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Effect of Nutrient Management on Growth and Yield of Foxtail Millet

S. Bala Vineetha [a++*], Shikha Singh [a#], M. Hepsibha [a++] and B. Bharathi Christina [b++]

[a] *Department of Agronomy, SHUATS, Prayagraj, India.*
[b] *Department of Agronomy, Naini Agriculture Institute, SHUATS, Prayagraj, India.*

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 2023 at experimental field of Crop Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. In the present study, the treatments consisting three levels of recommended dose of fertilizer (RDF) viz., 100% RDF (60-30-30 Kg/ha), 75% RDF (45-22.5-22.5 Kg/ha) and 50% RDF (30-15-15 kg/ha) along with three different micro nutrients viz., Zinc - 0.5 kg/ha, Boron - 0.5 kg/ha and Iron - 0.5 kg/ha. The experiment was laid out in a randomized block design with 10 treatments each replicated thrice. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.3), low available nitrogen (278.93 kg/ha), medium available phosphorus (15.4 kg/ha) and medium available potassium (173.7 kg/ha). Results revealed that higher plant height (84.20 cm), plant dry weight (10.61 g), number of tillers/ hill (4.53), length of ears (9.20 cm), number of ears/plant (4.47), test weight (3.47 g), grain yield (1.22 t/ha), straw yield (2.80 t/ha) were recorded in treatment 8 (NPK 100% RDF+ Boron 0.5 kg/ha). Maximum gross return (INR 48,408.33), net return (INR 30,913.33) and B:C ratio (1.77) were also recorded in treatment 8 (NPK 100% RDF + Boron 0.5 kg/ha). It can be concluded that the application of NPK 100% RDF +Boron 0.5kg/ha (Treatment 8) recorded higher yield and benefit cost ratio in Foxtail millet.

[++] *M. Sc Scholar;*
[#] *Assistant Professor;*
**Corresponding author: E-mail: Vineethareddy83@gmail.com;*

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1. INTRODUCTION

“Foxtail millet (*Setaria italica* L.) is known as Italian millet, German millet and Korralu, Kangu, Kangani, Koni and Kaon in different parts of India. It is one of the oldest crops cultivated for food, grain, hay and pasture. 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”, (Sahoo et al., 2020) [1]. Foxtail millet is high in iron, calcium and has low phytic acid content (mownika R *et al*.,) “In India, Andhra Pradesh, Karnataka and Tamil Nadu are the major foxtail millet growing states. Foxtail millet has a very good nutritional profile and is a head of rice and wheat in terms of proteins, fiber, minerals, vitamins. It has good nutritive value, as it is rich in proteins (12.3g), Carbohydrates (60.9g), fat (4.3g), crude fiber (8.0g), calcium (3.1g). The grain is a good source of Beta carotene, which is the precursor of vitamin A” (Murugan and Nirmala ,2006). According to FAO, “the world production of millets is 89.17 million metric tonnes from an area of 74 million ha. India is the largest producer of millets in the world”. “India is the global leader in production of millets with a share of around 15% of the world total production. In India, millets are cultivated majorly in 21 states in an area of 12.53 million hectares, producing 15.53 million tonnes with a yield of 1237 kg/ha” (Assocham, 2022). “In India area under the cultivation of small millets is 0.459 m. ha, production is 0.33 m. tons and its productivity is 809 kg/ha, Foxtail millet predominates all millets in terms of productivity, yielding about 2166 kg/ha” (GOI,2021-22).

“NPK fertilization practices not only enhance the crop yield and quality, such as oil content, soluble protein, vitamin C, and soluble sugar, but also increase fertilizer utilization efficiency, leading to optimal economic benefits. Thus, it is crucial to maintain a balanced supply of these essential nutrients to achieve optimal plant growth, development, and yield (Xing G *et al.*, 2023). Adequate N nutrition is required for full development of tillers, leaves and also enables the plant to operate at peak photosynthetic capacity (Arsheyar *et al*.,2018). Phosphorus involved in development of stalk and stem length, seed formation, crop maturity and production. Potassium contributes to protein synthesis, carbohydrate metabolism, and enzyme activation. [2].

“Zinc is one of the essential micronutrients required for optimal plant growth plays a vital role in metabolism. Zinc plays a role in plant resistance against diseases, photosynthesis, cell membrane integrity, protein synthesis and chlorophyll with in the plant tissues. Zinc is essential for plant functions, production of auxins, an essential growth hormone, it is necessary for starch formation, proper development, chlorophyll and carbohydrates” (Komal *et al*., 2018). [2].

