Journal of Experimental Agriculture International

43(9): 18-23, 2021; Article no.JEAI.74591
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Influence of Plant Growth Regulators and Micronutrients on Growth, Yield and Quality of Sorghum under Temperate Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2021/v43i930732
Editor(s):
(1) Dr. Mirjana Bulatovic-Danilovich, West Virginia University, USA.
Reviewers:
(1) Rekha R. Warrier, Institute of Forest Genetics and Tree Breeding (ICFRE-IFGTB), India.
(2) Jophr L. Galian, Benguet State Univeristy, Philippines.
Complete Peer review History: https://www.sdiarticle4.com/review-history/74591

Original Research Article

Received 28 July 2021
Accepted 02 October 2021
Published 11 October 2021

ABSTRACT

A field experiment was conducted at Dry land Agricultural Research Station, Rangreth, Srinagar, SKUAST-K in *Kharif* 2020 to study the effect of Plant Growth Regulators and micronutrients on growth, yield and quality of sorghum. The objective of the study was to assess the effect of Plant Growth Regulators and micronutrients on herbage yield and quality. The treatments included; T_1: Tricontanol 10 ppm at 30 DAS (foliar spray), T_2: Salicylic acid 100 ppm at 30 DAS (foliar spray), T_3: 5 kg Zn/ha soil application, T_4: 2 kg B/ha soil application, T_5: 5 kg Zn + 2 kg B/ha soil application, T_6: 5 kg Zn/ha (soil application) + Triacontanol 10 ppm at 30 DAS (foliar spray), T_7: 5 kg Zn/ha (soil application) + salicylic acid 100 ppm at 30 DAS (foliar spray), T_8: 2 kg B/ha (soil application) +

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Triacontanol 10 ppm at 30 DAS (foliar spray), T_9: 2 kg B/ha (soil application)+ salicylic acid 100 ppm at 30 DAS (foliar spray), $T_{10:}$ 5 kg Zn + 2 kg B/ha (soil application) + Triacontanol 10 ppm at 30 DAS (foliar spray), $T_{11:}$ 5 kg Zn + 2 kg B/ha (soil application) + salicylic acid 100 ppm at 30 DAS (foliar spray) and $T_{12:}$ Water spray at the time of PGR application. Zn and B were applied at the time of sowing in the soil. The crop was raised with recommended package of practices. In treatments, where zinc was not a treatment, an amount of sulphur through gypsum equivalent to sulphate supplied with 5 kg $ZnSO_4$ was applied to compensate. The crop was sown in 30.0 cm apart lines. The trial was laid out in Randomized Block Design with three replications. The results indicated that all the treatments improved the green fodder yield over control. Among different treatments, $T_{10:}$ 5 kg Zn + 2 kg B/ha soil application + Triacontanol 10 ppm at 30 DAS foliar spray and $T_{11:}$ 5 kg Zn + 2 kg B/ha soil application + salicylic acid 100 ppm at 30 DAS foliar spray produced maximum GFY (493.6 and 490.5q/ha) on locational mean basis. It was significantly superior to other treatments. These treatments improved the green fodder yields by 35.0 % and 34.2 %, respectively, over control (spray of water). In terms of dry matter, similar trend was noted and the improvement with $\mathbf{T_{10}}$ and $\mathbf{T_{11}}$ was to the tune of 36.8 % and 41.0 % over control. Tricontanol 10 ppm at 30 DAS (foliar spray) (T1) improved the green fodder yield and dry fodder yield by 13.6% and 14.3 % respectively over $\mathbf{T_{12}}$Water spray at the time of Plant Growth Regulator application. Similarly spray of T_2: Salicylic acid 100 ppm at 30 DAS (foliar spray) improved the green fodder yield and dry fodder yield by 14.4% and 15.4% respectively over $\mathbf{T_{12}}$Water spray at the time of Plant Growth Regulator application. Similar trend was observed with respect to quality parameters (crude protein content and crude protein yield) of sorghum.

Keywords: Sorghum; plant growth regulators; micronutrients; yield; quality.

