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Influence of boron nutrition on growth and yield attributes of grain sorghum (*Sorghum bicolor* L)

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Abstract
A field experiment was conducted at New Area, Department of Millets, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during Thaipattam (January-February) 2021 on sandy clay loam. Eight treatments were followed with boron nutrition. T_1 : Recommended Dose of Fertilizer (RDF = N, P, K, S, Zn), T_2 : RDF + 5 kg/ha boron (Soil application), T_3 : RDF + 2.5 kg/ha boron (Soil application) + 0.2% foliar spray at panicle initiation (PI) and flowering, T_4 : RDF + 2.5 kg/ha boron (Soil application) + 0.4% foliar spray at panicle initiation (PI) and flowering, T_5 : RDF + 2.5 kg/ha boron (Soil application) + 0.6% foliar spray at panicle initiation (PI) and flowering, T_6 : RDF + 0.2% foliar spray at panicle initiation (PI) and flowering, T_7 : RDF + 0.4% foliar spray at panicle initiation (PI) and flowering, T_8 : RDF + 0.6% foliar spray at panicle initiation (PI) and flowering and were tested in randomized block design with three replications. Results indicated that application of RDF + 2.5 kg/ha boron (Soil) + 0.6% foliar spray at PI and flowering (T_5) registered higher plant height, dry matter production, panicle length, 1000 grain weight, filled grains panicle^{-1} and grain yield over the control (T_1).

Keywords: Boron nutrition, panicle initiation, flowering, sorghum, *Sorghum bicolor* L.

Introduction

Sorghum (*Sorghum bicolor* L.) is the fifth most important cereal crop in the world after rice (*Oryza sativa* L.), maize (*Zea mays* L.), barley (*Hordeum vulgare* L.) and wheat (*Triticum aestivum* L.). Sorghum belongs to the family Poaceae with chromosome number 20 (2n =20). The worldwide sorghum cultivated area is around 42.71 m ha (2020-21), which yielded around 61.96 million metric tons. In production, India contributes about 16 per cent of the total world sorghum production. In India, sorghum was the staple food for the majority of the people during the 1950's and, understandably, the occupied area was more than 18 Mha, but currently the area has come down to 7.69 Mha.

The production of sorghum has decreased over time, not only in India but throughout the world except for a few patches of the African continent. There are several reasons for not cultivating sorghum; among the major ones is lower production. Lower production of sorghum may be attributed to boron as it is one of the major constituent for growth of reproductive organs of plants. In Indian soil, boron deficiency is prominent and occupies second place just after Zinc deficiency. So, sorghum production can be increased by applying boron from external sources.

Deficiencies of boron in India are common in laterite and lateritic soils. The deficiency of boron was also more prominent during drought periods as their root activity decreased. Generally, boron deficiencies are related to acidic soil conditions and high rainfall, which leads to leaching of boron due to greater water solubility in acidic soil conditions. It can be related to lower absorption and solubility under alkaline soil conditions. In crop production, boron deficiency is considered as one of the major constraints (Sillanpaa, 1982) [9]. Boron deficiency has been reported in more than 80 countries and for at least 132 crops during the last 60 years (Shorrocks, 1997) [8]. Soil which are developed from calcareous, alluvial soil or has high leaching tendency are generally accounted as boron deficient soil (Borkakati & Takkar, 2000) [2].

Like macronutrients, micronutrients are also essential for plant growth and development. Among micronutrient, boron plays a major role. Boron is essential for plant growth, pollen germination, and pollen tube growth. On the other hand, boron deficiency causes male sterility, various floral abnormalities, and decreased grain yield. Boron promotes the growth and retention of flowers, the lengthening and germination of pollen tubes, and the development of seeds and fruits (Vaughan, 1977; De Wet *et al.*, 1989). Continuous utilization of only common fertilizers, which do not provide necessary micronutrients, may lead to their deficiencies, which will result in low sorghum yields.

Materials and methods

A field experiment was conducted at New Area, Department of millets, Agricultural College and Research Institute (Tamil Nadu Agricultural University) during Thaipattam (January-February) 2021, which is situated at 11^0 N latitude and 76^0 E longitude at an elevation of 440 m above the mean sea level in the North Western Agro-climatic Zone of Tamil Nadu. The field experiment was comprised of eight treatments of boron nutrition. T_1 : RDF (N, P, K, S, Zn), T_2 : RDF + 5 kg/ha boron (Soil application), T_3 : RDF + 2.5 kg/ha boron (Soil application) + 0.2% foliar spray at panicle initiation (PI) and flowering, T_4 : RDF + 2.5 kg/ha boron (Soil application) + 0.4% foliar spray at panicle initiation (PI) and flowering, T_5 : RDF + 2.5 kg/ha boron (Soil application) + 0.6% foliar spray at panicle initiation (PI) and flowering, T_6 : RDF + 0.2% foliar spray at panicle initiation (PI) and flowering, T_7 : RDF + 0.4% foliar spray at panicle initiation (PI) and flowering, T_8 : RDF + 0.6% foliar spray at panicle initiation (PI) and flowering stage under randomized block design with three replications. The crop sorghum, Co 32 (variety), was used for the experiment. The recommended rate of 90:45:45 kg NPK ha^{-1} was applied as urea, single super phosphate and muriate of potash respectively. One fourth of the recommended nitrogen, a full dose of phosphorus and potash were applied basally. The remaining half doses of nitrogen were top dressed at 25 DAS and 45 DAS.

