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Effect of Nitrogen and Iron on Growth and Yield of Foxtail Millet (*Setaria italica* 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 the experimental field of Crop Research Farm, Department of Agronomy, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj and Uttar Pradesh, India. The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.3), 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 3 levels of Nitrogen (40 Kg, 50 Kg and 60 Kg/ ha) as a basal application and Iron (0.2, 0.4 and 0.6 %) as foliar spray along with control. The experiment was layout in Randomized Block Design with Ten treatments each replicated thrice. Growth attributes namely higher plant height (101.57cm), maximum dry weight/plant (14.83 g), more number of tillers/hill (8.87) and yield attributes namely higher panicle length (18.61 cm), grains/panicle (1389.30), grain yield (1.79 t/ha) and straw yield (2.53 t/ha) were observed with application of nitrogen 60 Kg/ha and iron 0.6%.

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1. INTRODUCTION

Foxtail millet (*Setaria italica* L.) is one of the oldest cultivated millet and most economically important species of the genus Setaria. It ranks second in the total world production of millets and it continues to have an important place in world agriculture providing food for millions of people in arid and semiarid regions. It is native to China and regarded as an elite drought-tolerant crop. In India, Andhra Pradesh, Karnataka and Tamil Nadu are the major foxtail miller growing states contributing about 79 per cent of the total cultivated area of about 6 lakh hectares with production of 3 lakh tones and productivity of 602 Kg/ha during 2017-2018. It has the total production of 2.29 m.t from the area of 1.057 m.ha in the world.

"Foxtail millet has a very good nutritional profile and is ahead of rice and wheat in terms of protein, fiber, minerals and vitamins. It has good nutritive values, 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 100 g. About 8-14% oil is being extracted from the bran of foxtail millet, which can be used as oil after refining". Munirathnam et al. [1]. Unlike rice, foxtail millet release glucose slowly without affecting the metabolism of the human body with low glyceric index.

"Nitrogen is one of the most important fertilizer for crop growth and is widely used in the farming community. Nitrogen is required for the formation of amino acids, proteins, nucleic acids, enzymes, co-enzymes, and alkaloids. In the presence of solar energy, nitrogen-containing chlorophyll fixes atmospheric carbon dioxide as carbohydrates, improving crop quality. Nitrogen fertilization improves food grain protein quality by increasing the proportion of glutamic acid. Grains should contain more proline, methionine, and less Lysine and Lucine. Numerous studies have shown that using N can boost millet production efficiency" [2].

"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" [3].

2. MATERIALS AND METHODS

In order to study, split application of nitrogen and foliar spray of iron were taken. The experiment was conducted during *Zaid* 2022, 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. 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 basal application of nitrogen (40, 50, and 60 Kg/ha) and foliar spray of iron (0.2, 0.4, and 0.6%). The experiment was layout in a randomized block design with ten treatments each replicated thrice and control i.e., recommended N, P and K (50:30:20 Kg/ha). The plots were prepared with dimension of 3m × 3m and seeds were sown with a spacing of 30cm × 10cm. At 14 DAS plants were thinned to maintain appropriate plant density. Weeds were controlled manually at 12, 21 DAS with the help of Khurpi to minimize crop weed competition. Growth characteristics namely plant height (cm), dry weight (g), and number of tillers/ hill, were recorded. "Irrigations were given uniformly and regularly to all plots as per requirement so as to prevent the crop from water stress at any stage. The crop was harvested at right physiological maturity stage and their post-harvest observations such as panicle length (cm), grains/panicle, grain yield (t/ha), and straw yield (t/ha) were recorded. The data recorded for different characteristics were subjected to statistical analysis by adopting the method of analysis of variance (ANOVA) as described by Gomez [4]. The crop was harvested separately from each plot taking 1.0 m^2 area i.e., 80 DAS.

