Original Research Article

Effect of Nitrogen and Boron on Growth and Yield of Foxtail Millet (*Setaria italica* L.)

Abstract

The field experiment titled "Effect of Nitrogen and Boron on Growth and Yield of Foxtail Millet" was conducted during Zaid-2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. 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 treatment combinations are T1: Nitrogen 40kg/ha + Boron 0.01%, T2: Nitrogen 40kg/ha + Boron 0.02%, T3: Nitrogen 40kg/ha + Boron 0.03%, T4: Nitrogen 50kg/ha + Boron 0.01%, T5: Nitrogen 50kg/ha + Boron 0.02, T6: Nitrogen 50kg/ha + Boron 0.03%, T7: Nitrogen 60kg/ha + Boron 0.01%, T8: Nitrogen 60kg/ha + Boron 0.02%, T9: Nitrogen 60kg/ha + Boron 0.03%, T10: Control (RDF 50:30:20 NPK kg/ha). Results obtained that significantly higher plant height (83.52 cm), plant dry weight (14.06 g), length of ear head (15.70 cm), number of grains/ear head (1413.09), test weight (3.88 g), grain yield (1.68 t/ha), stover yield (3.88 t/ha), harvest index (33.79%) maximum gross return (69,291.48 INR/ha), net return (48,099.98 INR/ha) and B:C ratio (2.27) were recorded in treatment 9 (Nitrogen 60kg/ha + Boron 0.03%).

Key words: - *Foxtail millet, Zaid, Nitrogen, Boron, Growth, Yield, Economics.*

INTRODUCTION

Foxtail millet (S. italica) is an important crop used as a staple food in many parts of the world including arid and semi-arid areas of China, some part of India and Japan, and is grown for silage and hay in South and North America. Foxtail millet is commonly known in India as Kangni (Hindi), Kang (Gujrati), Navane (Kanada), Tenai (Tamil). It is the second most cultivated millet after pearl millet. **(Bennetzen *et al.*, (2012)**

Foxtail millet grain is rich in protein (14-16%), crude fat (6–8%), and iron along with zinc and calcium **(Muthamilarasan *et al.*, (2016).** Foxtail millet bran contains 8-10% crude oil and is rich in linoleic 348 (66.5%) and oleic (13.0%) acids.In addition to that, the grains of foxtail millet require only 26% of their grain weight in water to germinate, whereas other major cereals such as rice, wheat, and maize require a minimum of 45% of their grain weight. Similarly, to produce 1 g dry biomass, foxtail millet requires only 257g of water, which is the minimum among other cereals, as wheat and maize requires 470 and 510 g, respectively **(Diao *et al.*, 2014).**

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Being a C4 photosynthetic crop, foxtail millet is naturally equipped with excellent WUE and nitrogen use efficiency, and, in addition, several morpho-physiological traits including dense and deep root systems, smaller leaf area, and thickening of cell walls which were thought to lead to durable tolerance to a range of abiotic stresses mainly drought, heat, and salinity **(Lata *et al.*, 2013; Diao *et al.*, 2014).**

Foxtail millet is a native of China and is one of the world's oldest known cultivated crops. It ranks second in the total world production of millets and continues to have an important place in world agriculture providing approximately six million tons of food per annum. It can grow at any altitudes from sea level to 2000 m above sea levels, escapes drought due as its early maturity but cannot tolerate water logging. The quick growth and its adaption to a wide range of elevations, soils and temperature makes it a short-term catch crop for humans and as feed to poultry and cage birds **(Rao *et al.,* 2017).** Currently, foxtail millet is distributed in most of China, some parts of India, USA, Canada, the Korean Peninsula, Japan, Indonesia, Australia, and the northern part of Africa **(Doust *et al.,* 2009).**