“Boron plays an important role in the physiological process of plants, such as cell elongation, cell division, germination and growth of pollen grains, sugar translocation and movement of growth regulators within the plant, lignin synthesis, cell maturation, meristematic tissue development and protein synthesis. The application of boron also promotes the absorption of nitrogen from soil” (Manjunath and Debbarma,2023).[2].

“Iron is important in many physiological and biochemical pathways in plants. Iron also activates many metabolic pathways and is a prosthetic group constituent of many enzymes. 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*.,).[3]

2. MATERIALS AND METHODS

A field experiment was conducted during Zaid season of 2022-2023 at Crop research farm of Department of Agronomy at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. which is located 98 m altitude above the mean sea level. The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 7.3), Low in available nitrogen (278.93 kg/ha), medium in available phosphorus (15.4 kg/ha) and medium in available potassium (173.7 kg/ha).The experiment were laid out in randomized block design with 10 treatments each replicated thrice *viz.,* T_1- NPK 50% RDF + Zinc 0.5 kg/ha, T_2 - NPK 50% RDF + Boron 0.5 kg/ha, T_3 - NPK 50% RDF +Iron 0.5 kg/ha, $T_{4,}$- NPK 75 % RDF+ Zinc 0.5 kg /ha, $T_{5,}$- NPK 75 % RDF+ Boron 0.5 kg /ha, T_6- NPK 75 % RDF+ Iron 0.5 kg /ha, $T_{7,}$ - NPK 100% RDF+ Zinc 0.5

kg/ha, T_8.- NPK 100% RDF+ Boron 0.5 kg/ha, T_9 - NPK 100% RDF+ Iron 0.5 kg/ha,T_{10}- 30 cm × 10 cm + RDF (control). Seeds were sown at a depth of 3-4 cm in lines at a spacing of 30× 10 cm. the gap filling was done 10 DAS whereas to maintain the recommended spacing, thinning was done by removing excess plants. In order to reduce crop density and weed competition, intercultural operations were carried out twice at 20 and 40 DAS. First light irrigation was done just after sowing then subsequent irrigations were applied as per the requirement of the crop. The observations on various growth and yield parameters were recorded from the selected plants. The observations were recorded for plant height (cm), dry weight (g/plant), number of tillers, whereas at harvest, Number of ears /plants, length of ears (cm), no of grains/ears, Test weight (g), grain yield (t/ha), stover yield (t/ha), harvest index (%). The data were subjected to statistical analysis by analysis of variance method (ANOVA) at 5% probability (Gomez and Gomez, 1976).

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

At 80 DAS, [Table 1] significantly highest plant height (84.20 cm) was recorded in treatment NPK 100% RDF + Boron 0.5 kg/ha. However, the treatment T_9 were found to be statistically at par with highest. This might be due to application of NPK and boron which increased the high photosynthetic activity and chlorophyll synthesis and application of boron forming a synergistic effect with nitrogen uptake which in turn enhances vegetative growth. Similar results reported by (Manjunath and Debbarma .2023) in finger millet. [2]

3.1.2 Plant dry weight

At 80 DAS, [Table 1] significantly highest plant dry weight/plant (10.61 g) was recorded in treatment NPK 100% RDF + Boron 0.5 kg/ha. However, the treatment T_9 were found to be statistically at par with T_8. This was due to application of NPK and boron which is significantly increased plant dry weight. The main contribution of photosynthetic activity which improved the cell division and cell enlargement due to increased photo synthetic rate subsequently increasing the plant dry weight. Similar findings reported by (Ravi raja *et al*.,2020) [4].

3.1.3 Number of tillers

At 80 DAS, [Table 1] significantly highest no. of tillers/plant (4.53) was recorded in treatment NPK 100% RDF + Boron 0.5 kg/ha. However, the treatment T_1, T_2, T_4, T_6 were found to be statistically at par with T_8. The number of tillers per plant were higher due to luxuriant availability of NPK and boron for growth and development of auxiliary buds from which tillers are emerged, rapid conversion of synthesized carbohydrates into protein and consequent increase in the number and size of growing cells, resulting ultimately in increased no. of tillers. Similar findings were reported by (Sandhya *et al*.,2017) [5] in millets, Louthar *et al.,*2020*)* in little millet. [6]

3.2 Yield Attributes

3.2.1 No. of ears/plant

At harvest, [Table 2] significantly highest number of ears/plants (4.47) was recorded in treatment of application of NPK 100% RDF + Boron 0.5 kg/ha. This might be due to cumulative effect on growth and vigour of plants. With more fertilizer applied, growth characteristics may have significantly improved because to an enhanced supply of metabolites. It's possible that higher growth components brought about by higher fertilizer levels stabilized the higher supply of photosynthates going into the ear. Similar findings reported in pearl millet by Bahadur and (S.K. Chauhan. 2014).

