The Pharma Innovation Journal 2023; 12(2): 2281-2283

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(2): 2281-2283

www.thepharmajournal.com
Received: 01-11-2022
Accepted: 06-12-2022

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Effect of boron nutrition on growth, yield and economics of *rabi* sorghum (*Sorghum bicolor* L. Moench) under rainfed condition in northern transition zone of Karnataka

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Abstract
A field experiment was conducted to study the "Effect of Boron nutrition on growth, yield and economics of *rabi* sorghum (*sorghum bicolor* L. Moench) under rainfed condition in northern transition zone of Karnataka during *rabi* 2021-22 at AICRP on Sorghum, MARS, University of Agricultural Sciences, Dharwad. The experiment was laid out in a Randomized Block Design with eight treatments and three replications. The results indicated that application of 50:25:15 kg N:P_2O_5:$ZnSO_4$ ha^{-1} + FYM @ 3 t ha^{-1} + Boron @ 1.0 kg ha^{-1} (soil)+ Boron @ 0.1 percent foliar spray at panicle initiation and flowering stage recorded significantly maximum plant height (225.3 cm), leaf area (50.10 dm^2 $plant^{-1}$), leaf area index (7.80 $plant^{-1}$), total dry matter accumulation (233.23 g $plant^{-1}$), higher grain yield (35.02 q ha^{-1}), fodder yield (67.22 q ha^{-1}) over control, but was on par with application of 50:25:15 kg N:P_2O_5:$ZnSO_4$ ha^{-1}+FYM @ 3 tha^{-1}+ Boron @ 1.0 $kgha^{-1}$ (soil)+ Boron @ 0.2 percent foliar spray at panicle initiation and flowering. Significantly higher gross returns(₹ 96522ha^{-1}), net returns (₹ 56526ha^{-1}) and BC ratio (2.41) was recorded with application of 50:25:15 kg N:P_2O_5:$ZnSO_4$ ha^{-1}+FYM @ 3t ha^{-1}+ Boron @ 1.0 $kgha^{-1}$ (soil)+ Boron @ 0.1 percent foliar spray at panicle initiation and flowering compared to control but was on par with 50:25:15 kg N:P_2O_5:$ZnSO_4ha^{-1}$ + FYM @ 3 t ha^{-1}+ boron @ 1.0 $kgha^{-1}$ (soil) +boron @ 0.2 percent foliar sprayat panicle initiation and flowering stage.

Keywords: Boron, FYM, zinc, foliar spray

Introduction
Sorghum (*Sorghum bicolor* L. Moench) is regarded as the "King of Millets" and is the fourth most widely grown crop in the Nation. Due to its tolerance to drought and water logging, sorghum is considered a "camel crop." Sorghum is grown in India over an area of 4.82 m ha, producing 4.60 m t with a productivity of 991 kg ha^{-1} (Anon., 2021) [1] and *rabi* sorghum is a prominent dryland crop in the Deccan plateau and is grown in the states of Maharashtra (2.29 m ha), Karnataka (0.82 m ha), and Andhra Pradesh (0.15 m ha) (Anon., 2021) [1]. *Rabi* sorghum is mostly grown in dryland conditions on residual soil moisture in post-rainy season. The productivity of *rabi* sorghum is dependent on the quantity of rain during the pre-sowing monsoon and the water-holding capacity of the soil. Boron is closely associated with the growth of plants and plays a vital role in cell division. Deficiency symptoms of boron can be observed in vegetative and reproductive parts, such as inhibition of growth of shoot and root tips. Although boron is an essential element in plant growth, its requirement is very low and it may cause toxic effects on plants at an excess. The present scenario suggests that application of micronutrients is also essential along with macronutrients to get the desired biological and grain yield. Boron is closely associated with the growth of plants and plays a vital role in cell division.

