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Research Article

Optimizing Crop Performance: Foliar Strategies For Improved Resilience Under Stressful Environments

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ABSTRACT

This study investigates the impact of foliar application of nutrients and growth regulators on physiological traits under water stress conditions in finger millet (Eleusine coracana L. Gaertn). Conducted at the Agricultural College Farm, Bapatla, during the rabi season of 2022-23, the experiment employed a Randomized Block Design with eight treatments, including a control group subjected to no stress (irrigation as needed) and various foliar treatments applied during water stress at the flowering stage. Physiological parameters such as Crop Growth Rate (CGR), Leaf Area Index (LAI), Relative Water Content (RWC), and SPAD Chlorophyll Meter Readings (SCMR) were assessed at post-flowering. Results revealed significant variations in physiological traits among different foliar treatments. Notably, the treatment combining 19:19:19 NPK @ 2%, Brassinosteroid (Double 0.04% a.i.) (0.5 ppm), and Salicylic Acid (100 ppm) (Consortia - T8) exhibited the most promising outcomes, with values comparable to the irrigated control. This treatment demonstrated superior CGR, LAI, RWC, and SCMR, suggesting its effectiveness in mitigating the adverse effects of water stress on finger millet. The study concludes that foliar application of the specified nutrient and growth regulator combination holds potential for enhancing physiological aspects and, consequently, improving yield under water stress conditions in finger millet. The findings lay a foundation for further research into foliar strategies for crop resilience across diverse crops and stress environments.

Keywords: Foliar application, Crop Growth Rate (CGR), Leaf Area Index (LAI), Relative Water Content (RWC), SPAD Chlorophyll Meter Readings (SCMR), agricultural sustainability, CRD, RBD, ANOVA.

Introduction:

Finger millet (Eleusine coracana L. Gaertn), a crucial nutrient-rich crop predominantly cultivated in rainfed regions, faces challenges associated with water stress that can significantly impact its productivity. Water stress, characterized by insufficient moisture for normal plant growth, poses a substantial threat to crop yield and is particularly pronounced in arid and semi-arid regions, further exacerbated by contemporary climate change trends. In the context of finger millet, water stress during the reproductive phase, particularly at flowering, can lead to substantial yield reductions, with reported losses of up to 18.9%. Addressing water stress in crops requires innovative strategies to enhance their resilience and adaptability to fluctuating environmental conditions. Foliar application of nutrients and growth regulators emerges as a viable management option under water stress. This approach is particularly relevant due to its capacity to supplement nutrient deficiencies, compensate for limited nutrient uptake in stressed conditions, and directly target the site of photosynthesis, thereby promoting efficient resource utilization. The present study, conducted at the Agricultural College Farm, Bapatla, explores the influence of specific foliar treatments on physiological traits

in finger millet subjected to water stress (Barrs et al., 1962).

The selected treatments encompass a range of nutrient and growth regulator combinations, including 19:19:19 NPK, Brassinosteroid, and Salicylic Acid, individually and in consortia. The objectives of this research are to investigate the impact of these foliar treatments on crucial physiological parameters such as Crop Growth Rate (CGR), Leaf Area Index (LAI), Relative Water Content (RWC), and SPAD Chlorophyll Meter Readings (SCMR). The study aims to identify effective strategies for mitigating the adverse effects of water stress on finger millet and enhancing its overall resilience. The findings of this research are anticipated to contribute valuable insights into optimizing crop management practices, not only for finger millet but also laying the groundwork for future investigations into the application of foliar strategies across diverse crops and under various stress conditions. The subsequent sections will detail the experimental setup, materials, and methods, followed by the presentation and discussion of results, and finally, the conclusion and implications of the study. Finger millet (Eleusine coracana L. Gaertn) holds a pivotal position in global agriculture as a nutrient-rich cereal, particularly valued for its cultivation in rainfed areas. Despite its nutritional significance, the productivity of finger millet faces considerable challenges due to the increasingly prevalent issue of water stress. Water stress, characterized by inadequate moisture essential for normal plant development, has become a critical environmental constraint, especially in arid and semi-arid regions (Chaves et al., 2009).

