Comparative Evaluation of Biostimulants on Growth and Yield of Finger Millet (*Eleusine coracana* L. Gaertn.) in the Red Lateritic Region of West Bengal

ABSTRACT

Finger millet (*Eleusine coracana* L. gaertn.), an ancient crop cultivated in India since 2300 BC, is highly valued in traditional production systems for its role in alleviating malnutrition, with a rich nutritional profile comprising 9.2% protein, 1.29% fat, 76.32% carbohydrates, and the highest calcium (344 mg%) and potassium (408 mg%) content among all cereals and millets. The present experiment entitled on "A Comparative Evaluation of Various Biostimulants on Finger Millet (*Eleusine coracana* L. gaertn.) Growth and Yield in the Red Lateritic Region of West Bengal" was conducted during *kharif* season of 2022 at Farmers' field,Chandrakona, PaschimMedinipur, West Bengal. The experiment was laid out in Randomized Block Design replicated thrice consisting of 6 treatments[T_1: RDF + Seaweed Extracts @ 0.2%, T_2: RDF + Moringa Extracts @ 2%, T_3: RDF + Protein Hydrolysates & Amino acids @ 0.2%) T_4: RDF + Fulvic acid substances @ 0.2%, T_5: RDF + Panchagavya@ 3%, T_6: RDF (N: P: K- 30:15:15 kg ha^{-1})]. The objective of this study is to find out the effect of foliar nutrition on growth and yield attribute of Finger millets. The grain and straw yield of finger millet as influenced by different treatments are found to be significant. Foliar spray of nutrition has resulted variable yield differences among the treatments. The highest grain yield 26.19q.ha^{-1} and straw yield 34.70q.ha^{-1} were recorded by RDF + Protein Hydrolysates & Amino acids @ 0.2% followed by T_1:RDF + Seaweed Extracts @ 0.2%, with the values of 25.12q.ha^{-1} and 31.56q.ha^{-1} respectively. From the above investigation it was evident that the foliar application of various biostimulantson finger millets had a positive impact on growth and yield, especially in nutrient-stressed soils.In this context, the present study aims to assess the feasibility and performance of finger millet cultivation with minimal nutrient input and the application of biostimulants in various combinations.

Keywords:1.Biostimulants; 2.Finger millet 3.Moringa Extract; 4. Seaweed Extract 5.Panchagavya; 6.Foliar application; 7.Protein Hydrolysates; 8.Fulvic acid

1. Introduction

Millets are small-seeded grasses that are hardy and grow well in dry zones as rain-fed crops under marginal conditions of soil fertility and moisture. Millet is possibly the best solution for "climate smart agriculture," as it is easy to grow, much more versatile, and more climate-proof than riceor wheat.Amongst the small millets, finger mille (Ragi) is the most climate resilient crop, which can be grown under a wide spectrum of extreme climatic conditions.

Finger millet (*Eleusinecoracana* L.gaertn) is cultivated in the tropical and subtropical regions, has been reported to thrive on hardly 28 per cent of the water requirement of rice **(Triveni*et al.*, 2017)**. In India, finger millet (Ragi) occupied an area of 1.19 million hectares accounting for a production of 1.98 million tonnes and an average productivity of 1661 kg ha-1 **(Sakamma*et al.*, 2018)**.Finger millet, a nutrient-rich cereal, is a staple in many parts of the world due to its resilience to adverse climatic conditions and minimal input requirements. Finger millet, valued in traditional production systems for alleviating malnutrition, contains 9.2% protein, 1.29% fat, 76.32% carbohydrates, 2.2% minerals, 3.90% ash, and 0.33% calcium **(Reddy *et al.*, 2018; Shobana*et al.*, 2013)**. Despite its agronomic advantages, the cultivation of finger millet in West Bengal's red and lateritic belt remains largely unexplored. This region is characterized by nutrient-deficient soils, moderate to low organic matter, and limited water retention capacity. These challenges, coupled with the relatively low adoption of Ragi cultivation, have contributed to a lack of research on its potential in this area.

The red and lateritic soils possess inherent fertility traits, albeit limited, that could support low-input crops like finger millet and Its ability to thrive under minimal management conditions offers a promising alternative to conventional crops in the region, especially under scenarios where sustainable farming practices and resource efficiency are prioritized**(Mukesh *et al*., 2024)**. However, a systematic evaluation of its growth and productivity under different nutrient regimes and biostimulant applications is still missing.Biostimulants, such as seaweed extracts, humic and fulvic acids, and protein hydrolysates, have gained attention as sustainable tools for improving crop performance under suboptimal growing conditions**(Kundu *et al*.,2023)**. These compounds enhance nutrient uptake, improve plant resilience to abiotic stress, and stimulate growth and yield. Integrating biostimulants into finger millet cultivation could potentially unlock new opportunities for resource-poor farmers in the red and lateritic belt.