Material and Methods
A field experiment was conducted during *rabi* 2021-22 on clay loam soil at AICRP on sorghum, MARS, University of Agricultural Sciences, Dharwad. The experiment was laid out a Randomozed Block Design with eight treatments and three replications. The experiment consists of eight treatments viz., T_1-RPP (50:25:15 kg N:P_2O_5: $ZnSO_4$ ha^{-1}+ FYM 3 t ha^{-1}), T_2-RPP + Boron @ 1.0 kg ha^{-1} (soil application), T_3-RPP + Boron @ 2.0 kg ha^{-1} (soil application), T_4-RPP + Boron @ 0.1 percent foliar spray at PI and flowering, T_5-RPP + Boron @ 0.2 percent foliar spray at PI and flowering, T_6-RPP + Boron @ 1.0 kg ha^{-1} (soil) + Boron @ 0.1

percent foliar spray at PI and flowering, T_7-RPP + Boron @ 1.0 kg ha^{-1} (soil) + Boron @ 0.2 percent foliar spray at PI and flowering, T_8-RPP + water spray at PI and flowering (control). All the recommended dose of nitrogen, phosphorus and zinc were applied in the form of urea, DAP and $ZnSO_4$ respectively at the time of sowing. Seeds of sorghum variety SPV-2217 was sown with a spacing of 45 cm x 15cm.Yield and yield parametes were recorded The economics was worked out as by taking prevailing prices of grain and stiver. The data collected were subjected to statistical analysis as described by Gomez and Gomez (1984) [4].

Results and Discussion

Effect on growth and growth parameters

Significantly maximum plant height (225.3 cm), Leaf area (50.10 dm^2 $plant^{-1}$), Leaf area index (7.8/plant) and total dry matter (233.23 g/plant) was recorded with application of 50:25:15 kg N:P_2O_5:$ZnSO_4$$ha^{-1}$ + FYM @ 3t ha^{-1} + Boron @ 1.0kgha^{-1} (soil)+ Boron @0.1 percent foliar spray at panicle initiation and flowering stageas compared to rest of the treatments but was on par with application of 50:25:15 kgN:P_2O_5:$ZnSO_4$$ha^{-1}$+FYM @3t ha^{-1} + Boron @1.0 kg ha^{-1} (soil) + Boron @ 0.2 percent foliar spray at panicle initiation and flowering (Table 1). The improved above growth parameters might be associated with improved roles in cell division, synthesis of cell wall general metabolism and nucleic acid metabolism. The results obtained in this present study are in line with Tahir *et al.* (2012) [6] and he also reported that boron regulated the production of auxin in plants, which promotes growth of the plant.

Table 1: Plant height, Leaf area, leaf area index $plant^{-1}$and total dry matter (g) of *rabi* sorghum as influenced by boron nutrition.

Treatment	Plant height (cm)	Leaf area (dm^2 $plant^{-1}$)	Leaf area index $plant^{-1}$	Total dry matter (g/plant)
T_1-RPP (50:25:15 kg N:P_2O_5:$ZnSO_4$+ FYM 3 t ha^{-1})	215.8	45.60	6.82	196.17
T_2-RPP + Boron @ 1.0 kg ha^{-1} (soil application)	217.6	46.43	6.88	204.83
T_3-RPP + Boron @ 2.0 kg ha^{-1} (soil application)	216.7	45.70	6.84	199.57
T_4-RPP + Boron @ 0.1 percent foliar spray at PI and flowering	219.7	47.00	6.96	214.70
T_5-RPP + Boron @ 0.2 percent foliar spray at PI and flowering	220.7	47.50	7.03	218.00
T_6-RPP + Boron @ 1.0 kg ha^{-1} (soil) + Boron @ 0.1 percent foliar spray at PI and flowering	225.3	50.10	7.80	233.23
T_7-RPP + Boron @ 1.0 kg ha^{-1} (soil) + Boron @ 0.2 percent foliar spray at PI and flowering	223.6	49.30	7.63	229.23
T_8-RPP + water spray at PI and flowering (control)	214.6	45.20	6.80	194.13
S.Em±	0.70	0.62	0.06	1.48
CD at 5%	2.11	1.88	0.19	4.48