1. INTRODUCTION

Sorghum (*Sorghum bicolor* L.) is a C4 short day plant with high photosynthetic efficiency. It is a principle dry land crop grown in India for food, feed, fodder and ethanol production. Nowadays, it is gaining importance as an alternative for bio-fuel production [1]. Sorghum is a versatile crop grown for various purposes in temperate, tropical and subtropical environments. It has relatively low production costs, a particular ability to resist water stress as compared to other cereals [2] and it produces a large residue biomass that improves the soil physico-chemical properties [3]. It is resistant to drought, poor drainage and salinity. Sorghum is the fifth cereal in importance after wheat, maize, rice and barley, with a global production of around 45 million tonnes [4]. The area under sorghum in India is 5.82 m ha with production and productivity of 5.39 million tonnes and 926 kg/ha, respectively [5]. It is not possible to bring more area under cultivation due to population burden, industrialization and urbanization so to enhance the productivity, it is important to apply inputs judiciously especially nutrients. The balanced application of nutrients is important in over all development of the plant (growth, development and biological yield) as compared to single nutrient or in combination. Micro-nutrients play an important role in maintaining soil health and also the productivity of the crops. Adoption of High yielding varieties (HYVs) and intensive cropping has resulted in degradation of soil and removal of micronutrients from the soil. Due to increased removal of nutrients, there has been a shift towards high analysis of NPK fertilizers which resulted in decline of micro nutrients to below normal at which productivity of crops ca not be sustained. About 43% and 18% of Indian soils have been reported to be deficient in Zn and B status, respectively. Zinc is known to improve the metabolism of the plant and yield; whereas boron improves the productivity by triggering source and sink relationship. The role of zinc in crop groth is well known for its role in bio-synthesis of plant auxins, nitrogen metabolism, oxidation-reduction reactions, which are considered to be essential for plant growth and development, chlorophyll formation, photosynthesis, important enzyme system and respiration in plants. Boron also plays a very significant role in vital functions of the plant, including meristem, sugar and hydrocarbon metabolism and their transfer, RNA and cytokinin production and transfer, pollen building and seed formation, Murthy et al. [6]. Boron deficiency affects vegetative and reproductive growth of plants, resulting in inhibition of cell expansion and death of meristem. Application of micronutrient fertilizers through soil application is the most efficient and economical method of getting these nutrients into the crops. Plant growth regulators increase the productivity of the crops under environmental stress. Plant growth regulators are chemical chemicals that can change the way plants grow and develop, resulting in higher yields, better grain quality, and easier harvesting [7]. Triacontanol has been found effective in inducing physiological efficiencies including photosynthetic efficiency which subsequently results in better growth and yield of crops without increase in cost of cultivation (Sumeriya et al., 2020). Plant growth regulators and micronutrients, in small amounts, play a critical role in plant growth and development.

2. MATERIALS AND METHODS

A field experiment was conducted in *kharif* 2020 at Dry land Agricultural Research Station, Rangreth, Srinagar, Jammu and Kashmir. It is geographically in northern side of the country. The site is situated at 34º 05' N latitude, 74º50' E longitude and an altitude of 1640m above mean sea level. The Physico-chemical properties of the soil are silty clay in texture with sand, clay and silt percentage of 9.5, 27.9 & 62.6, respectively. With respect to the chemical properties, the soil of the experimental site was having pH 7.2, electrical conductivity 0.15 dsm^{-1} and organic carbon 0.38%, medium in available nitrogen (480.2 kg/ha), phosphorus (9.5 kg/ha) and potash (202.4 kg/ha). The experiment consisted of twelve (12) treatment combinations *viz;* T_1: Triacontanol 10 ppm at 30 DAS (foliar spray), T_2: Salicylic acid 100 ppm at 30 DAS (foliar spray), T_3: 5 kg Zn/ha (soil application), T_4: 2 kg B/ha (soil application), T_5: 5 kg Zn + 2 kg B/ha (soil application), T_6: 5 kg Zn/ha (soil application) + Triacontanol 10 ppm at 30 DAS (foliar spray), T_7: 5 kg Zn/ha (soil application) + salicylic acid 100 ppm at 30 DAS (foliar spray), T_8: 2 kg B/ha (soil application) + Triacontanol 10 ppm at 30 DAS (foliar spray), T_9: 2 kg B/ha (soil application) + salicylic acid 100 ppm at 30 DAS (foliar spray), $T_{10:}$ 5 kg Zn + 2 kg B/ha (soil application) + Triacontanol 10 ppm at 30 DAS (foliar spray), $T_{11:}$ 5 kg Zn + 2 kg B/ha (soil application) + salicylic acid 100 ppm at 30 DAS (foliar spray) and $T_{12:}$ Water spray at the time of plant growth regulator application and replicated thrice. The treatments were evaluated in a completely randomized block design. Micronutrients (Zn and B) were applied at the time of sowing whereas plant growth regulators were sprayed at 30 days after sowing as per treatment details. Recommended dose of NPK (80, 130 and 50 kg/ha, respectively) were applied in all the plots, half dose of N and full dose of P and K was applied as basal and remaining half dose of nitrogen was applied in two split doses, 1^{st} at knee high stage and 2^{nd} at flag leaf stage. Total amount of rainfall during the crop growth period was 158.4 mm. The mean maximum and minimum temperature for the entire crop growth period were 28.8ºC and 13.0ºC, respectively. The crop was sown by following all the agronomic practices.