This findings underscore the potential of biostimulants in enhancing productivity of Finger millet (ragi), through improved physiological and biochemical mechanisms. The primary objectives include evaluating the growth parameters and yield of finger millet under these conditions. This study is expected to provide critical insights into the potential of finger millet as a viable crop in the red and lateritic soils of West Bengal, contributing to sustainable agricultural practices in the region.

2. Materials and Methods

The experiment was conducted during *kharif* season of 2022 at Farmers' field Chandrakona block, PaschimMedinipur, West Bengal. (22.68^{0}N latitude, 87.55^{0}E longitude) comes under Red and Lateritic zone of West Bengal with average annual rainfall is 1500-1600 mm.The soil of the experimental field was sandy loam in nature (containing 43.9% sand, 49.8% silt, and 6.3% clay), having pH of 5.5. The experiment was laid out in Randomized Block Design replicated thrice consisting of 6 treatmentsT_1: RDF + Seaweed Extracts @ 0.2%, T_2: RDF + Moringa Extracts @ 2%, T_3: RDF + Protein Hydrolysates (PH) & Amino acids @ 0.2%) T_4: RDF + Fulvic acid substances @ 0.2%, T_5: RDF + Panchagavya@ 3%, T_6: RDF (N: P: K- 30:15:15 kg ha^{-1})**(Table No-1)**. The experimental field was prepared thoroughly with the help of tractor followed by power tiller and leveling for final land preparation considering the seed size.After leveling, the standard package of practices was followed and finger millet was direct sown in the month of July with row to row spacing of 30 cm. Growth parameters of the crop were recorded at intervals of 30 days and yield attributes were recorded at the time of harvest. The source of nitrogen, phosphorus and potassium were Urea, Single Super Phosphate and Muriate of potash, respectively.Foliar application of different biostumulants as mention in treatments detail has been applied in the finger millets plants at 30 DAS and at 60 DAS. Among the biostimulants utilized, Kazuki Gold (AGMA Energy) served as sources of Protein Hydrolysates (PH) and amino acids; Seasol (derived from *Ascophyllum nodosum*) was employed as a seaweed extract; Biohume provided fulvic acid substances. Additionally, Moringa extract and Panchagavya were prepared in-house following standard protocols

3. RESULTS AND DISCUSSION

3.1 Plant height (cm)

The plant height due to various biostimulants application as foliar spray showed statistically significant, and the results were presented in **Table No-2 and Figure No-1**. During the investigation, the plant heights were recorded at 30 days after sowing, 60 days after sowing, and at the time of harvest.. It was observed that at 30 DAS, maximum plant height of 17.87cm was obtained from the application of Protein Hydrolysates & Amino Acids (T_3)@ 0.2% followed by T_1 and T_2. Similarly when the plant height was recorded at 60 days and as well as at harvest the same treatment was given maximum plant height of 67.14cm and 100.65cm, respectively. The minimum plant height of 16.68 cm, 62.06cm, and 91.26.cm were recorded respectively during 30 DAS, 60 DAS and at harvest from the T_6 which received only RDF (N, P_2O_5 and K_2O: 30, 15, 15 kg ha^{-1}). From the above observation it was cleared that foliar application of Protein Hydrolysates & Amino Acidshas a positive influence on the height of the plants due to easy assimilation of the nutrients and better uptake of nutrients from the soils.The results are in conformity with **Sunitha *et al*. (2004) and Chethan*et al*.,(2023)**

3.2 Number of tillers per plant

Number of tillers per plantfor different biostimulantapplication was statistically significant at the all observation days. The detailed observation has presented in the **Table No-3and Figure No-2**. The number of tillers per plant was significantly affected by the application of all fivebiostimulants in all the three sampling days (30DAS, 60DAS and at harvest). It was revealed that number of tillers per plant increased progressively from 30DAS to 60 DAS and ultimately at final harvest. When the plants were observed at 60 DAS and at harvest the maximum number of tillers per plant were obtained from T_3(3.52& 5.33 respectively) followed by T_1 (3.16& 5.23 respectively) and T_2(3.04& 4.95 respectively). Similar trendof increasing of the tillers numbers by foliar application of biostimulantswere observed by**Karak *et al*. (2024)** on rice and **Lavanya *et al*.(2018).**

3.3 Number of fingers per ear

The perusal of data **(Table No.-4 and Fig. No-3)** indicated that the number of fingers per ear with different treatments ranges from 3.80 to 5.92. Highest number of fingers perear (3.80) was reflected in the T_3(RDF + Protein Hydrolysates & Amino Acids @ 0.2%) which was *at par* with the T_1(RDF + Seaweed Extracts @ 0.2%)having the value of 5.35 .The minimum number of fingers per ear was obtained from T_6.This result is supported by **Karak *et al.*(2023)** for increasing the number of tubers in potato by using the application of biostimulants.