Nitrogen (N) is an essential macronutrient for plant growth, development, and production. As an essential component of nucleic acids and proteins, N actively participates in most physiological and biological processes in crop production including photosynthesis, carbohydrate allocation, root patterning, and flower development, and hence signifies itself as a critical macronutrient controlling crop yield and quality.Nitrogen fertilizer is one of the most yield limiting nutrients for crop production and it is applied in large quantity for most annual crops **(Huber and Thompson, 2007).** It plays an important role in building units of proteins in the plant system. Thus, N nutrition not only influences productivity but also quality. Nitrogen is the major nutrient required by the millets which positively increases the growth, yield attributes and finally improve the yield **(Prasad *et al.,* 2014).**

Boron plays an important role in plant growth and nutrition and it promotes cell division, cell elongation, cell wall resistance, flowering, pollination, fruit set and sugar translocation. The main function of boron in plant growth and development is its ability to form complexes with compounds with the cisdiol configuration. It has been observed that in most plant species, the boron requirement for reproductive development is much higher than the boron requirement for vegetative growth. Boron is one of the most important micronutrients for plant growth and plays an important role in the physiological processes within plant. According to some studies, B sorption heightens due to elevated levels of calcite in soil and liming diminished the water-soluble B content of soils **(Goldberg and Forster, 1991)**

In addition, to include millets into the mainstream and exploit its nutritionally superior qualities and promote its cultivation, Government of India has declared Year 2018 as the "Year of Millets" and FAO Committee on Agriculture (COAG) forum has declared Year 2023 as "International Year of Millets." **Satyavathi *et al.,* (2021).**

MATERIAL AND METHODS:

The experiment was conducted during Zaid 2022. The experiment was conducted in Randomized Block Design (RBD) consisting of ten treatments which are replicated thrice and

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was laid out with the different treatments allocated randomly in each replication. The soil of the experimental field was sandy loam in texture, slightly alkaline reaction (pH 7.1) with low level of organic carbon (0.48%), available N (225 Kg/ha), P (13.6 kg/ha) and higher level of K (215.4 kg/ha). The treatment combinations are T1: Nitrogen 40kg/ha + Boron 0.01%, T2: Nitrogen 40kg/ha + Boron 0.02%, T3: Nitrogen 40kg/ha + Boron 0.03%, T4: Nitrogen 50kg/ha + Boron 0.01%, T5: Nitrogen 50kg/ha + Boron 0.02, T6: Nitrogen 50kg/ha + Boron 0.03%, T7: Nitrogen 60kg/ha + Boron 0.01%, T8: Nitrogen 60kg/ha + Boron 0.02%, T9: Nitrogen 60kg/ha + Boron 0.03%, T10: Control (RDF 50:30:20 NPK kg/ha). The observations were recorded on different growth parameters at harvest viz. plant height(cm), plant dry weight (g/plant), ear head length(cm), no.of grains/ear head, test weight(g), grain yield(t/ha) and stover yield(t/ha).

RESULTS AND DISCUSSION

1. Growth Parameters:

1.1. Plant Height

The plant height measurements improved as per crop growth progressed. Treatment nine with the application of 60kg/ha Nitrogen+ 0.03% Boron was recorded higher plant height (83.52 cm) and treatments eight found to be statistically at par with treatment nine in Table 1. The maximum plant height was attained by the regular supply of plant nutrients during all growth stages, through a supply of Nitrogen and Boron. Nitrogen (N) is an essential macronutrient for plant growth, development, and production. As an essential component of nucleic acids and proteins, N actively participates in most physiological and biological processes in crop production including photosynthesis, carbohydrate allocation, root patterning, and flower development, and hence signifies itself as a critical macronutrient controlling crop yield and quality **(Stitt, 1999).** Boron is essential in enhancing carbohydrate metabolism, sugar transport, cell wall formation, protein metabolism, root growth and stimulating other physiological process of the plant **(Ashour and Reda, 1972).** Boron enhances the differentiation of tissue cell division and nitrogen absorption from the soil. **Singh *et al.*, (2014).**

1.2. Dry weight

Treatment nine with the application of Nitrogen 60kg/ha + Boron 0.03% was recorded a higher dry matter (14.06g) in Table 1. Treatment eight and six were statistically at par with treatment nine. This might be due to Nitrogen 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. **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).**