Thereafter, the produce from net plot was tied in bundles separately and then tagged. The tagged bundles were allowed for sun drying in field and after drying on the threshing floor, the weight of bundles was recorded for obtaining biological yield. Threshing of foxtail millet was done manually by beating with stick and then grains were separated by winnowing" [5].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Table 1 Pertaining the details of effect of nitrogen and iron on growth parameters of foxtail millet.

3.2 Plant Height (cm)

The data revealed that significant and higher plant height (101.57 cm) was recorded in treatment no.9 [N at 60Kg/ha + 0.6% Iron]. However, treatment no.8 [N at 60Kg/ha + 0.6% Iron] (100.65 cm) was found to be statistically at par with treatment no. 9.

This might be due to nitrogen application as nitrogen increases the number of internodes and the length of the internodes, resulting in a progressive increase in plant height. Similar findings were reported by Kakarla et al. [6].

Further, with the increase in the availability of iron to plants might have stimulated the metabolic and enzymatic activities resulting in increase in the growth of the crop. Similar findings were reported by Yadav et al. [7].

3.3 Plant Dry Weight (g)

The data revealed that significant and maximum plant dry weight (14.83 g) was recorded in treatment no.9 [N at 60Kg/ha + 0.6% Iron]. However, treatment no.8 [N at 60Kg/ha + 0.4% Iron] (14.62 g) was found to be statistically at par with treatment no. 9.

This might be due to the application of nitrogen as nitrogen is the main component of the protoplasm which is involved in metabolic processes like photosynthesis, cell division, and cell elongation. Which has contributed to increase in dry matter accumulation. Similar findings are reported by Rekha and Prasad et al. [8].

3.4 Number of Tillers/ Hill

The data revealed that significantly more tillers/ hill (8.87) were recorded significantly in treatment no.9 [N at 60Kg/ha + 0.6% Iron]. However, treatment no.8 [N at 60Kg/ha + 0.4% Iron] (8.80) was found to be statistically at par with treatment no. 9.

A considerable rise in plant dry matter might be due to increased nitrogen levels could be linked to nitrogen's effect on raising the amount and effectiveness of chlorophyll, which influences photosynthetic efficiency and the synthesis of other nitrogen compounds. Similar findings were reported by Arshewar et al. [9].

Further, with the application of iron, several enzymatic processes benefits. Many of these enzymes are involved in chlorophyll synthesis, grain formation, and dry matter production, all of which result in an increase in yield characteristics such as the number of effective tillers/ plant in pearl millet. Similar findings were reported by Maharana and Singh et al. [10].

3.5 Yield Attributes

Table 2 Pertaining the details of effect of nitrogen and iron on yield attributes of foxtail millet.

3.6 Panicle Length (cm)

The data revealed that significant and higher panicle length (18.61 cm) was recorded in treatment no.9 [N at 60 Kg/ha + 0.6% Iron]. However, treatment no.8 [N at 60Kg/ha + 0.4% Iron] (18.19 cm) was statistically at par with treatment no.9.

The application of nitrogen fertilizer at the appropriate time improves numerous physiological processes involving photosynthesis, root growth and development, and elongation of structural tissues such as the stalk in cereals. Similar findings were reported by Isah et al. [11].

3.7 Grains/Panicle

The data revealed that significant and more number of grains/panicle (1389.30) was recorded in treatment no.9 [N at 60Kg/ha + 0.6% Iron]. However, treatment no.8 [N at 60Kg/ha + 0.4% Iron] (1337.97) was statistically at par with treatment no.9.

Table 1. Effect of Nitrogen and Iron on growth attributes of Foxtail millet

Sl. No.	Treatment combination	Plant height (cm)	Plant dry weight (g)	No. of tillers/hill
1.	N 40Kg/ha + 0.2% Iron	90.80	12.51	7.20
2.	N 40Kg/ha + 0.4% Iron	91.47	12.65	7.33
3.	N 40Kg/ha + 0.6% Iron	92.64	12.98	7.33
4.	N 50Kg/ha + 0.2% Iron	93.90	13.25	7.47
5.	N 50Kg/ha + 0.4% Iron	94.83	13.60	8.13
6.	N 50Kg/ha + 0.6% Iron	97.03	13.85	8.33
7.	N 60Kg/ha + 0.2% Iron	99.15	14.35	8.40
8.	N 60Kg/ha + 0.4% Iron	100.65	14.62	8.80
9.	N 60Kg/ha + 0.6% Iron	101.57	14.83	8.87
10.	Control (RDF-50:30:20 NPK Kg/ha)	91.20	13.19	7.27
	F Test	S	S	S
	SEm (±)	0.35	0.07	0.08
	CD (p=0.05)	1.04	0.21	0.23