The crop was sown at the seed rate of 15 kg/ha with planting geometry of 40 cm x 10 cm and was irrigated twice i.e., at knee high stage and booting stage. In order to control the weeds, Atrazine @ 1 kg a.i/ha was applied at 1-3 days of sowing and the crop was harvested after flowering stage. Plant height was measured from the base of the plant to the tip of the longest leaf stretched from randomly labelled five plants in each net plot area and expressed in cm. For dry matter accumulation, five plants were randomly selected from penultimate rows of each plot. These plants were cut from ground level and sun dried for 2-3 days and were chopped into small pieces after sun drying, mixed homogenously and dried in hot air oven at 60ºC temperature till constant weight.

The plants from the net plot area, including the tagged plants were harvested to the ground level at 90 per cent moisture, cut in to bits of one meter length and the weight of the green fodder was recorded and expressed in q ha^{-1} for recording of green fodder yield. The green fodder was sun dried on the threshing floor for 7 days and later dry fodder yield was recorded at 15 per cent moisture and the weights were expressed as dry fodder yield in q ha^{-1}.

Yield (Green fodder and dry matter) was recorded by using standard procedure from five randomly selected plants from each plot. Crude Protein content of fodder was determined by multiplying respective nitrogen concentration with a factor 6.25 [8] and the crude protein yield is determined by multiplying crude protein content with yield.

The Software package used for analysis of data was "OPstat," wherever the „F-test" was found significant at 5 per cent probability; critical difference values were used to compare the treatment means.

Table 1. Effect of PGRs and micro-nutrients on growth, yield and quality of Sorghum (*Sorghum bicolor* L.)

Treatment	Plant height (cm) at 45 DAS	Plant height (cm) at harvest	Leaf:stem ratio	Dry matter accumulation (q/ha)	Green fodder yield (q/ha)	Crude protein content (%)	Crude protein yield (q/ha)
T_1: Tricontanol 10 ppm at 30 DAS	47.07	167.9	0.60	90.75	376.9	8.80	7.70
T_2: Salicylic acid 100 ppm at 30 DAS (foliar spray)	47.47	170.3	0.63	91.72	381.3	8.70	7.73
T_3: 5 kg Zn/ha soil application	42.13	157.8	0.63	85.01	362.5	9.00	7.41
T_4: 2 kg B/ha soil application	43.17	159.2	0.67	88.74	364.5	8.35	7.39
T_5: 5 kg Zn + 2 kg B/ha soil application	46.87	164.6	0.68	91.60	379.9	8.43	7.69
T_6: 5 kg Zn/ha soil application + triacontanol 10 ppm at 30 DAS foliar spray	50.07	171.2	0.69	110.01	434.1	8.80	9.34
T_7: 5 kg Zn/ha soil application + salicylic acid 100 ppm at 30 DAS foliar spray	48.23	169.6	0.69	108.89	439.9	8.70	9.21
T_8: 2 kg B/ha soil application + triacontanol 10 ppm at 30 DAS foliar spray	49.13	174.2	0.70	105.60	441.1	9.03	9.22
T_9: 2 kg B/ha soil application + salicylic acid 100 ppm at 30 DAS foliar spray	49.57	170.4	0.69	109.58	443.3	8.47	9.31
T_{10}: 5 kg Zn + 2 kg B/ha soil application + triacontanol 10 ppm at 30 DAS foliar spray	53.23	205.5	0.71	114.73	464.4	9.07	10.41
T_{11}: 5 kg Zn + 2 kg B/ha soil application + salicylic acid 100 ppm at 30 DAS foliar spray	51.73	199.9	0.71	114.12	460.1	8.97	10.21
T_{12}: Water spray at the time of PGR application	36.10	149.7	0.74	81.33	326.9	8.27	7.01
SE(m) ±		3.74			6.11		0.33
C.D. (P=0.05)	5.91	11.07	N.S	4.60	17.9	N.S	0.98
CV (%)	7.37	3.78	7.02	2.71	2.57	8.91	6.75