2. Yield Parameters:

2.1. Ear head length

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A significant impact was experiential by the statistical analysis of ear head length. Treatment with Nitrogen 60kg/ha+ Boron 0.03% as recorded higher ear head length (15.70 cm). However, statistical parity was obtained with Nitrogen 60kg/ha + Boron 0.02% in Table 2. Nitrogen 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 panicle 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 yield attributes like panicle length. These results agree with the findings of **Sreelatha *et al.*, (2004).**

2.2. Number of grains/ear head

A significant impact was experiential by the statistical analysis of number of grains/ear head. Treatment with Nitrogen 60kg/ga + Boron 0.03% was recorded higher number of grains/ear head (1413.09). However, statistical parity was obtained with Nitrogen 60kg/ha + Boron 0.02%. Nitrogen provides potential for many of the enzymatic transformations. Several of these enzymes are involved in chlorophyll synthesis and grain formation resulting in higher grains/panicle. Similar results are observed by **Vaja *et al.*, (2022).** 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).**

2.3. Grain yield

The highest grain yield was obtained in treatment nine Nitrogen 60 kg/ha + Boron 0.03% (1.68 t/ha). However, Treatment nine Nitrogen 60 kg/ha + Boron 0.03% is statistically at par with Nitrogen 60kg/ha + Boron 0.02%. Nitrogen 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).**

2.4. Stover yield

Application of nitrogen and boron has significantly impact on stover production of the foxtail millet. At nitrogen 60kg/ha + boron 0.03%, the higher stover yield (3.88t/ha) was obtained. Nitrogen 60kg/ha + boron 0.03% was statistically at par with nitrogen 60kg/ha + boron 0.02%. This might be due to favourable effect of nitrogen 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 *et al.*, (2019).** Boron is 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 reported by **Movalia *et al.*, (2020).**

3. Economic Analysis

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Observations regarding economics of different treatments of foxtail millet are given in table 3.

3.1. Gross Return (INR/ha)

Data pertaining to the gross returns as influenced by various treatments are presented in Table.3 Gross returns (69291.48 INR/ha) was found to be higher in treatment with application of Nitrogen 60kg/ha + Boron 0.03% and the minimum gross (49365.63 INR/ha) was found to be in treatment 10 (Control RDF-50:30:20 NPK kg/ha).

3.2. Net Returns (INR/ha)

Data pertaining to the net returns as influenced by various treatments are presented in Table.3 Net returns (48,099.98 INR/ha) was found to be higher in treatment with application of Nitrogen 60kg/ha + Boron 0.03% and minimum net returns (29384.13 INR/ha) was found to be in treatment 10 (Control RDF-50:30:20 NPK kg/ha).

3.3. Benefit cost ratio (B:C)

Data pertaining to the B:C ratio as influenced by various treatments are presented in Table.3 Benefit cost ratio (2.27) was found to be highest in treatment with application of Nitrogen 60kg/ha + Boron 0.03% and the minimum Benefit cost ratio (1.47) was found to be in treatment 10 (Control RDF-50:30:20 NPK kg/ha).

CONCLUSION

Based on experimental findings it is concluded that Treatment (9) application of Nitrogen 60kg/ha + Boron 0.03% performed better in growth, yield parameters and economics. As it was more productive it can be recommended to farmers after further trail.

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Table.1 Effect of Nitrogen and Boron on Growth and Yield of Foxtail Millet.