$ZnSO_4$ @15 kg ha^{-1} was applied as basal for zinc and sulphur supplementation. Along with this, Borax was applied @ 2.5 kg ha^{-1} and 5 kg ha^{-1} according to the treatments. Foliar application of borax was done @ 0.2, 0.4, 0.6% at panicle initiation and flowering stage.

Results and Discussions

Growth attributes

Sorghum growth characteristics were significantly higher over control by the application of boron nutrition (Table 1). Application of RDF + 2.5 kg/ha boron (Soil application) + 0.6% foliar spray at PI and flowering (T_5) recorded significantly higher plant height at 30, 60 and 90 DAS. This was on par with RDF + 2.5 kg/ha boron (Soil application) + 0.4% foliar spray at PI and flowering (T_4), RDF + 2.5 kg/ha boron (Soil application) + 0.2% foliar spray at PI and flowering (T_3), RDF + 5 kg/ha boron (Soil application) (T_2). This was followed by the treatments RDF + 0.6% foliar spray at PI and flowering (T_8), RDF + 0.4% foliar spray at PI and flowering (T_7) and RDF + 0.2% foliar spray at PI and flowering (T_6). Yu & Bell. (1998) [13] reported that in rice, plant height increased with the addition of boron. Tahir *et al.* (2012) [12] also observed that the addition of 0.30 kg/ha of boron increased the plant height of maize. Soomro *et al.* (2011) [10] observed that early, middle, and late whorl stages of the maize plants received foliar applications of 0.5 percent boron as a boric acid, which led to taller plants (195.05 cm). Similarly, maximum sunflower plant height (160.6 cm) was achieved with the application of micronutrients like boron and zinc (Baloch *et al.*, 2015) [1].

Dry matter production was significantly influenced by different levels of boron fertilization. Application of RDF + 2.5 kg/ha boron (Soil application) + 0.6% foliar spray at PI and flowering (T_5) recorded significantly higher plant dry matter at 30, 60 and 90 DAS. This was on par with RDF + 2.5 kg/ha boron (Soil application) + 0.4% foliar spray at PI and flowering (T_4), RDF + 2.5 kg/ha boron (Soil application) + 0.2% foliar spray at PI and flowering (T_3), RDF + 5 kg/ha boron (Soil application) (T_2). This was followed by the treatments RDF + 0.6% foliar spray at PI and flowering (T_8), RDF + 0.4% foliar spray at PI and flowering (T_7) and RDF + 0.2% foliar spray at PI and flowering (T_6). Yu & Bell. (1998) [13] reported that dry matter increased with the addition of boron in maize. Similarly, Karaman *et al.* (2017) [5] reported that the application of 20 mg boron kg^{-1} along with the applications of H.A. (Humic Acid) at the rates of 60 and 120 mg kg^{-1}, respectively, resulted in the maximum dry matter yields of 50.71 and 51.09 g pot^{-1} in maize. In pearlmillet, application of RDF along with boron @ 0.5% also significantly increased dry matter accumulation (Gurjar *et al.*, 2022) [4].

Table 1: Effect of boron nutrition on plant height and dry matter of sorghum

Treatments	Plant height (cm)			Dry matter (kg/ha)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T1	65.27	149.33	176.33	1065.43	5308.64	12913.58
T2	74.33	165.87	189.87	1777.78	6877.77	14804.92
T3	76.00	170.40	194.47	1881.48	7171.60	15974.06
T4	78.67	174.07	203.33	2260.49	7506.17	16814.80
T5	82.00	177.27	209.00	2491.36	7903.70	17025.92
T6	68.40	155.33	178.67	1091.36	5743.21	13271.60
T7	70.67	158.20	182.87	1467.90	6085.18	13999.99
T8	72.67	161.93	186.00	1508.02	6420.98	14560.48
SEd	3.99	8.05	9.74	120.48	489.19	738.03
CD (P=0.05)	8.55	17.26	20.89	258.43	1049.31	1583.07

