



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

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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

During the rainy season (kharif) of 2021, a field trial "Effect of phosphorus and boron on growth and yield of foxtail millet (*Setaria italica*)" was conducted treatments with three levels of phosphorus and boron (i.e. P with 25, 30, 35kg/ha and B with 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 Science, Prayagraj, Uttar Pradesh. The soil of the experimental plot had a 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). Treatments included T1 – 25 kg P/ha + 1.5 kg B/ha, T2 – 25 kg P/ha + 3.0 kg B/ha, T3 – 25 kg 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 kg P/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 registered higher plant height (113.65 cm), number of tillers/m² (66.00), dry plant weight (13.72 g/hill), number of productive tillers/m² (54.67), grain yield (1695.00 kg/ha), straw yield (2514.00 kg/ha).

Keywords: *Economics; growth; foxtail millet; phosphorus; boron; yield.*

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1. INTRODUCTION

Foxtail millet (*Setaria italica*) is one of the oldest cultivated millets and maximum economically essential species of the genus *Setaria*. It ranks 2nd with inside the general global manufacturing of millets and it keeps to have an essential vicinity in global agriculture offering meals for tens of thousands and thousands of human beings in arid and semiarid regions. It is local to China and appeared as an elite drought-tolerant crop. Andhra Pradesh, Karnataka and Tamil Nadu are the most important foxtail miller developing states in India contributing approximately 79 per cent of the entire area [1]. Foxtail millet normally referred to as Koralu in Andhra Pradesh. It has been popular for its wider adaptability, low enter requirement.

Foxtail millet has exceptional dietary profile and is miles beforehand of rice and wheat in phrases of protein, fiber, minerals and nutrients. It has top nutritive cost as it's far wealthy 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) in keeping with 100 g. The grain is a superb supply of Beta- carotene, that is the precursor of Vitamin A (Murugan and Nirmalakumari, 2006). About 8-14% oil is being extracted from the bran of foxtail millet, which may be used as oil after refinement (Munirathnam et al. 2006). Unlike rice, foxtail millet launch glucose step by step without affecting the metabolism of the human frame with low glyceric index.

Phosphorus is found in plant and animal cells and is crucial to all flora for harvesting the sun's energy and changing it into growth and reproduction. Phosphorus is the second one critical nutrient proscribing agriculture production and maximum of the Indian soils are both low (or) medium in available (Prasad, 2000). Adequate phosphorus outcomes in better grain production, advanced crop quality, greater stalk strength, extended root increase in advance earlier crop maturity, stimulates flowering, aids in seed formation, enhance the quality of food grains, increase the ratio of grain to stalk, deliver fast and energetic begin to flora, fortify straws and reduces lodging tendency, reduces the consequences of immoderate nitrogen. Phosphorus is likewise an crucial constituent of majority of enzymes which might be of awesome significance withinside the transformation of energy, in carbohydrate metabolism, fats metabolism and additionally in respiration

(catabolism of carbohydrates) in plants. It intently associated with cell division and development. When carried out to legumes, it complements the activity of rhizobia and will increase the formation of root nodules. Thus, it allows in solving extra of atmospheric nitrogen in root nodules. With phosphorus deficiency, leguminous flowers might also additionally concurrently be afflicted by nitrogen in addition to potassium deficiency. Excess of phosphorus might also additionally motive in a few motive hint detail deficiencies (Particularly Iron and Zinc), however might also additionally at instances alleviate the unfavorable outcomes of over-liming.

Boron is an important micronutrient for plant growth, seed improvement and crop yield. Although cereals and millets usually much less touchy to B deficiency than pulses, it nonetheless influences cereals by a deficiency in numerous elements of the world. The number one position of boron seems to be worried with calcium metabolism, each with its uptake with the aid of using roots and its green use in plants. Tends to preserve calcium soluble and will increases its mobility with inside the plant. Acts as a regulator in potassium/calcium ratio withinside the plant. Is worried with precipitation extra cations, buffer action, preservation of accomplishing tissues and with regulatory impact different elements. Is vital for translocation of sugars in plants. Helps the vascular machine in roots to present out branches (rootlets) to suppl nodule microorganism with carbohydrates food in order that microorganisms won't end up parasitic. Millets grains can gather great quantity of zinc and boron as compared to cereals. Hence the observe is carried out to discover the reaction of foxtail millet to distinct ranges of phosphorus and boron application.

2. 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°N latitude, 81.54°E longitude and 98 m altitude above the mean sea level. The test specified in Randomized Block Design which include nine treatments with T1 – 25 kg P/ha + 1.5 kg B/ha, T2 – 25 kg P/ha + 3.0 kg B/ha, T3 – 25 kg 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 kg P/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 have been replicated thrice.

The experimental web website online became uniform in topography and sandy loam in texture, almost neutral in soil reaction (P^H 7.1), low in Organic carbon (0.38%), medium to be had N (225 kg ha^{-1}), higher available P (19.50 kg ha^{-1}) and medium to be had K (213.7 kg ha^{-1}). The Urea and MOP have been implemented to fulfill the needs of nitrogen and potassium. SSP and Borax is implemented as according to the remedies information for phosphorous and Boron In length from germination to harvest numerous plant growth parameters have been recorded at common durations in conjunction with it after harvest numerous yield parameters have been recorded the ones parameters have been 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 the usage of evaluation of variance (ANOVA) as relevant to Randomized Block Design [2].