3.2.2 Length of ears

At harvest, [Table 2] significantly highest Length of ear (cm) (9.20 cm) was recorded in treatment of application of NPK 100% RDF + Boron 0.5 kg/ha. However, the treatment T_7, T_9 were statistically at par with treatment T_8. This might be due to the better supply of nutrients to the plants which increased the rapid growth and development. Thus, the plant received optimum nutrients produced the maximum length of ear. Similar findings reported in pearl millet by (Akhil *et al*.,2023). [7].

3.2.3 No. of Seeds/ear

At harvest, [Table 2] significantly highest seeds/ears (262.47) was recorded in treatment of application of NPK 100% RDF + Zinc 0.5 kg/ha.

However, the treatment T_4, T_6, T_8 were found to be statistically at par with T_7. This might be due to be application of NPK favorably affected the balanced macro nutrients and zinc which acts as an activator of enzymes in plants and is directly involved in the biosynthesis of auxin which increased the seeds/ear. Similar findings reported by (Swaroop *et al*.,2023) [8].

3.2.4 Test weight (g)

At harvest, [Table 2] significantly highest test weight (3.47 g) was recorded in treatment of application of NPK 100% RDF + Boron 0.5 kg/ha. However, the treatment T_1, T_3, T_4, T_5, T_7, T_9 were found to be statistically at par T_8. The probable reason for increased test weight was mainly due to balanced supply of nutrients throughout the grain filling and development period which might have resulted in bold grains and consequently higher test weight. Similar findings reported in pearl millet by (Kalaliya *et al*.,2022) [9].

3.2.5 Grain yield (t/ha)

At harvest, [Table 2] significantly highest seed yield (1.22 t/ha) was recorded in treatment of NPK 100% RDF + Boron 0.5 kg/ha. Application of RDF and boron increased the concentration of nutrient ions in the soil solution and availability of sufficient nutrients might have helped in higher nutrient uptake. Which increased the growth and yield contributing characters like number of tillers, dry weight, number of seeds/ear and ear head length. which results in higher yield (Mubeena *et al.,*2019) [10].

Table 1. Effect of nutrient management on growth attributes of Foxtail millet

S. No	Treatments	80 DAS Plant height (cm)	80 DAS Dry weight (g/plant)	80 DAS No. of tillers
1.	NPK 50% RDF + Zinc 0.5 kg/ha	78.36	9.50	3.80
2.	NPK 50% RDF + Boron 0.5 kg/ha	78.60	9.75	3.67
3.	NPK 50% RDF + Iron0.5 kg/ha	79.17	9.69	3.00
4.	NPK 75% RDF + Zinc 0.5 kg/ha	78.00	9.87	3.80
5.	NPK 75% RDF + Boron 0.5 kg/ha	76.53	9.63	3.00
6.	NPK 75% RDF + Iron 0.5 kg/ha	77.25	9.66	3.53
7.	NPK 100% RDF + Zinc 0.5 kg/ha	80.89	10.32	2.67
8.	NPK 100% RDF + Boron 0.5 kg/ha	84.20	10.61	4.53
9.	NPK 100% RDF + Iron 0.5 kg/ha	83.12	10.50	3.00
10.	Control +(N, P, K-60,30,30 kg/ha)	76.47	9.56	2.67
	S. Em (±)	1.06	0.14	0.35
	C.D (p=0.05)	3.16	0.44	1.06

Table 2. Effect of Nutrient management on yield attributes and yield of Foxtail millet

