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Response of rabi sorghum to antitranspirants and mulching and optimization of irrigation management using the critical stage approach under South Gujarat conditions

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Abstract
Sorghum (*Sorghum bicolor* L.) is one of the most important cereal crops in India, with a significant contribution to the food security of the country. In South Gujarat, where water resources are limited, optimizing irrigation management is essential for improving sorghum productivity. At the Agriculture Research Station, an experiment was carried out in the field during the 2018-19 rabi season, Navsari Agricultural University, Mangrol to study response of rabi sorghum to antitranspirants and mulching and optimization of irrigation management using the Critical Stage Approach under South Gujarat. This research paper investigates the response of rabi sorghum to antitranspirants, mulching and varying irrigation regimes using the critical stage approach. Field experiments were conducted rabi seasons in the South Gujarat region to evaluate the impact of these agronomic practices on sorghum growth and yield. The findings provide valuable insights into sustainable sorghum cultivation practices under water-scarce conditions.

Keywords: Critical stage, antitranspirants, mulching, knee height stage, Kaoline, PMA

Introduction
Sorghum, commonly known as "Jowar" in India, is an important cereal crop that holds significant agricultural and economic value in the country. It is primarily grown for its grains, which are used for various purposes, including food, fodder and industrial applications. Sorghum cultivation is widespread across India, including in the southern region of Gujarat. Sorghum is a drought-tolerant cereal crop that plays a crucial role in the agriculture and food security of India. South Gujarat, characterized by erratic rainfall and limited water resources, faces significant challenges in sustaining crop yields, particularly during the rabi season. To address this issue, optimizing irrigation management and adopting water-saving techniques such as antitranspirants and mulching are essential. The critical stage approach offers a promising strategy for efficient water use during crop growth.

Sorghum is one of the major staple food crops in India, particularly in regions with semi-arid and arid climates. It serves as a vital source of nutrition for millions of people. Sorghum is also used in the production of various industrial products, such as biofuels and alcohol. Sorghum thrives in regions with hot and dry climates. South Gujarat, with its tropical climate, is suitable for sorghum cultivation. South Gujarat, including districts like Surat, Navsari, Valsad and Bharuch, has a significant sorghum cultivation area. South Gujarat contributes a substantial share to the overall sorghum production in the state of Gujarat, which is one of the leading sorghum-producing states in India. The average yield of sorghum in South Gujarat varies depending on several factors, including rainfall and agricultural practices. Yield per hectare can range from 1,000 to 2,000 kilograms or more, depending on the conditions.

Antitranspirants are substances that are used to reduce water loss from plant leaves through transpiration. They are often applied to crops to help them conserve water during periods of stress, such as drought or hot weather. Sorghum, a drought-tolerant cereal crop, can benefit from the use of antitranspirants in certain situations. Here's how antitranspirants can be used for sorghum crops drought stress management, heat stress management, frost protection and increase water use efficiency.

Using rice straw as mulch in sorghum farming can be a sustainable and cost-effective way to improve soil health, conserve moisture and suppress weed growth. Collect rice straw after the rice harvest. Ensure that the straw is dry and free from any diseases or pests. Lay the chopped rice straw evenly around the sorghum plants. Aim for a mulch layer that's about 2-4 inches (5-10 cm) thick. Ensure that the straw doesn't touch the sorghum stems to prevent rot and pests.

Materials and Methods

The field experiments were conducted at Agriculture Research Station, NAU, Mangrol during the rabi seasons of 2018-19. The experiments followed a split plot design (SPD) with three replications. The treatments included three various level of Irrigation level (I_1= Knee height stage, I_2= I_1 + Booting to 50% flowering stage, I_3= I_2 + Soft dough stage), three level of antitranspirant (A_1= Kaoline @ 6%, A_2= PMA @ 300 ppm, A_3= Kaoline @ 6% + PMA @ 300 ppm) and Mulch (M_1=No mulch, M_2=Rice straw). During the month of July, the sorghum seeds of the BP-53 variety were manually sowing 45 x 15 cm between two rows and plant to plant distance at a rate of 12 kg per ha. At the time of planting, all treatments received the same amount of phosphorus and nitrogen through diammonium phosphate and urea (80-40-00 NPK/ha). In general, the weather was good for plant growth and no serious pests or illnesses were found during experimentation. To sustain the crop, the recommended practices package was used.

Table 1: Effect of various treatments on grain and straw yields of sorghum

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)
Irrigation		
I_1= Knee height stage	1386	6513
I_2= I_1 + Booting to 50% flowering stage	1689	8098
I_3= I_2 + Soft dough stage	1818	8917
S.Em. (+)	21.33	180.13
CD @ 5%	61.35	518.15
Antitranspirant		
A_1= Kaoline @ 6%	1548	7251
A_2= PMA @ 300 ppm	1639	7878
A_3= Kaoline @ 6% + PMA @300 ppm	1704	8398
S.Em. (+)	21.33	180.13
CD @ 5%	61.35	518.15
Mulch		
M_1=No mulch	1601	7595
M_2=Rice straw	1660	8090
S.Em. (+)	17.41	147.07
CD @ 5%	50.09	423.07
CV%	5.55	9.74
Interaction	NS	NS

Data presented in Table 1 showed that various treatments was significantly influence on sorghum crop. Application of irrigation was I_3 (I_2 + Soft dough stage) was recorded highest grain (1818 kg/ha) and straw (8917 kg/ha) yields of sorghum crop. It might be due to application of irrigation at Knee height stage + Booting to 50% flowering stage + Soft dough stage produced higher panicle length, panicle girth and panicle weight to other treatments (I_1= Knee height stage and I_2= I_1 + Booting to 50% flowering stage). Because increase in growth traits which helped to increase in synthesis of carbohydrates which was utilized for the development of crop. The result were conformation with Solaimalai *et al.*, (2001) [6], Maman *et al*., (2003) [4], Thorve *et al.*, (2009) [7] and Balazzii Naaiik *et al.* (2015) [1]. Application of antitranspirant A_3 = Kaoline @ 6% + PMA @ 300 ppm was found the highest grain and straw yields as compared with other treatment. This might be due to sufficient moisture available because of reduced transpirational loss and increased translocation of photosynthates to the sink. The thousand grain weight gave significant influence due to the application of kaolin. Application of antitranspirants gave significantly higher thousand grain weights over control. Similar results were observed by Kumar *et al.*, (2015) [3] and Balwan *et al.* (2017) [2]. Using of rice straw registered the highest grain and straw yield as compared to no mulch. Rice straw mulching has many advantageous effects when compared with no mulching. Research results have shown that mulch provides numerous benefits to crop production by improving the physical, chemical, and biological soil properties. It dampens the influence of environmental factor on soil by decreasing soil temperature and controlling diurnal/seasonal fluctuation in soil temperature. Organic carbon content of the soil increased by straw mulching. The results are in conformity with the findings of Singh *et al*., (2019) [5].

Conclusion

This research paper provides valuable insights into enhancing Rabi sorghum production in South Gujarat under water-scarce conditions. The key findings include: Antitranspirant application significantly reduces transpiration rates, conserving soil moisture and increasing grain yield. Mulching contributes to improved soil moisture retention, though its impact on grain & straw yield as well provide the favourable condition of crop. These findings have important implications for sustainable sorghum cultivation in South Gujarat, where water resources are limited and climate variability is a challenge. precise irrigation management based on the critical growth stage approach can contribute to higher sorghum yields, improved resource use efficiency and greater resilience to changing climate conditions.

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