3.4 Finger length (cm)

The character on finger length showed a good amount of differences due to the application of different biostimulants**(Table No.-4 and Fig. No-3)**.Finger lengthvaried from 6.92cm to 8.86 cm. The maximum finger length of 8.86 cm was obtained from the application of Protein Hydrolysates & Amino Acids.followed by T_1& T_2..In T_3, the increased nutrient translocation and improved nutrient uptake likely enhanced cellular metabolic processes, contributing to improved growth parameters in finger millet. The application of moringa extracts, rich in phytohormones such as cytokinins, auxins, and gibberellins, may have played a critical role in regulating growth and developmental processes. This hormonal stimulation possibly enhanced photosynthesis, nutrient assimilation, and sink capacity, leading to increased crop biomass. Moreover, it likely supported efficient partitioning of assimilates toward productive plant parts, thereby improving sink size and overall crop performance.**(Gangaraddi*et al*., 2020)**

3.5 Grain and Straw Yield (q.ha^{-1})

The grain and straw yield of finger millet as influenced by different treatments are also found to be significant (**Table No.-4 and Fig. No-4).**Foliar spray of different biostimulantshas resulted variable yield differences among the treatments.The highest grain yield 26.19 q.ha^{-1}and straw yield 34.70q.ha^{-1}were recorded by the application of Protein Hydrolysates & Amino Acids (Kazuki Gold).The second highest grain and straw yield was obtained from T_1 (Seaweed Extracts @ 0.2%) with the values of 25.12q.ha^{-1}and 31.56 q.ha^{-1}, respectively. The application of moringa extracts at a 2% concentration resulted in significantly higher grain yield (23.74 q.ha^{-1}) and straw yield (30.41 q.ha^{-1}) compared to fulvic acid and Panchagavya applications. This increase can be attributed to the presence of phytohormones such as auxins, cytokinins, and gibberellins in moringa extracts. The Increased yield in these treatments is due to the overall improvement in crop growth and development by promoting cell division, elongation, and nutrient uptake**(Sathiyabama *et al*., 2021)**. Additionally, they may have improved photosynthetic efficiency, metabolic activity, and the allocation of assimilates, contributing to better biomass accumulation and yield formation. The similar kind of result was found by **Reddy et al., (2021)** in finger millet, **Rathinapriya *et al.* (2020)** for foxtail millet and **Chowdary*et al.(*2022)** in Pearl millet.

3.6 Harvest Index (%)

Harvest index was found significant due to different foliar application of biostimulants. The highest Harvest index of 44.31 % was observed in the T_1which was significantly superior over rest of the other treatments. The numerically increase in harvest index with varying levels of fertilizer dose might have enhanced adequate supply of nutrients, enhanced carbohydrate synthesis and rate of metabolic activities resulting in higher dry matter and finally the grain yield had favoured for higher harvest index value**(Laane*et al*., 2017).**

CONCLUSION

This comparative study of various biostimulantshighlights the positive impact of on the growth, yield, and overall performance of finger millet under field conditions in West Bengal's Red and Lateritic zone. The application of Protein Hydrolysates (PH) and Amino Acids (Kazuki Gold) resulted in significant improvements in plant height, number of tillers, number of fingers per ear, finger length, grain yield, and straw yield compared to other treatments. The enhanced performance of T_3, $T_1$and T_2can be attributed to the efficient translocation of nutrients, improved cellular metabolism, and better nutrient assimilation due to the presence of phytohormones, Plant growth stimulators and better nutrient uptake from the soil which enhances photosynthetic efficiency and biomass partitioning. Harvest index improvements indicate effective assimilate allocation under optimized nutrient management. Biostimulants enhance nutrient use efficiency, promote root development, and improve plant resilience under abiotic stresses like water scarcity. Their ability to stimulate physiological and biochemical processes supports better growth and yield in finger millet, making them a sustainable tool for ensuring productivity in challenging environments, especially in resource-poor, problematic, and drought-prone soils.