Table 2. Effect of Nitrogen and Iron on yield attributes and yield of Foxtail millet

Sl. No.	Treatment combination	Yield attributes and yield			
		Panicle length (cm)	Grains/panicle	Grain yield (t/ha)	Straw yield (t/ha)
1.	N 40Kg/ha + 0.2% Iron	16.19	1220.00	1.43	2.14
2.	N 40Kg/ha + 0.4% Iron	16.32	1223.80	1.47	2.17
3.	N 40Kg/ha + 0.6% Iron	16.45	1240.90	1.48	2.20
4.	N 50Kg/ha + 0.2% Iron	16.74	1255.27	1.50	2.21
5.	N 50Kg/ha + 0.4% Iron	17.23	1276.33	1.54	2.27
6.	N 50Kg/ha + 0.6% Iron	17.51	1299.57	1.61	2.30
7.	N 60Kg/ha + 0.2% Iron	17.83	1316.73	1.69	2.36
8.	N 60Kg/ha + 0.4% Iron	18.19	1337.97	1.76	2.46
9.	N 60Kg/ha + 0.6% Iron	18.61	1389.30	1.79	2.53
10.	Control (RDF-50:30:20 NPK Kg/ha)	16.34	1222.47	1.46	2.16
	F Test	S	S	S	S
	SEm (±)	0.20	17.54	0.24	0.41
	CD (p=0.05)	0.60	52.12	0.71	1.23

Higher number of grains/ panicle might due to the application of nitrogen increase the fertility of flowers and increase in leaf area and duration and resulted into increase in supplying assimilates for the sink Similar findings were reported by Kakarla et al. [6].

3.8 Grain Yield (t/ha)

The data revealed that significant and higher grain yield (1.79 t/ha) was recorded in treatment no.9 [N at 60Kg/ha + 0.6% Iron]. However, treatment no.8 [N at 60Kg/ha + 0.4% Iron] (1.76 t/ha) was statistically at par with treatment no.9.

Increased grain yield could be attributed to nitrogen being a significant nutrient, which influenced all physicochemical processes. Similar findings were reported by Arshewar et al. [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. [12].

3.9 Straw Yield (t/ha)

The data revealed that significant and higher stover yield (2.53 t/ha) was recorded in treatment no.9 [N at 60Kg/ha + 0.6% Iron]. However, treatment no.8 [N at 60Kg/ha + 0.4% Iron] (2.46 t/ha) was statistically at par with treatment no.9.

“Nitrogen is a component of chloroplast porphyrins, hence greater nitrogen fertilization boosted crop growth and yield due to maximum photosynthates generation. This resulted in improved morphological characteristics, including as plant height, leaf area, and dry matter buildup, which was reflected in better straw yield” [13].

“Iron is important in the production of IAA, particularly in the start of the primordial reproductive component and the portioning of photosynthetic energy towards them, which increases yield”. Maharana and Singh [10].

4. CONCLUSION

By the above study we suggest that higher plant height (101.57 cm), maximum dry weight (14.83 g), more number of tillers/ hill (8.87) was recorded in treatment no.9 with application of Nitrogen 60 Kg/ha with combination of Iron 0.6%. Maximum yield attributes *viz.,* panicle length (18.61 cm), grains/ panicle (1389.30), grain yield (1.79 t/ha), straw yield (2.53 t/ha) were recorded in treatment no.9 with the application of Nitrogen 60 Kg/ha and Iron 0.6%.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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