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

3.1.1 Plant height

Significantly most plant height (113.65 cm) changed into recorded with remedy 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) changed into recorded with treatment of 25 kg P/ha + 1.5 kg B/ha in foxtail millet. Plant height of foxtail millet was changed into motivated via way of means of the utility of each phosphorus and boron. Plant height of Foxtail millet extended appreciably with the application of 35 kg P/ha. At all of the of observation, plant height changed into observed to be extended with extended stages of phosphorus. It carefully associated with cell division and development. Phosphorus is the second one critical nutrient proscribing agriculture manufacturing and maximum of the Indian soils are both low (or) medium in available (Prasad, 2000).

3.1.2 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 notably better variety of tillers consistent with meter period in comparison to 30 kg and 25 kg P/ha. This elevated variety of tillers because of utility of 35 kg P/ha became associated with their physiological position in plant further, it's far widely known truth that the endurance of the assimilatory floor region is pre considered necessary for extended photosynthetic activity, higher number of tillers and in the long crop productivity. Phosphorus is a key constituent of nucleic acids, phospholipids and ATPs and play a position in array of plant cell method consisting of mobile division, energy storage and transfer, respiration, photosynthesis and enzymatic regulation and tillering [3] (Lambers and Plaxton, 2015, Muhammad Irfan et al. 2019)

3.1.3 Plant dry weight (g/plant)

At Harvest most 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-needful for buying better yields in any crop is better general dry be counted manufacturing and it's partitioning in to numerous plant parts. The total dry matter production of Foxtail millet differed significantly. Significantly better dry be counted manufacturing become recorded with the application of 35 kg P/ha as compared to 25 and 30 kg P/ha. Phosphorus is involved in seedling development, developing of early roots, early heading formation and quickness maturity to crops [4] which leads to better dry be counted production. Boron is a second most important micronutrient after zinc its deficiency impaired the biomass production via way of means of manipulation relative attention of man or woman detail in addition to the stability amongst positive nutrient factors inside plants [5].

3.1.4 Yield attributes and yield

Application of 35 kg P/ha + 4.5 kg B/ha led to appreciably better wide variety of effective tillers (54.67). However, 35 kg P/ha + 3.0 kg B/ha has

been determined to be statistically on par with 35 kg P/ha + 4.5 kg B/ha. Lowest number of tillers/m² (30.33) become recorded with treatment 25 kg P/ha + 1.5 kg B/ha in foxtail millet. The maximum wide variety of effective tillers become recorded with application of 35 kg P/ha. This is probably because of stepped forward availability of required quantities of vitamins to provide a wider variety of tillers m² after which transformed to a wider variety tillers/m². Similar effects has been suggested with the aid of using Kalaghatagi et al. [6] and Hasan et al. (2013). Application of 35 kg P/ha recorded appreciably better wide variety of effective tillers in keeping with meter length. The statistical evaluation on test weight was found to be non-significant. However maximum check weight (2.89 g) become 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 confirmed growing fashion with the application of phosphorus and boron in foxtail millet. Significant and maximum grain yield (1695.00 kg/ha) changed into located below 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 have been determined to be statistically on par with 35 kg P/ha + 4.5 kg B/ha. Lowest grain yield (1398.00 /ha) changed into recorded with application of 25 kg P/ha + 1.5 kg B/ha in foxtail millet. The grain yield of Foxtail millet because of interplay results of phosphorus and boron stages had been determined widespread and considerably better grain yield of changed into recorded with the interaction of 35 kg P/ha + 4.5 kg B/ha. The increase in grain yield suggests a advantageous courting among P and B exists for the uptake and usage of P via way of means of flora to shape protein and amino acids which in the end have an effect on the fine and yield of crops. Number of spikelets per spike, rate of spikelet initiation and duration replied definitely to applied phosphorus (Ahmad and Rashid, 2003). Number of fertility spikelet's according to spike changed into considerably improved via way of

means of growing phosphorus (Hussain et al. 2008).

The straw yield of foxtail millet became additionally inspired via way of means of the utility of phosphorus and boron. Highest straw yield (2514.00 kg/ha) became recorded with 35 kg P/ha + 4.5 kg B/ha. However, 35 kg P/ha + 3.0 kg B/ha have been located 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 became recorded with application of 35 kg P/ha in comparison to 30 kg P/ha. This became because of stepped forward vegetative growth and growth parameters, inclusive of general dry matter production at harvest and its accumulation in one of a kind plant elements like leaf, stem and improved range of tillers at harvest. Similar effects had been pronounced via way of means of 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 was at par with 3.0 kg B/ha. The important motive for this was boron improves the root growth, increases the tillering, ensuring in improved quantity of interception of photosynthetically lively radiation and more photosynthesis via way of means of the crop and builds the cellulose and decreases accommodations and except greater of leaves consistent with plant, leaf area, total dry matter production and its accumulation in distinct plant elements like leaf stem and improved quantity of tillers. Similar effects had been acquired via way of means of Fathima (1990) in sweet Sorghum crop [7,8].

The statistics confirmed full-size distinction 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 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

Treatments	Plant height (cm)	No. of leaves/plant	Dry weight (g)
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 (\pm)	0.44	0.43	0.02
CD (P = 0.05)	1.33	1.28	0.07

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 \pm	0.40	0.01	11.42	2.52	0.04
	CD (P=0.05)	1.20	-	34.23	7.56	0.11

4. CONCLUSION

It is concluded that application of treatment 35 kg P/ha + 4.5 kg B/ha done highly in acquiring most 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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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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