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Table No.-1: Details of the Treatments

Treatments	Details
T_1	**RDF + Seaweed Extracts @ 0.2%**
T_2	**RDF + Moringa Extracts @ 2%**
T_3	**RDF + Protein Hydrolysate & Amino acid Substances @ 0.2%**
T_4	**RDF + Fulvic acid substances @ 0.2%**
T_5	**RDF + Panchagavya@ 3%**
T_6	**Only RDF**

(RDF = Recommended Dose of Fertilizers (N: P: K- 30:15:15 kg ha^{-1})

Table 2. Response of various biostimultant on plant height

Treatments	Plant Height (cm)		
	30 DAS	60 DAS	At harvest
T_1	17.71	65.67	97.63
T_2	17.15	65.09	97.01
T_3	17.87	67.14	100.65
T_4	16.83	64.10	95.63
T_5	16.26	63.76	93.75
T_6	16.68	62.06	91.26
S.Em(±)	0.30	0.196	0.209
CD (5%)	0.91	0.59	0.63

Treatments	Number of tillers per plant		
	30 DAS	60 DAS	At harvest
T_1	1.87	3.16	5.23
T_2	1.83	3.04	4.95
T_3	2.29	3.52	5.33
T_4	1.84	3.09	4.70
T_5	1.75	2.98	4.75
T_6	1.48	2.93	4.06
S.Em(±)	0.064	0.06	0.09
CD (5%)	0.20	0.18	0.27

Table: 3 Response of variousbiostimultant on number of tillers per plant

Treatments	Number of fingers per ear	Finger length (cm)	Grain yield (q/ha)	Straw Yield (q/ha)	Harvest Index (%)
T_1	5.35	8.15	25.12	31.56	44.31
T_2	5.03	7.94	23.74	30.41	43.84
T_3	5.92	8.86	26.19	34.70	43.01
T_4	4.93	7.75	23.05	27.41	43.43

Table: 4. Response of various biostimulants on some characters

T_5	**4.32**	**6.92**	**20.16**	**26.35**	**43.34**
T_6	**3.80**	**6.04**	**17.83**	**23.17**	**43.49**
S.Em(±)	**0.087**	**0.079**	**0.68**	**0.161**	**0.20**
CD (5%)	**0.26**	**0.24**	**2.06**	**0.49**	**0.61**

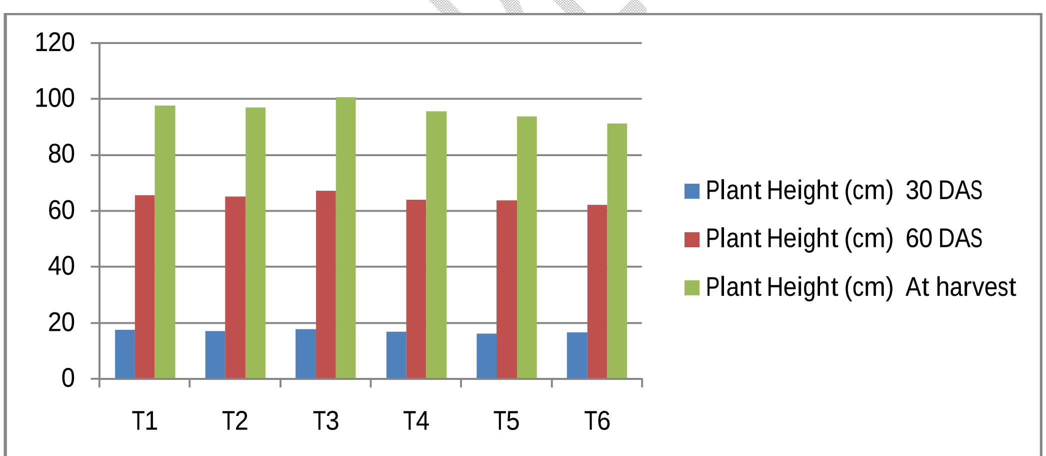

Fig.-1: Response of various biostimulants on plant height (cm) at different sampling days