Treatment No	Treatments	Plant height (cm) At 80 DAS	Plant dry weight (g/P) At 80 DAS
1.	Nitrogen 40 kg/ha + Boron 0.01% 20DAS	72.60	9.80
2.	Nitrogen 40 kg/ha + Boron 0.02% 40 DAS	73.18	10.42
3.	Nitrogen 40 kg/ha + Boron 0.03% 60DAS	74.24	11.11
4.	Nitrogen 50 kg/ha + Boron 0.01% 20 DAS	75.40	11.95
5.	Nitrogen 50 kg/ha + Boron 0.02% 40 DAS	77.37	12.26
6.	Nitrogen 50 kg/ha + Boron 0.03% 60 DAS	78.47	13.24
7.	Nitrogen 60 kg/ha + Boron 0.01% 20 DAS	81.86	12.85
8.	Nitrogen 60 kg/ha + Boron 0.02% 40 DAS	82.86	13.48
9.	Nitrogen 60 kg/ha + Boron 0.03% 60 DAS	83.52	14.06
10.	Control (RDF 50:30:20 NPK kg/ha)	72.13	10.24
	SEm(±)	0.53	0.76
	CD (p=0.05)	1.62	1.13

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Table.2 Effect of Nitrogen and Boron on Growth and Yield of Foxtail millet.

Treatment No	Treatments	Ear head length (cm)	No. of grains/ear head	Test weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	Nitrogen 40 kg/ha + Boron 0.01% 20DAS	11.42	1076.03	2.55	1.06	2.83	33.65
2.	Nitrogen 40 kg/ha + Boron 0.02% 40 DAS	11.64	1110.69	2.75	1.24	3.14	32.93
3.	Nitrogen 40 kg/ha + Boron 0.03% 60DAS	12.41	1169.36	3.26	1.31	3.34	32.48
4.	Nitrogen 50 kg/ha + Boron 0.01% 20 DAS	12.77	1190.69	3.06	1.38	3.69	31.33
5.	Nitrogen 50 kg/ha + Boron 0.02% 40 DAS	13.71	1226.42	3.19	1.45	3.85	31.28
6.	Nitrogen 50 kg/ha + Boron 0.03% 60 DAS	14.28	1286.42	3.24	1.51	4.18	30.24
7.	Nitrogen 60 kg/ha + Boron 0.01% 20 DAS	14.61	1309.76	3.30	1.58	4.14	31.17
8.	Nitrogen 60 kg/ha + Boron 0.02% 40 DAS	15.27	1373.76	3.40	1.61	3.78	33.60
9.	Nitrogen 60 kg/ha + Boron 0.03% 60 DAS	15.70	1413.09	3.64	1.68	3.88	33.79
10.	Control (RDF 50:30:20 NPK kg/ha)	12.90	1024.67	2.78	1.11	2.98	33.17
	SEm (±)	0.25	24.76	0.10	0.04	0.08	0.72
	CD (p=0.05%)	0.75	73.57	0.31	0.11	0.23	2.14

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Table 3. Effect of Nitrogen Boron on economics of production of Foxtail Millet.

Treatment No.	Treatment combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	Benefit: Cost ratio
1.	Nitrogen 40 kg/ha + Boron 0.01% 20DAS	20,261.50	49,949.43	29,687.93	1.47
2.	Nitrogen 40 kg/ha + Boron 0.02% 40 DAS	20,511.50	53,994.38	33,482.88	1.63
3.	Nitrogen 40 kg/ha + Boron 0.03% 60DAS	20,761.50	56,254.33	35,492.83	1.71
4.	Nitrogen 50 kg/ha + Boron 0.01% 20 DAS	20,481.50	58,942.22	38,460.72	1.88
5.	Nitrogen 50 kg/ha + Boron 0.02% 40 DAS	20,731.50	61,396.53	40,665.03	1.96
6.	Nitrogen 50 kg/ha + Boron 0.03% 60 DAS	20,981.50	63,366.10	42,384.60	2.02
7.	Nitrogen 60 kg/ha + Boron 0.01% 20 DAS	20,691.50	65,661.05	44,969.55	2.17
8.	Nitrogen 60 kg/ha + Boron 0.02% 40 DAS	20,941.50	66,874.15	45,932.65	2.19
9.	Nitrogen 60 kg/ha + Boron 0.03% 60 DAS	21,191.50	69,291.48	48,099.98	2.27
10.	Control (RDF 50:30:20 NPK kg/ha)	19,981.50	49,365.63	29,384.13	1.47

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