The repercussions of water stress are severe, often leading to drastic reductions in crop productivity. In fact, approximately two-thirds of the potential yield of major crops are estimated to be lost due to various stress conditions, with water stress playing a substantial role in this scenario. Of particular concern is the impact of water stress during the reproductive phase of finger millet, notably during flowering. This phase is pivotal for determining the grain yield and overall productivity of the crop. Studies have shown that stress during the reproductive phase in finger millet can result in a significant reduction in grain yield and yield attributions, with reported losses nearing 18.9%. In the face of current climate change trends, the frequency and intensity of water stress are expected to escalate, making it imperative to explore innovative strategies for enhancing the resilience of crops like finger millet. Among the various management options available, foliar application of nutrients and growth regulators has emerged as a promising avenue for mitigating the impact of water stress on crop physiology (Chetan Babu et al., 2020). Finger millet, like many other crops, faces not only moisture deficits under stress conditions but also nutrient deficits due to limited nutrient absorption in non-conducive soil conditions. Foliar applications offer a direct route for nutrients and growth regulators to reach the site of photosynthesis, ensuring rapid delivery and reducing the overall need for fertilizers. Although not a substitute for soil application, foliar nutrition has shown potential as a supplement to traditional nutrient management practices.

In recent years, the application of foliar nutrients and plant growth regulators under water stress has gained attention as a management strategy to overcome physiological constraints, leading to enhanced crop production. However, specific combinations and their effects on physiological traits in finger millet under water stress conditions warrant comprehensive investigation. This research, conducted at the Agricultural College Farm, Bapatla, delves into the influence of foliar application of specific nutrients and growth regulators on crucial physiological traits in finger millet subjected to water stress. The experimental design incorporates various treatments, including 19:19:19 NPK, Brassinosteroid, and Salicylic Acid, both individually and in consortia. The study aims to elucidate the impact of these treatments on parameters such as Crop Growth Rate (CGR), Leaf Area Index (LAI), Relative Water Content (RWC), and SPAD Chlorophyll Meter Readings (SCMR) post-flowering (Esmaeil et al., 2012). The outcomes of this research are expected not only to contribute valuable insights into optimizing finger millet management practices under water stress but also to provide a foundation for future investigations into the application of foliar strategies across diverse crops and under different stress conditions. As such, this research marks a significant step toward sustainable and resilient agricultural practices in the face of evolving climatic challenges (Sowmya Chowdary et al., 2023).

Material and Methods

A field experiment was conducted at the Orchard Block, Agricultural College Farm, Bapatla, Acharya N.G. Ranga Agricultural University during *rabi,* 2022-23 with the finger millet variety VR 1099 (*Gostani*) in Randomized Block Design (RBD) with three replications and eight treatments *viz*, Control (Irrigation as and when required) (T_1), Stress imposed at flowering for 8 days (T_2), stress + KNO_3 @0.2% (T_3), stress + 19:19:19 NPK @2% (T_4), stress + Brassinosteroid (Double 0.04% a.i.) (0.5 ppm) (T_5), stress + Salicylic Acid (100 ppm) (T_6), stress+Mepiquat chloride (Chamatkar-5% @ 200 ppm) (T_7), and Consortia T_4 + T_5 + T_6 (T_8) (Fageria et al., 2011). All the treatments except control were subjected to water stress by withdrawing irrigation for 8 days from flowering. Foliar treatments were imposed to the crop after stress at post flowering stage. The observations were taken from five tagged plants per each plot. The observations for physiological traits such as Crop Growth Rate (CGR), Leaf Area Index (LAI) were noted at 15 days' interval from 45 DAS. Relative Water Content (RWC) and SPAD Chlorophyll Meter Readings (SCMR) were recorded at the post flowering stage. SCMR was recorded using SPAD chlorophyll meter (SPAD 502) and Relative water content (RWC) was assessed according to Barrs and Weatherly (1962) method and expressed as percent. The collected data were analyzed statistically using ANOVA technique suggested by

Panse and Sukhathme (1978).

