Effect of Phosphorus and Boron on Growth and Yield of Foxtail Millet (*Setaria italica*)

Abstract

A field experiment was conducted **"Effect of Phosphorus and Boron on Growth and Yield of Foxtail millet (*Setaria italica*)**" during the rainy season (*Kharif*) of 2021. The experimentwas conducted in Randomized Block Design consisting of 3 replications and 9 treatments comprising three levels of phosphorus and boron (viz. P at 25, 30, 35kg/ha respectively and B at 1.5, 3.0, 4.5 kg/ha respectively) at the CRF (Crop Research Farm) SHIATS, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The soil of the experiment plot was sandy loam in texture, nearly neutral in soil reaction (pH 6.9), low in organic carbon (0.112%), available nitrogen (278.93 kg/ha), available phosphorus (10.8 kg/ha) and available potassium (206.4 kg/ha).The treatments comprised T1 – 25 kg P/ha + 1.5 kg B/ha, T2 – 25 kg P/ha + 3.0 kg B/ha, T3 – 25kg P/ha + 4.5 kg B/ha, T4 – 30 kg P/ha + 1.5 kg B/ha, T5 – 30 kg P/ha + 3.0 kg B/ha, T6 – 30 kgP/ha + 4.5 kg B/ha, T7 – 35 kg P/ha + 1.5 kg B/ha, T8 – 35 kg P/ha + 3.0 kg B/ha, T9 – 35 kg P/ha + 4.5 kg B/ha. Application of 35 kg P/ha + 4.5 kg B/ha recorded highest plant height (113.65 cm),number of tillers/m^2 (66.00), plant dry weight (13.72 g/hill), number of productive tillers/m^2 (54.67), grain yield (1695.00 kg/ha), straw yield (2514.00 kg/ha).

Key words: Economics, Growth, Foxtail millet, Phosphorus, Boron, Yield

Introduction

Foxtail millet (*Setaria italica*) is one of the oldest cultivated millets and most economically important species of the genus Setaria. It ranks second in the total world productionof 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. Andhra Pradesh, Karnataka and Tamil Nadu are the major foxtail miller growing states in India contributing about 79 per cent of the total area **(Munirathnam *et al*, 2006).**Foxtail millet commonly known as Koralu in Andhra Pradesh. It has been popular for its wider adaptability, low input requirement.

Foxtail millet has excellent nutritional profile and is miles ahead of rice and wheat in terms of protein, fiber, minerals and vitamins. It has good nutritive value as it is rich in 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. The grain is a good source of Beta- carotene, which is the precursor ofVitamin A **(Murugan and Nirmalakumari, 2006).** About 8-14% oil is being extracted from the branof foxtail millet, which can be used as oil after refinement **(Munirathnam*et al*, 2006)**. Unlike rice,foxtail millet release glucose steadily without affecting the metabolism of the human body with low glyceric index.

Phosphorus is present in plant and animal cells and is vital to all plants for harvestingthe sun's energy and converting it into growth and reproduction. Phosphorus is the second important nutrient limiting agriculture production and most of the Indian soils are either low (or) medium in available **(Prasad, 2000).** Adequate phosphorus results in higher grain production, improved crop quality, greater stalk strength, increased root growth earlier crop maturity, stimulates flowering, aids in seed formation, improve the quality of foodgrains, increase the ratio of grain to stalk, give rapid and vigorous start to plants, strengthen straws and decreases lodging tendency, reduces the effects of excessive nitrogen. Phosphorus is also an essential constituent of majority of enzymes which are of great importance in the transformation of energy, in carbohydrate metabolism, fat metabolism and also in respiration (catabolism of carbohydrates) in plants. It closely related to cell division and development. When applied to legumes, it enhances the activity of rhizobia and increases the formation of root nodules. Thus, it helps in fixing more of atmospheric nitrogen in root nodules. With phosphorus deficiency, leguminous plants may simultaneously suffer from nitrogen as well aspotassium deficiency. Excess of phosphorus may cause in some cause trace element deficiencies (Particularly Iron and Zinc), but may at times alleviate the detrimental effects of over-liming.

