

## Original research article

### Effect of Nitrogen and Boron on Growth and Yield of Foxtail Millet (*Setariaitalica*L.)

#### Abstract

The field experiment titled “Effect of Nitrogen and Boron on Growth and Yield of Foxtail Millet” was conducted during *Zaid-2023* 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 T<sub>1</sub>: Nitrogen 40kg/ha + Boron 0.01%, T<sub>2</sub>: Nitrogen 40kg/ha + Boron 0.02%, T<sub>3</sub>: Nitrogen 40kg/ha + Boron 0.03%, T<sub>4</sub>: Nitrogen 50kg/ha + Boron 0.01%, T<sub>5</sub>: Nitrogen 50kg/ha + Boron 0.02, T<sub>6</sub>: Nitrogen 50kg/ha + Boron 0.03%, T<sub>7</sub>: Nitrogen 60kg/ha + Boron 0.01%, T<sub>8</sub>: Nitrogen 60kg/ha + Boron 0.02%, T<sub>9</sub>: Nitrogen 60kg/ha + Boron 0.03%, T<sub>10</sub>: 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 (1,413.09), test weight (3.88 g), grain yield (1.68 t/ha), stover yield (3.88 t/ha), harvest index (33.79%) higher 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 (*Setariaitalica* L.) 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(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 1g 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). “Being a C<sub>4</sub> photosynthetic crop, foxtail millet is naturally equipped with excellent water use efficiency and nitrogen use efficiency, 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).

“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 is an essential macronutrient for plant growth, development, and production. As an essential component of nucleic acids and proteins, 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, Nitrogen 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, boron sorption heightens due to elevated levels of calcite in soil and liming diminished the water-soluble boron 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 forum has declared Year 2023 as “International Year of Millets.” Satyavathiet *al.*(2021).

## **MATERIALAND METHODS:**

The experiment was conducted during *Zaid2023*. The experiment was conducted in Randomized Block Design (RBD) consisting of ten treatments which are replicated thrice and 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 Nitrogen (225 Kg/ha), Phosphorus (13.6 kg/ha) and higher level of potassium (215.4 kg/ha). The treatment combinations are T<sub>1</sub>: Nitrogen 40kg/ha + Boron 0.01%, T<sub>2</sub>: Nitrogen 40kg/ha + Boron 0.02%, T<sub>3</sub>: Nitrogen 40kg/ha + Boron 0.03%, T<sub>4</sub>: Nitrogen 50kg/ha + Boron 0.01%, T<sub>5</sub>: Nitrogen 50kg/ha + Boron 0.02, T<sub>6</sub>: Nitrogen 50kg/ha + Boron 0.03%, T<sub>7</sub>: Nitrogen 60kg/ha + Boron 0.01%, T<sub>8</sub>: Nitrogen 60kg/ha + Boron 0.02%, T<sub>9</sub>: Nitrogen 60kg/ha + Boron 0.03%, T<sub>10</sub>: 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),stover yield(t/ha) and harvest index (%).

## **RESULTS AND DISCUSSION**

### **1. Growth Parameters:**

#### **1.1. Plant Height**

The plant height measurements improved as per crop growth progressed. The significantly higher plant height (83.52 cm) was recorded in treatment 9 with application of Nitrogen 60 kg/ha + Boron 0.03% at 80 DAS. However, treatment 6 (78.86cm) Nitrogen 60 kg/ha + Boron 0.02% was found statically at par with treatment 9 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 is the primary nutrient and plays a vital role in growth as well development of the plant. Plant height is controlled by the genetic makeup of the species and the environment to which the plant is subjected during the growth and development. The effect of nitrogen levels on plant height was significant at all growth stage. In general plant growth increase with advancement of crop growth stages and reached to maximum at harvest” (**Dadhich and Gupta, 2003**). “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 *etal.*(2014)**.

#### **1.2. Dry weight**

The significantly higher plant dry weight (14.06 g) was recorded in treatment-9 with the application of (60kg/ha Nitrogen + 0.03 % Boron). However. Treatment 8 (13.48 g) 60kg/ha Nitrogen + 0.02 % Boron and treatment 6 (13.24 g) 50kg/ha Nitrogen + 0.03% Boron were found statically at par with treatment 9 in Table 1. 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. **Sriharietal. (2023)**.