		At harvest						
S. No	Treatments	Number of ears/ plants	Length of ears (cm)	No. of seeds /ear	Test weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	NPK 50% RDF + Zinc 0.5 kg/ha	4.07	8.33	242.27	3.37	1.03	2.45	29.52
2.	NPK 50% RDF + Boron 0.5 kg/ha	3.93	8.13	241.13	2.80	0.85	2.18	28.18
3.	NPK 50% RDF + Iron0.5 kg/ha	4.13	8.27	243.87	3.10	0.94	2.29	29.23
4.	NPK 75% RDF + Zinc 0.5 kg/ha	4.07	8.27	251.87	3.17	0.86	2.43	26.17
5.	NPK 75% RDF + Boron 0.5 kg/ha	4.07	8.40	243.07	3.10	0.95	2.39	28.61
6.	NPK 75% RDF + Iron 0.5 kg/ha	4.00	8.17	254.67	2.90	0.96	2.26	29.83
7.	NPK 100% RDF + Zinc 0.5 kg/ha	4.07	8.87	262.47	3.23	1.10	2.71	28.85
8.	NPK 100% RDF + Boron 0.5 kg/ha	4.47	9.20	258.87	3.47	1.22	2.80	30.30
9.	NPK 100% RDF + Iron 0.5 kg/ha	4.00	9.00	245.27	3.10	0.95	2.64	26.51
10.	Control +(N, P, K-60,30,30 kg/ha)	4.13	8.27	246.20	2.60	0.88	2.16	28.99
	S. Em (±)	0.08	0.21	4.39	0.16	0.03	0.12	1.19
	C.D (p=0.05)	0.25	0.63	13.06	0.49	0.10	0.38	-

Table 3. Effect of nutrient management on economics of Foxtail millet

S.No	Treatments	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1.	NPK 50% RDF + Zinc 0.5 kg/ha	17,350.00	42,066.67	24,716.67	1.42
2.	NPK 50% RDF + Boron 0.5 kg/ha	174,95.00	35,308.33	17,813.33	1.02
3.	NPK 50% RDF + Iron0.5 kg/ha	168,30.00	38,625.00	21,795.00	1.30
4.	NPK 75% RDF + Zinc 0.5 kg/ha	168,00.00	36,050.00	19,250.00	1.15
5.	NPK 75% RDF + Boron 0.5 kg/ha	174,95.00	39,100.00	21,605.00	1.23
6.	NPK 75% RDF + Iron 0.5 kg/ha	169,00.00	39,133.33	22,233.33	1.32
7.	NPK 100% RDF + Zinc 0.5 kg/ha	173,50.00	45,283.33	27,933.33	1.61
8.	NPK 100% RDF + Boron 0.5 kg/ha	174,95.00	48,408.33	30,913.33	1.77
9.	NPK 100% RDF + Iron 0.5 kg/ha	182,00.00	39,850.00	21,650.00	1.19
10.	Control +(N, P, K-60,30,30 kg/ha)	185,50.00	37,033.33	18,483.33	1.00

3.2.6 Stover yield (t/ha)

At harvest, [Table 2] Significantly highest stover yield (2.80 t/ha) was recorded in treatment of NPK 100% RDF + Boron 0.5 kg/ha. However, the treatment T_7, T_9 were found to be statistically at par with T_8. The straw yield increased due to better root activity and high physiological activities This was due to enhanced translocation of photosynthates from source to sink and induced growth as well as due to optimum doses of borax and NPK, improved vegetative growth, better root activity and high physiological activities. Similar findings reported in finger millet by (Manjunath and Debbarma.2023) [2].

3.2.7 Harvest index (%)

At harvest, [Table 2] significantly highest harvest index (30.30%) was recorded in treatment of NPK 100% RDF + Boron 0.5 kg/ha. However, the treatment T_1, T_2, T_3, T_4, T_5, T_6, were found to be statistically at par with T_8. Harvest index is directly correlated to the seed yield and haulm yield. Increased harvest index was due to better crop growth from early stages to at harvest. Better performance of crop from vegetative to reproductive stage [11].

3.3 Economics

3.3.1 Cost of cultivation:

Significantly highest cost of cultivation (18,550.00 INR/ha) was recorded in control [12].

3.3.2 Gross returns

Significantly highest gross return (48,408.33 INR/ha) was recorded in treatment NPK 100% RDF + Boron 0.5 kg/ha.

3.3.3 Net returns

Significantly highest net return (30,913.33 INR/ha) was recorded in treatment NPK 100% RDF + Boron 0.5 kg/ha.

3.3.4 Benefit-cost ratio

Significantly highest benefit-cost ratio (1.77) was recorded in treatment NPK 100% RDF + Boron 0.5 kg/ha.

4. CONCLUSION

Based on a above findings it is concluded that the application of NPK 100% along with Boron 0.5kg/ha in foxtail millet, performed better in growth and yield, and also proven profitable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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