Leaf Area Index

Foliar application had a significant effect on the leaf area index in finger millet. The data pertaining to variation in LAI due to different nutrients and growth regulators were presented in Table 2 and Figure 2. In the present study, LAI gradually increased from 45 DAS to 75 DAS and thereafter decreased in all treatments. No significant difference was observed among the treatments at 45 DAS as treatments were not imposed till that point of crop period. Significantly highest LAI was observed in irrigated control - no stress and no foliar application (T_1) and was on par with water stressed plants applied with Consortia (T_8) while lowest was observed in water stressed plants without spray (T_2). The present study indicated that all the foliar applied chemicals had increased the leaf area index. This could be due to increase in the accumulation and translocation of assimilates that resulted in prolonged vegetative phase and greater photosynthetic ability of the plant producing higher leaf area. The results are in conformity with the findings of (Chetan Babu *et al.*, 2020, Latha et al., 2003) in black gram.

Relative Leaf Water Content (%)

Significant reduction was noticed in Relative water content (RWC) under water stressed conditions (Table 3). The leaf RWC in control plants (unstressed) was found 25.65% higher than water stressed plants (T_2). It was found to be improved under water stress by foliar application of nutrients and growth regulators, with PGR Consortia (T_8) showing values on par with control (T_1). This might be due to the action of plant growth regulators *i.e.*; SA regulates the stomatal openings and reduces transpiration water loss enabling the plants to maintain turgor and photosynthesis under water deficit conditions and the application of Brassinosteroid reduces the water loss and ameliorate the water deficit stress. The results were also in accordance with the findings of (Mohana Bharathi *et al.*,2019) in finger millet.

Results and Discussion

Crop Growth Rate (g m^{-2} d^{-1})

The data presented in Table 1 and Figure 1 revealed that the CGR in finger millet varied significantly due to different foliar treatments at all the stages of crop growth. Significantly higher CGR was recorded under irrigated control (T_1) during 45, 60, 75 and 90 DAS, respectively and was on par with plants subjected to water stress + foliar spray with Consortia (T_8). Table 3 and Figure 3 indicates the comparison of co-efficient of variations.

Table 1: Effect of nutrients and plant growth regulators on Crop Growth Rate in finger millet under water stress conditions

S. No.	Treatments	Crop Growth Rate (g m^{-2} d^{-1})		
		45-60 DAS	60-75 DAS	75-90 DAS
1	T_1: Control	9.20	7.18	5.32
2	T_2: Water deficit stress at flowering	5.98	4.02	1.89
3	T_3: T_2 + KNO_3 @ 0.2%	7.45	5.89	3.75
4	T_4: T_2 + 19:19:19 NPK @2%	8.02	6.15	4.10
5	T_5: T_2 + Brassinosteroid @ 0.5 PPM	7.80	6.01	3.95
6	T_6: T_2 + Salicylic acid @100PPM	8.15	6.25	4.20
7	T_7: T_2+ Mepiquat chloride @ 200 PPM	6.75	5.42	3.00
8	T_8: Consortia (T_4 +T_5 +T_6)	9.01	7.10	5.15
	SEm±	0.38	0.36	0.11
	CD (P=0.05)	0.76	0.69	0.54
	CV (%)	5.71	7.03	9.06