3. RESULTS AND DISCUSSION

The observations pertaining to growth and yield of sorghum recorded during the course of investigation were statistically analyzed and significance of results tested. The results obtained from the experiment revealed that various growth and yield attributes (Table 1) were significantly influenced by plant growth regulators and micro-nutrients. Among growth parameters, plant height (cm) recorded at 45 DAS and at harvest as influenced by plant growth regulators and micro-nutrients given in the table revealed that the highest plant height (53.23 cm and 205.5 cm) at 45 DAS and at harvest was found with treatment T_{10} where 5 kg of zinc with 2 kg B and Triacontanol @ 10 ppm was applied which was found at par (51.73 cm and 199.8 cm) at 45 DAS and at harvest respectively with teatment T_{11}. The improvement in growth parameters with these plant growth regulators and micronutrients might be due to their role in modifying various physiological and metabolic processes in the plant system. Similar results were reported by Sumeriya & Singh [9] and Syed Ismail et al. [10]. An increase in plant growth might also be due to higher quantity of chlorophyll synthesis in the leaf tissue and delayed senescence of plant leaves [11]. The results indicated that all the treatments improved the green fodder yield over control. Among different treatments, $T_{10:}$ 5 kg Zn + 2 kg B/ha soil application + Triacontanol 10 ppm at 30 DAS foliar spray and $T_{11:}$ 5 kg Zn + 2 kg B/ha soil application + salicylic acid 100 ppm at 30 DAS foliar spray produced maximum green fodder yield (493.6 and 490.5q/ha) on mean basis. It was significantly superior to other treatments. These treatments improved the green fodder yields by 35.0% and 34.2%, respectively, over control (spray of water). Zn and Fe has an important role in photosynthesis and metabolic process augments the production of photosynthates and the translocation of these photosynthates to different parts of plant and iron plays an important role in catalytic function in biological oxidation and reduction in plant as well as it is principle constituent of a large number of metabolically active compounds like cytochromes, heme and nonheme enzymes and other functional metalloproteins, which ultimately increases the green fodder yield of fodder crops [12]. In terms of dry matter, similar trend was noted and the improvement with T_{10} and T_{11} was to the tune of 36.8 % and 41.0 % over control. Triacontanol 10 ppm at 30 DAS (foliar spray) (T1) improved the green fodder yield and dry fodder yield by 13.6% and 14.3% respectively over T_{12} Water spray at the time of plant growth regulator application. Similarly, spray of T_2: Salicylic acid 100 ppm at 30 DAS (foliar spray) improved the green fodder yield and dry fodder yield by 14.4% and 15.4% respectively over T_{12} Water spray at the time of plant growth regulator application. Similar trend was observed in case of crude protein yields on mean basis. It might be due to highest dty matter production and crude protein content as crude protein yield is a function of crude protein content and dry matter yield. Similar results were reported by Pawar et al. [13] and Joshi et al [14].

4. CONCLUSION

The results of the study infer that treatment T_{10}; 5 kg Zn/ha with 2 kg B/ha and Triacontanol @10ppm improved both growth and yield of sorghum which was statistically at par with 5 kg Zn/ha with 2 kg B/ha and 100 PPM Salicylic acid and the lowest growth and yield parameters were recorded with the treatment T12 (water spray at the time of PGR application).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/74591