RPP- Recommended package of practice, PI - Panicle initiation

Yield and Yield parameters

Significantly higher grain yield (35.02qha^{-1}), stover yield (67.22 q ha^{-1}) and harvest index (35.1%) were recorded with RPP + boron @ 1.0 kg ha^{-1} (soil) + boron @ 0.1 percent foliar spray at PI and flowering as compared to rest of the treatments RPP + Boron @ 1.0 kg ha^{-1} (soil) + Boron @ 0.2 percent foliar spray at PI and flowering (Table. 2). The increase in grain yield and stover yield were to an extent of 11 and 8.9 percent, respectively, over RPP + water spray at PI and flowering (control). This might be due to combined effect of soil and foliar application boron aided in reproductive growth and development, including improved flowering, photosynthetic sugar transport, and seed set. These results are in conformity with findings of Choudhary *et al.* (2017) [2] and Devi *et al.* (2016) [3].

Table 2: Grain yield, stover yield and harvest index of *rabi* sorghum as influenced by boron nutrition

Treatment	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
T_1-RPP (50:25:15 kg N:P_2O_5:$ZnSO_4$+ FYM 3 t ha^{-1})	31.16	64.71	31.9
T_2-RPP + Boron @ 1.0 kg ha^{-1} (soil application)	31.51	65.83	32.0
T_3-RPP + Boron @ 2.0 kg ha^{-1} (soil application)	31.39	65.61	31.9
T_4-RPP + Boron @ 0.1 percent foliar spray at PI and flowering	32.66	66.40	33.2
T_5-RPP + Boron @ 0.2 percent foliar spray at PI and flowering	32.90	66.53	33.7
T_6-RPP + Boron @ 1.0 kg ha^{-1} (soil) + Boron @ 0.1 percent foliar spray at PI and flowering	35.02	67.22	35.1
T_7-RPP + Boron @ 1.0 kg ha^{-1} (soil) + Boron @ 0.2 percent foliar spray at PI and flowering	33.59	66.69	34.9
T_8-RPP + water spray at PI and flowering (control)	31.16	61.24	31.8
S.Em±	0.49	0.06	0.3
CD at 5%	1.49	0.19	1.14

RPP- Recommended package of practice, PI - Panicle initiation

Economics

With regard to economics, RPP + Boron @ 1.0 kg ha^{-1} (soil) + Boron @ 0.1 percent foliar spray at PI and flowering recorded significantly higher gross returns (₹ 96522 ha^{-1}), net returns (₹ 56526 ha^{-1}) and BC ratio (2.41) as compared to other treatments but at par with RPP + Boron @ 1.0 kg ha^{-1} (soil) + Boron @ 0.2 percent foliar spray at PI and flowering (Table 3). This might be due to higher grain and stover yield These results are in agreement with Tahir *et al.* (2009) [7].

Table 3: Economics of *rabi* sorghum as influenced by boron nutrition

Treatment	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
T_1-RPP (50:25:15 kg N:P_2O_5:$ZnSO_4$ha^{-1}+ FYM 3 t ha^{-1})	87875	48329	2.21
T_2-RPP + Boron @ 1.0 kg ha^{-1} (soil application)	88835	48489	2.22
T_3-RPP + Boron @ 2.0 kg ha^{-1} (soil application)	88410	48464	2.21
T_4-RPP + Boron @ 0.1 percent foliar spray at PI and flowering	90766	51170	2.30
T_5-RPP + Boron @ 0.2 percent foliar spray at PI and flowering	91198	51602	2.29
T_6-RPP + Boron @ 1.0 kg ha^{-1} (soil) + Boron @ 0.1 percent foliar spray at PI and flowering	96522	56526	2.41
T_7-RPP + Boron @ 1.0 kg ha^{-1} (soil) + Boron @ 0.2 percent foliar spray at PI and flowering	93466	53470	2.33
T_8-RPP + water spray at PI and flowering (control)	87832	48286	2.20
S.Em±	1176	1176	0.03
CD at 5%	3567	3567	0.09

RPP- Recommended package of practice, PI - Panicle initiation

Conclusion

Based on the experimental results, it could be concluded that, soil application (1.0 kg ha^{-1}) and foliar spray (0.1%) of boron at both panicle initiation and flowering stage along with Recommended package of practice resulted in significantly higher growth, yield and economic returns.

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