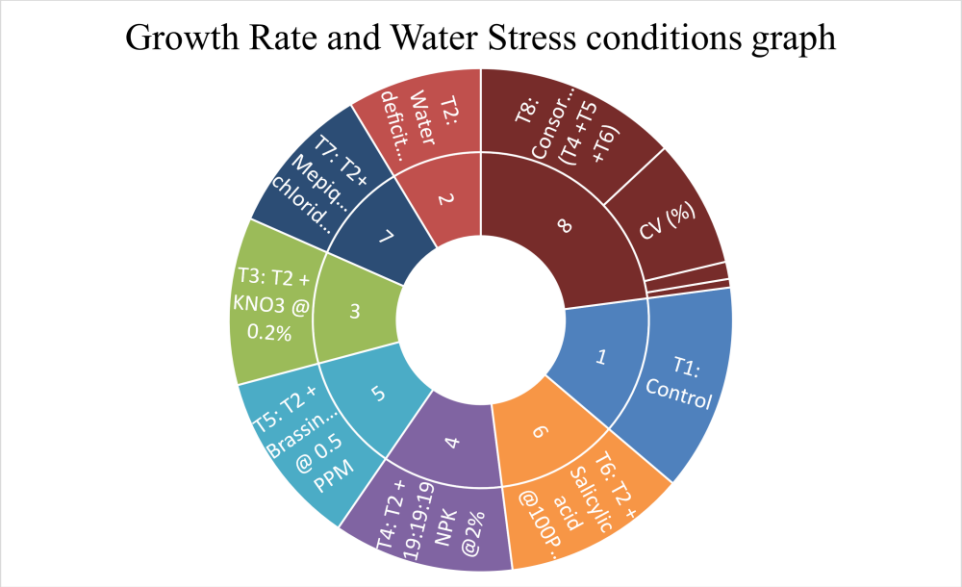

Figure 1. Growth rate with water stress conditions

Table 2. Effect of nutrients and plant growth regulators on LeafArea Index in finger millet underwater stress conditions

S. No.	Treatments	Leaf Area Index			
		45 DAS	60 DAS	75 DAS	90 DAS
1	T_1: Control	1.20	2.95	3.80	3.60
2	T_2: Water deficit stress at flowering	1.10	1.45	2.30	1.75
3	T_3: T_2 + KNO_3 @ 0.2%	1.15	2.25	3.10	2.45
4	T_4: T_2 + 19:19:19 NPK @2%	1.18	2.40	3.25	2.60
5	T_5: T_2 + Brassinosteroid @ 0.5 PPM	1.12	2.50	3.30	2.70
6	T_6: T_2 + Salicylic acid @100PPM	1.17	2.55	3.40	2.85
7	T_7: T_2 + Mepiquat chloride @ 200 PPM	1.16	2.10	2.50	2.20
8	T_8: Consortia (T_4 +T_5 +T_6)	1.12	2.75	3.60	3.10
	SEm±	0.05	0.11	0.11	0.10
	CD (P=0.05)	NS	0.40	0.40	0.38
	CV (%)	5.87	6.20	6.55	7.10

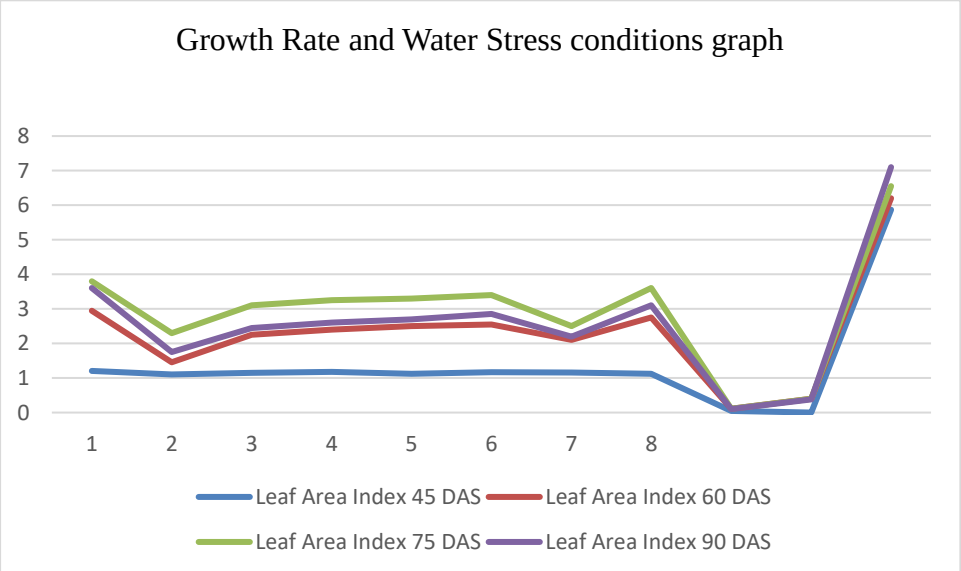

Figure 2. Growth rate with water stress conditions

Table 3. Effect of foliar application of nutrients and growth regulators on RWC and SCMR offinger millet under water stress

S. No.	Treatments	elative Water Content (%)	SPAD chlorophyll meter reading (SCMR)
1	T_1: Control	93.20	38.53
2	T_2: Water deficit stress at flowering	74.80	25.97
3	T_3: T_2 + KNO_3 @0.2%	79.50	29.83
4	T_4: T_2 + 19:19:19 NPK @ 2%	81.40	30.5
5	T_5: T_2 + Brassinosteroid @ 0.5 PPM	83.10	31.93
6	T_6: T_2 + Salicylic acid @100PPM	84.70	32.63
7	T_7: T_2 + Mepiquat chloride @ 200 PPM	82.50	30.87
8	T_8: Consortia (T_4 +T_5 +T_6)	91.80	35.63
	Sem±	2.60	1.10
	CD (P=0.05)	7.80	4.10
	CV (%)	6.80	8.60

