8.	Iron 15kg/ha + Zinc 20 kg/ha	70.66	2.55	2166.66	3590	2.39
9.	Iron 15kg/ha + Zinc 25 kg	73.33	2.68	2116.66	3230	2.19
10.	N- P- K 20-20-10 kg/ha (Control)	61.33	2.14	1381.66	2690	1.74
	F-Test	S	NS	S	S	-
	S Em±	4.00	0.43	191.11	145.38	-
	CD (p=0.05)	11.88	-	567.73	431.90	-

Conclusion

It was concluded that the application of Iron 10kg/ha and Zinc 25kg/ha was recorded higher seed yield and benefit cost ratio in foxtail millet.

Acknowledgement

The authors are thankful to department of agronomy, Naini Agricultural Institute, Prayagraj, Sam Higginbottom University of Agriculture Technology and Sciences, (U.P).

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