Boron is an essential micronutrient for plant growth, seed development and crop yield. Although cereals and millets generally less sensitive to B deficiency than pulses, it still affects cereals by a deficiency in several parts of the world. The primary role of boron appears to be concerned with calcium metabolism, both with its uptake by roots and its efficient use in plants. Tends to keep calcium soluble and increases its mobility in the plant. Acts as a regulator in potassium/calcium ratio in the plant. Is concerned with precipitation excess cations, buffer action, maintenance of conducting tissues and with regulatory effect on other elements. Is necessary for translocation of sugars in plants. Helps the vascular system in roots to give out branches (rootlets) to suppl nodule bacteria with carbohydrates food so that bacteria may not become parasitic. Millets grains can accumulate more amount of zinc and boron compared to cereals. Hence the study is conducted to find the response of foxtail millet to different levels of phosphorus and boron application.

Materials and Methods

The present examination was carried out during *Kharif* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, UP, which is located at 25.28^{o}N latitude, 81.54^{o}E longitude and 98 m altitude above the mean sea level. The experiment laid out in Randomized Block Design which consisting of nine treatments with T1 – 25 kg P/ha + 1.5 kg B/ha, T2 – 25 kg P/ha + 3.0 kg B/ha, T3 – 25kg P/ha + 4.5 kg B/ha, T4 – 30 kg P/ha + 1.5 kg B/ha, T5 – 30 kg P/ha + 3.0 kg B/ha, T6 – 30 kgP/ha + 4.5 kg B/ha, T7 – 35 kg P/ha + 1.5 kg B/ha, T8 – 35 kg P/ha + 3.0 kg B/ha, T9 – 35 kg P/ha + 4.5 kg B/ha were replicated thrice.

The experimental site was uniform in topography and sandy loam in texture, nearly neutral in soil reaction (P^H 7.1), low in Organic carbon (0.38%), medium available N (225 kg ha^{-1}), higher available P (19.50 kg ha^{-1}) and medium available K (213.7 kg ha^{-1}. The Urea and MOP were applied to meet the demands of nitrogen and potassium. SSP and Borax is applied as per the treatments details for phosphorous and Boron In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded those parameters are growth parameters like plant height (cm), No. of tillers/plant and Plant dry weight (g) were recorded. The yield parameters like No. of productive tillers/m^2, test (kg/ha), Straw yield (kg/ha)and Harvest index (%) were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984).

Results and Discussion

Growth attributes

Plant height

Significantly maximum plant height (113.65 cm) was recorded with treatment 35 kg P/ha + 4.5 kg B/ha. However, treatment 35 kg P/ha + 3.0 kg B/ha, 112.44 cm respectively recorded statistically at par with the treatment 35 kg P/ha + 4.5 kg K/ha. However, lowest plant height (102.15 cm) was recorded with treatment of 25 kg P/ha + 1.5 kg B/ha in foxtail millet. Plant height of foxtail millet was influenced by the application of both phosphorus and boron. Plant height of Foxtail millet increased significantly with the application of 35 kg P/ha. At all the stages of observation, plant height was found to be increased with increased levels of phosphorus. It closely related to cell division and development. Phosphorus is the second important nutrient limiting agriculture production and most of the Indian soils are either low (or) medium in available **(Prasad, 2000).**

No. of Tillers/plant

Maximum number of tillers/m^2 (66.00) was recorded with treatment 35 kg P/ha + 4.5 kg B/ha, whereas treatment 35 kg P/ha + 3.0 kg B/ha reported statistically at par with the treatment 35 kg P/ha + 4.5 kg K/ha. However, lowest number of tillers (39.33) was recorded with treatment of 25 kg P/ha + 1.5 kg B/ha in foxtail millet. Application of 35 kg P ha-1 recorded significantly higher number of tillers per meter lengthas compared to 30 kg and 25 kg P/ha. This increased number of tillers due to application of 35 kg P/ha was related to their physiological role in plant further, it is well known fact that the persistence of theassimilatory surface area is pre-requisite for prolonged photosynthetic activity, higher number of tillers and ultimately crop productivity. Phosphorus is a key constituent of nucleic acids, phospholipids and ATPs and play a role in array of plant cellular process such as cell division, energystorage and transfer, respiration, photosynthesis and enzymatic regulation and tillering **(Watanable *et al.*, 2006; Lambers and Plaxton, 2015). Muhammad Irfan *et al.*, 2019.**