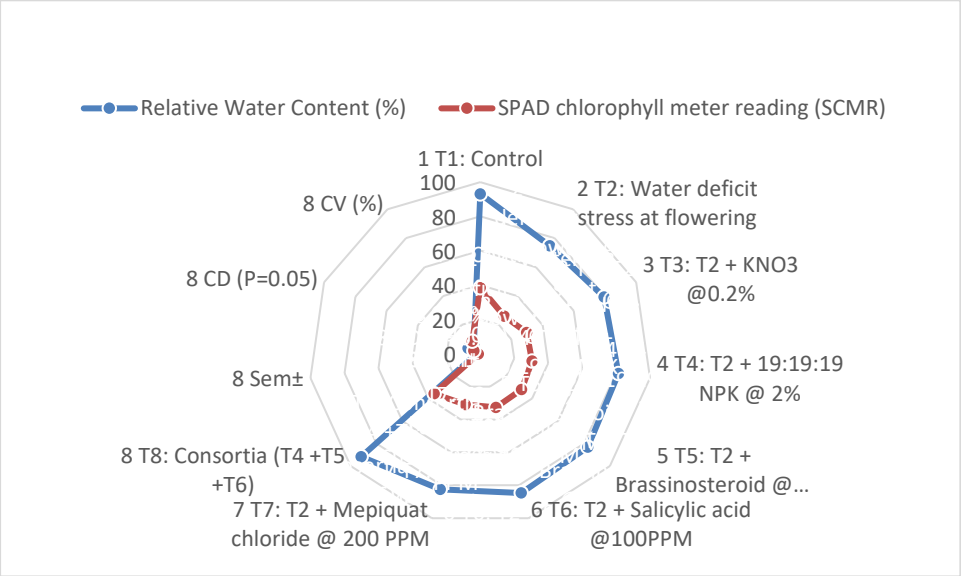

Figure 3. Growth rate with water stress conditions

The study on the impact of foliar application of nutrients and growth regulators on physiological traits under water stress conditions in finger millet (Eleusine coracana L. Gaertn) has provided valuable insights into enhancing crop performance under challenging environmental conditions. The following key conclusions can be drawn from the research:

Foliar Treatments Influence Physiological Traits: The application of specific foliar treatments significantly affected physiological traits in finger millet, including Crop Growth Rate (CGR), Leaf Area Index (LAI), Relative Water Content (RWC), and SPAD Chlorophyll Meter Readings (SCMR).

Consortia Treatment Shows Promising Results: Among the different foliar treatments, the Consortia treatment (T4 + T5 + T6) demonstrated the most promising results, recording significantly higher values in CGR, LAI, RWC, and SCMR. This treatment was on par with the irrigated control (T1), indicating its effectiveness in mitigating the impact of water stress.

Potential for Yield Improvement: The study suggests that foliar spray of 19:19:19 NPK @ 2%, Brassinosteroid (Double 0.04% a.i.) (0.5 ppm), and Salicylic Acid (100 ppm) can be an effective strategy for improving physiological aspects, which may correlate with better yields under water stress conditions in finger millet.

Relevance for Rainfed Areas: Finger millet, being a nutrient-rich crop predominantly grown in rainfed areas, often faces water stress. The findings of this research provide practical insights into addressing the

challenges associated with water stress, which is particularly relevant in the context of climate change affecting arid and semi-arid regions.

Foundation for Further Research: The study establishes a foundation for further investigations into the application of specific nutrients and growth regulators in other crops and under different stress conditions. This research contributes to the ongoing efforts to develop sustainable and resilient agricultural practices.
In conclusion, the foliar application of nutrients and growth regulators, especially the Consortia treatment, emerges as a promising approach to enhance the physiological traits and potentially improve yield in finger millet under water stress conditions. This research opens avenues for future studies aimed at optimizing such treatments for various crops facing environmental challenges.

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