### **2. Yield Parameters:**

#### **2.1. Ear head length**

The significantly higher ear head length (15.70 cm) was recorded in treatment 9 with the application of (Nitrogen 60 kg/ha + Boron 0.03%). However. Treatment 8 (15.27 cm) Nitrogen 60 kg/ha + Boron 0.02% was found statically at par with treatment 9.

“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” (**Maharana and Singh 2021**).

#### **2.2. Number of grains/ear head**

The significantly higher no. grains/ear head (1413.09) was recorded in treatment9 with the application of Nitrogen 60 kg/ha + Boron 0.03%. However, treatment8 (1373.76) Nitrogen 60 kg/ha + Boron 0.02% was found statically at par with treatment9.

“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” (Movaliaet *al.*, 2020). 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 Vajaet *al.*(2022).

### **2.3. Grain yield**

The significantly higher grain yield (1.68 t/ha) was recorded in treatment9 with the application of Nitrogen 60 kg/ha + Boron 0.03 %. However, treatment8 (1.61 t/ha) Nitrogen 60kg/ha + Boron 0.02 % was found statically at par with treatment9.

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 Raoet *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 Banothet *al.*(2022).

### **2.4. Stover yield**

The significantly higher stover yield (3.88 t/ha) was recorded in treatment9 with the application of (Nitrogen 60 kg/ha + Boron 0.03 %). However. Treatment8 (3.78 t/ha) (Nitrogen 60 kg/ha + Boron 0.02 %) was found statically at par with treatment9.

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 (Raoet *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 supported by Movaliaet *al.*(2020).

### **2.5. Harvest Index (%)**

The higher harvest index (33.79) was recorded in treatment9 with the application of (Nitrogen 60 kg/ha + Boron 0.03 %). However, there was no significant difference among the treatments.

## **3. Economic Analysis**

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

### **3.1. Cost of cultivation (INR/ha)**

Data pertaining to the gross returns as influenced by various treatments are presented in Table.3

Cost of cultivation (INR/ha 21,191.50) was recorded higher in treatment9 with application of Nitrogen 60 kg/ha + Boron 0.03% as compared to other treatments.

### **3.2. Gross Return (INR/ha)**

Data pertaining to the net returns as influenced by various treatments are presented in Table.3

Higher gross return (INR/ha 69,291.48) was recorded in treatment9 with the application of (Nitrogen 60 kg/ha + Boron 0.03%) as compared to other treatments.

### **3.3. Net return (INR/ha)**

Data pertaining to the B:C ratio as influenced by various treatments are presented in Table.3

Net return (INR/ha 48,099.98) was recorded higher in treatment-9 with the application of (Nitrogen 60kg/ha + Boron 0.03%) as compared to other treatments.

### **3.4. Benefit cost ratio (B:C)**

Data pertaining to the B:C ratio as influenced by various treatments are presented in Table.3

Higher benefit cost ratio (2.27) was recorded in treatment 9 with the application of (Nitrogen 60 kg/ha + Boron 0.03%) as compared to other treatment.

## **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.



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

<b>Treatment No</b>	<b>Treatments</b>	<b>Plant height (cm) At 80 DAS</b>	<b>Plant dry weight(g)At 80 DAS</b>
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
	<b>SEm(±)</b>	0.53	0.76
	<b>CD (P=0.05)</b>	1.62	1.13

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

<b>Treatment No</b>	<b>Treatments</b>	<b>Ear head length (cm)</b>	<b>No. of grains/ear head</b>	<b>Test weight (g)</b>	<b>Grain yield (t/ha)</b>	<b>Stover yield (t/ha)</b>	<b>Harvest index (%)</b>
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
	<b>SEm (±)</b>	0.25	24.76	0.10	0.04	0.08	0.72
	<b>CD (P=0.05%)</b>	0.75	73.57	0.31	0.11	0.23	2.14

**Table 3. Effect of Nitrogen Boron on economics (INR/ha) of production of Foxtail Millet.**

<b>Treatment No.</b>	<b>Treatment combinations</b>	<b>Cost of cultivation (INR/ha)</b>	<b>Gross return (INR/ha)</b>	<b>Net return (INR/ha)</b>	<b>Benefit: Cost ratio</b>
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