Plant dry weight (g/plant)

At Harvest maximum plant dry weight (13.72 g/plant) was recorded with the treatment 35 kg P/ha + 4.5 kg B/ha, whereas treatment 35 kg P/ha + 3.0 kg B/ha recorded statistically at par with the treatment 35 kg P/ha + 4.5 kg B/ha. However, lowest plant dry weight (11.44 g/plant) was recorded with treatment of 25 kg P/ha + 1.5 kg B/ha in foxtail millet. The pre-requisite for getting higher yields in any crop is higher total dry matter production and it's partitioning in to various plant parts. The total dry matter production of Foxtail millet differed significantly. Significantly higher dry matter production was recorded with the application of

35 kg P/ha as compared to 25 and 30 kg P/ha. Phosphorus is involved in seedling development, growing ofearly roots, early heading formation and accelerates maturity to crops **(Alinajoati *et al*., 2011)** which results in higher dry matter production. Boron is a second most important micronutrient after zinc itsdeficiency impaired the biomass production by manipulation relative concentration of individual element as well as the balance among certain nutrient elements within plants **(Tariq and Mott, 2007).**

Table 1 Effect of phosphorus and boron on growth parameters foxtail millet

Treatments		Plant height (cm)	No. of leaves/plant	Dry weight (g)
1.	25 kg P/ha + 1.5 kg B/ha	102.15	39.33	11.44
2.	25 kg P/ha + 3.0 kg B/ha	102.71	45.00	11.75
3.	25 kg P/ha + 4.5 kg B/ha	103.55	47.33	11.98
4.	30 kg P/ha + 1.5 kg B/ha	105.27	52.67	12.33
5.	30 kg P/ha + 3.0 kg B/ha	106.91	57.33	12.65
6.	30 kg P/ha + 4.5 kg B/ha	108.44	60.67	12.95
7.	35 kg P/ha + 1.5 kg B/ha	111.22	63.33	13.42
8.	35 kg P/ha + 3.0 kg B/ha	112.44	65.67	13.66
9.	35 kg P/ha + 4.5 kg B/ha	113.65	66.00	13.72
S. EM (±)		0.44	0.43	0.02
CD (P = 0.05)		1.33	1.28	0.07

Yield attrubutes and Yield

Application of 35 kg P/ha + 4.5 kg B/ha resulted in significantly higher number of productivetillers (54.67). However, 35 kg P/ha + 3.0 kg B/ha were found to be statistically on par with 35 kg P/ha + 4.5 kg B/ha. Lowest number of tillers/m^2 (30.33) was recorded with treatment 25 kg P/ha + 1.5 kg B/ha in foxtail millet. The highest number of productive tillers was recorded with application of 35 kg P/ha. This might be due to improved availability of required quantities of nutrients to produce a greater number of tillers m^2 and then converted to a greater number of productive tillers m^2. Similar results were reported by **Kalaghatagi et al. (2000) and Hasan et al. (2013)**. Application of 35 kg P/ha recorded significantly higher number of productive tillers per meter length. The statistical analysis on test weight was found to be non-significant. However, highest test weight (2.89 g) was recorded with treatment 35 kg P/ha + 3.0 kg B/ha and lowest test weight (2.82 g) was recorded with treatment 25 kg P/ha + 1.5 kg B/ha in foxtail millet.