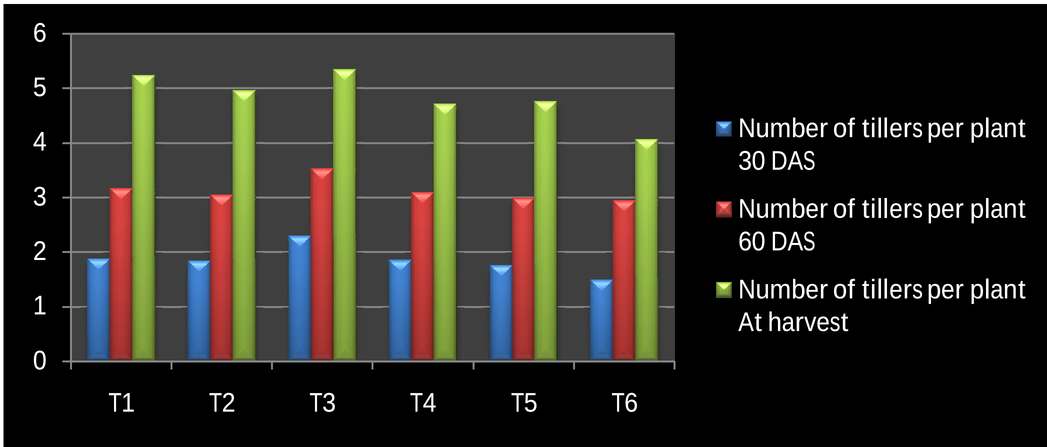

Fig.-2: Response of various biostimulants on number of tillers per plant

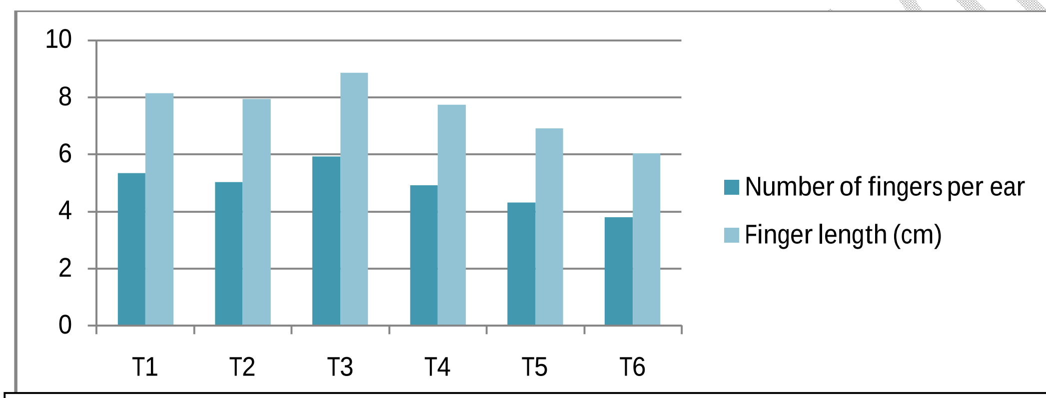

Fig.-3: Response of various biostimulants on number of fingers per ear and finger length (cm)

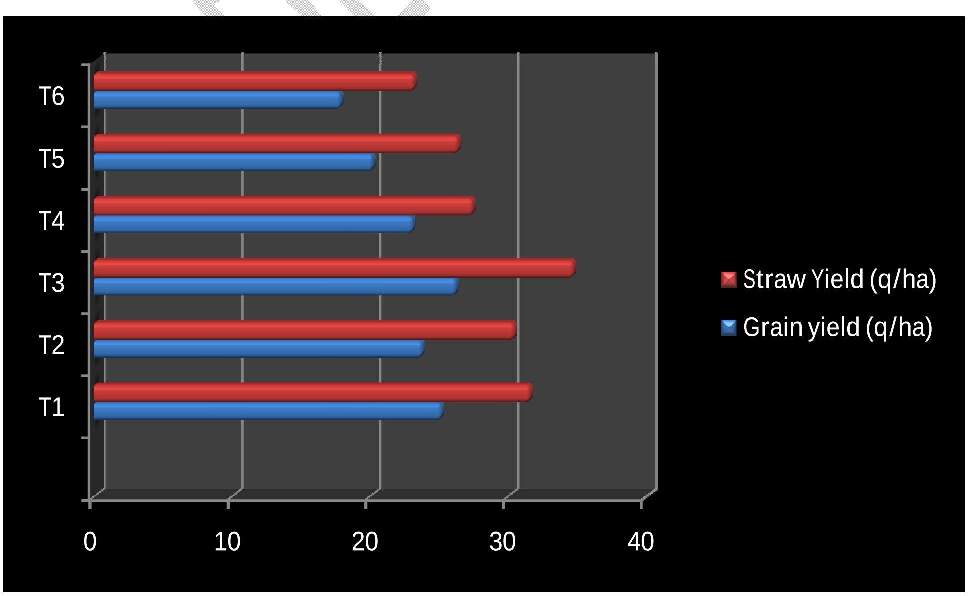

Fig.-4: Response of various biostimulants on grain yield ($q.ha^{-1}$) and straw yield ($q.ha^{-1}$) of finger millet

Fig.-5: Experimental field of Finger millet