Yield attributes and yields

Panicle length was significantly influenced by the different levels of boron fertilization (Table 2). RDF + 2.5 kg/ha boron (Soil application) + 0.6% foliar spray at PI and flowering (T_5) registered significantly higher panicle length (26.13 cm) which was on par with RDF + 2.5 kg/ha boron (Soil application) + 0.4% foliar spray at PI and flowering (T_4), RDF + 2.5 kg/ha boron (Soil) + 0.2% foliar spray at PI and flowering (T_3), RDF + 5 kg/ha boron (Soil application) (T_2). This was followed by the treatments RDF + 0.6% foliar spray at PI and flowering (T_8), RDF + 0.4% foliar spray at PI and flowering (T_7) and RDF + 0.2% foliar spray at PI and flowering (T_6). The least panicle length was recorded in control (21 cm). In pearlmillet, the application of RDF along with boron @ 0.5% significantly increased panicle length (Gurjar *et al.*, 2022) [4].

RDF + 2.5 kg/ha boron (Soil application) + 0.6% foliar spray at PI and flowering (T_5) registered significantly higher filled grains (2450) and it was on par with RDF + 2.5 kg/ha boron (Soil application) + 0.4% foliar spray at PI and flowering (T_4) and RDF + 2.5 kg/ha boron (Soil application) + 0.2% foliar spray at PI and flowering (T_3). This was closely followed by RDF + 5 kg/ha boron (Soil application) (T_2) and RDF + 0.6% foliar spray at PI and flowering (T_8) (Table 2). The least number of filled grains was recorded in control (1917). Similarly, Rani & Latha. (2017) [7] reported that due to increased pollen and anther growth and pollen germination, boron increases fertility and decreases panicle sterility in rice. This increases the number of filled grains panicale^{-1} in rice.

RDF + 2.5 kg/ha boron (Soil application) + 0.6% foliar spray at PI and flowering (T_5) registered significantly higher 1000 grain weight (24.13 g) and it was on par with RDF + 2.5 kg/ha boron (Soil application) + 0.4% foliar spray at PI and flowering (T_4). This was closely followed by RDF + 2.5 kg/ha boron (Soil application) + 0.2% foliar spray at PI and flowering (T_3), RDF + 5 kg/ha boron (Soil application) (T_2) and RDF + 0.6% foliar spray at PI and flowering (T_8). The least 1000 grain weight was recorded in control (18.53 g) (Table 2). Choudhary *et al.* (2017) [3] reported that in comparison to control, the combined application of micronutrients (Fe+ Zn+ B) considerably enhanced the 1000 grain weight of sorghum.

The perusal of yield data clearly indicated that boron fertilization positively influenced the grain yield of sorghum. RDF + 2.5 kg/ha boron (Soil application) + 0.6% foliar spray at PI and flowering (T_5) registered significantly higher grain yield (2457.33 kg ha^{-1}) and it was on par with RDF + 2.5 kg/ha boron (Soil application) + 0.4% foliar spray at PI and flowering (T_4) and RDF + 2.5 kg/ha boron (Soil application) + 0.2% foliar spray at PI and flowering (T_3). This was closely followed by RDF + 5 kg/ha boron (Soil application) (T_2) and RDF + 0.6% foliar spray at PI and flowering (T_8). The least grain yield was recorded in control (1661 kg ha^{-1}) (Table 2). Nadim *et al.* (2011) [6] reported that at 49 and 98 days after planting, boron application @ 2 kg ha^{-1} resulted in a greater grain yield (3.67 t ha^{-1}) in wheat. Similarly, Soylu *et al.* (2005) [11] reported that in durum wheat and bread wheat, respectively, boron application boosted grain production by an average of 9.6% and 10.9%.

Table 2: Effect of boron nutrition on yield attributes and yields of sorghum

Treatments	Panicle length (cm)	Filled grains panicle^{-1}	1000 grain weight	Grain yield (kg/ha)
T1	21.00	1916.67	18.53	1661.00
T2	23.92	2216.67	21.07	1905.00
T3	24.13	2283.33	21.67	1991.67
T4	25.33	2350.00	22.67	2148.33
T5	26.13	2450.00	24.13	2457.33
T6	21.67	2033.33	19.07	1733.67
T7	22.60	2100.00	19.67	1807.00
T8	23.03	2180.00	20.07	1840.00
SEd	1.43	111.75	1.21	103.29
CD (P=0.05)	3.06	239.71	2.59	221.56

Conclusion

The results of this field experiment showed that applying RDF along with 2.5 kg/ha boron (soil application) and 0.6% foliar spray at panicle initiation (PI) and flowering improved sorghum plant height, dry matter production, panicle length, 1000 grain weight, filled grains per panicle^{-1}, and grain yield.

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