The grain yield showed increasing trend with the application of phosphorus and boron in foxtail millet. Significant and highest grain yield (1695.00 kg/ha) was observed under 35 kg P/ha + 4.5 kg B/ha. However, 35 kg P/ha + 1.5 kg B/ha and 35 kg P/ha + 3.0 kg B/ha were found to be statisticallyon par with 35 kg P/ha + 4.5 kg B/ha. Lowest grain yield (1398.00 /ha) was recorded with applicationof 25 kg P/ha + 1.5 kg B/ha in foxtail millet. The grain yield of Foxtail millet due to interaction effects of phosphorus and boron levels werefound significant and significantly higher grain yield of was recorded with the interaction of 35 kg P/ha + 4.5 kg B/ha. The increase in grain yield shows a positive relationship between P and B exists for the uptake and utilization of P by plants to form protein and amino acids which ultimately affect the quality and yield of crops. Number of spikelets per spike, rate of spikelet initiation and length responded positively to applied phosphorus **(Ahmad and Rashid, 2003).** Number of fertility spikelets per spike was significantly increased by increasing phosphorus **(Hussain *et al*., 2008).**

The straw yield of foxtail millet was also influenced by the application of phosphorus and boron. Highest straw yield (2514.00 kg/ha) was recorded with 35 kg P/ha + 4.5 kg B/ha. However, 35 kg P/ha + 3.0 kg B/ha were found to be statistically on par with 35 kg P/ha + 4.5 kg B/ha. Lowest straw yield(2145.00 kg/ha) was recorded with treatment 25 kg P/ha + 1.5 kg B/ha in foxtail millet. Higher straw yield was recorded with application of 35 kg P/ha as compared to 30 kg P/ha. Thiswas due to improved vegetative growth and growth parameters, such as total dry matter production atharvest and its accumulation in different plant parts like leaf, stem and increased number of tillers at harvest. Similar results have been reported by **Lingegowda et al. (1986), Intodia (1994) and Basavarajappa et al. (2002).** Significantly higher straw yield was recorded with the application of 4.5 kg P/ha and which wasat par with

3.0 kg B/ha. The main reason for this was boron improves the root growth, increases the tillering, resulting in increased amount of interception of photosynthetically active radiation and greater photosynthesis by the crop and builds the cellulose and reduces lodging and besides more of leaves per plant, leaf area, total dry matter production and its accumulation in different plant parts like leaf, stem and increased number of tillers. Similar results were obtained by **Fathima (1990)** in sweetSorghum crop.

The data showed significant difference in harvest index, however, 35 kg P/ha + 1.5 kg B/ha recorded highest value of (39.98%). However, 30 kg P/ha + 4.5 kg B/ha was found to be statistically on par with 35 kg P/ha + 1.5 kg B/ha. Lowest harvest index (38.87%) was recorded with application of 25 kg P/ha + 4.5 kg B/ha.

Table. 2 Effect of phosphorus and boron on Yield attributes and Yield of foxtail millet

S.No.	Treatments	No. of productive tillers/m^2	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
1.	25 kg P/ha + 1.5 kg B/ha	30.33	2.82	1398.00	2145.00	39.46
2.	25 kg P/ha + 3.0 kg B/ha	32.00	2.83	1421.00	2196.00	39.29
3.	25 kg P/ha + 4.5 kg B/ha	36.67	2.85	1461.00	2298.00	38.87
4.	30 kg P/ha + 1.5 kg B/ha	40.67	2.84	1502.00	2326.00	39.24
5.	30 kg P/ha + 3.0 kg B/ha	46.67	2.85	1563.00	2375.00	39.69
6.	30 kg P/ha + 4.5 kg B/ha	50.00	2.86	1592.00	2395.00	39.92
7.	35 kg P/ha + 1.5 kg B/ha	52.67	2.85	1634.00	2423.00	40.28
8.	35 kg P/ha + 3.0 kg B/ha	53.67	2.89	1666.00	2508.00	39.91
9.	35 kg P/ha + 4.5 kg B/ha	54.67	2.88	1695.00	2514.00	40.27
SEm±		0.40	0.01	11.42	2.52	0.04
CD (P=0.05)		1.20	-	34.23	7.56	0.11

CONCLUSION

It is concluded that application of treatment 35 kg P/ha + 4.5 kg B/ha performed exceptionally in obtaining maximum grain yield of Foxtail millet. Hence, 35 kg P/ha + 4.5 kg B/ha is beneficial under eastern Uttar Pradesh Conditions.

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