



Comparative study of salinity tolerance in finger millet varieties CO 15 and CFMV1 under single and bulk planting based on physiological and morphological traits

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Abstract

Soil salinity is a critical abiotic stress that adversely impacts plant physiology, growth, and productivity. Elevated salt concentrations, primarily sodium chloride (NaCl), disrupt cellular homeostasis, impair nutrient uptake, and induce osmotic and ionic stress. These conditions can lead to reduced photosynthesis, stunted growth, and, ultimately, lower crop yields. Investigating the effects of salinity on plants is essential for developing strategies to enhance salt tolerance and ensure sustainable agricultural production under increasingly saline conditions. Globally, salinity threatens about 1 billion hectares of land over 835 million hectares are saline soils, posing threats to the livelihood of poor farmers. In India alone, around 6.73 million hectares are saline, worsened by poor management practices. The research performed at Mother Teresa College of Agriculture in the testing of salt tolerance of diverse millet cultivars using different NaCl concentration (0, 50, 100, 150, and 200 Mm) and different planting (single and bulk) of crops with 14 parameters viz., plant height (cm), plant girth(cm), number of tillers per plant, number of panicle per plants, number of fingers per panicle, shoot and fresh weight, shoot and root dry weights, Salinity stress considerably inhibits the physiological character of plants across millets, as indicated by evidence of pronounced differences and in the study reported as future to need to develop the salt tolerant variety of finger millet in sustainable agriculture.

Keywords: Abiotic stress, plant physiology, salt tolerance, sustainable and agriculture

Introduction

Finger millet (*Eleusine coracana* L.) is a hardy, drought-resistant cereal crop. its tolerance to salinity is relatively low to moderate compared to other cereals (Reddy et al., 2022) [12]. In India, finger millet accounts for about 7% of the cultivated area and contributes 11% of the total millet production (Salma et al., 2024) [13]. The major finger millet-growing states include Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, Maharashtra, Uttar Pradesh, and Gujarat. Salinity refers to the condition in which soluble salts accumulate in soil to levels that adversely affect crop growth and productivity (Childs & Hanks, 1975) [3]. Excess salinity limits plant water uptake, reduces nutrient absorption, and leads to ionic and osmotic stress, which ultimately reduces germination, seedling vigor, and yield (Akbarimoghaddam et al., 2011; Singh et al., 2023) [2, 15]. It has been projected that by 2050, more than 50% of global arable land will be affected by salinity (Jamil et al., 2011) [7], while India alone has about 7 million hectares of saline soil (Patell et al., 2011) [10]. Saline soils are complex, often containing salts such as NaCl, CaCl₂, Na₂SO₄, and CaSO₄, with elevated boron levels and alkaline pH. Thus, promising genotypes must be evaluated under multiple saline environments to ensure stable tolerance (Joseph & Jini, 2010; Huang et al., 2023) [6, 8].

The CO 15 genotype is known for its blast resistance and high yield potential of 2268 kg ha⁻¹ during the rabi season (Sendhilvel & Veeramani, 2020) [13, 14], while CFMV-1 exhibits significantly higher grain and straw yields of 3104 and 5456 kg ha⁻¹, respectively, in Karnataka (Salma et al., 2024) [13]. Recent studies emphasize screening finger millet

for salinity tolerance as a strategy to enhance resilience under changing climatic conditions (Kumar et al., 2021; Devi et al., 2022; Gao et al., 2025) [4, 5, 9]. The present investigation aimed to evaluate the response of two finger millet genotypes, CO 15 and CFMV-1, to varying NaCl concentrations and identify tolerant and sensitive cultivars based on morphological and physiological traits.

Methodology

The study was carried out at the Mother Terasa College of Agriculture, Illupur, Pudukkottai, located in the central agro climatic zone of Tamil Nadu, during the Kharif season of 2023–2024. Seeds of two finger millet genotypes CFMV1 and CO 15 were procured from the ICAR Indian Institute of Millets Research (IIMR), Hyderabad, and Tamil Nadu Agricultural University (TNAU), Coimbatore, respectively. The experiment was designed to assess the salt tolerance of the two cultivars under five NaCl concentrations: 0 (control), 50, 100, 150, and 200 mM. Salt solutions were prepared by dissolving 2.9 g (50 mM), 5.8 g (100 mM), 8.77 g (150 mM), and 11.77 g (200 mM) of NaCl in one liter of distilled water treat with 2 genotype. Two transplanting methods were evaluated: 1. Single seedling per hill (30 × 30 cm spacing) following TNAU SRI Recommendations and bulk seedling per hill (2–3 seedlings per hill at 30 × 30 cm spacing).The experiment was laid out in a Randomized Block Design (RBD) with three replications. At harvest, data were recorded on plant height, plant girth, number of tillers per plant, number of panicles per plant, number of fingers per panicle, fresh and dry weights of shoot and root, and total dry matter production. Statistical analyses were

conducted to identify significant differences among treatments, and based on the results; genotypes were categorized as salt tolerant or salt sensitive. This approach aligns with recent studies emphasizing multitrait assessment for salinity screening in small millets (Ramesh et al., 2023; Ahmed et al., 2022; Patel et al., 2024) [1, 11, 18, 19].

Result

Growth and Yield Attributes

Plant height exhibited a wide range, from 70.20 cm (T9) to 112.20 cm (T2) under single seedling planting and 86.80 cm (T10) to 108.60 cm (T2) under bulk seedling planting. In most entries, bulk seedling plants recorded slightly higher plant height than single seedlings, indicating enhanced vegetative growth under dense establishment. The number of tillers per plant ranged from 3.50 to 8.00 in single seedling planting and 4.50 to 10.20 in bulk seedling planting. The highest tiller number (10.20) was observed in T1 and T3 under bulk seedling planting, showing that grouped establishment enhanced tillering efficiency. The number of panicles per plant ranged from 2.80 to 7.00 in single seedling planting and 2.00 to 8.40 in bulk seedling planting, with T2 under bulk planting producing the maximum number of panicles (8.40). Similarly, the number of fingers per panicle varied from 5.00 to 10.40 under single seedling and 4.60 to 9.20 under bulk seedling conditions. The maximum value (10.40) was recorded in T1 under single seedling planting present in Table 1.

Biomass and Physiological Traits Significant differences were also recorded in plant girth shoot and root biomass between the two establishment methods. Plant girth ranged from 4.60 cm to 7.02 cm under single seedling planting and 5.14 cm to 6.70 cm under bulk seedling planting. The

maximum girth (7.02 cm) was observed in T3 under single seedling planting, indicating better stem robustness in individually spaced plants. The fresh weight of shoot varied from 150.33 g (T10) to 478.00 g (T1) in single seedlings and 235.00 g (T 10) to 520.00 g (T1) in bulk seedlings. Likewise, dry weight of shoot ranged between 43.50 g and 105.16 g under single seedling and 36.00 g to 96.50 g under bulk seedling establishment, with the highest dry weight recorded in T1 under single seedling planting. For root traits, the fresh weight of root ranged from 6.20 g to 69.00 g in single seedlings and 7.00 g to 76.50 g in bulk seedlings. The dry weight (bulk weight) of root ranged between 3.00 g and 25.43 g in single seedlings and 6.00 g to 23.30 g in bulk seedlings. T1 consistently performed better across both shoot and root biomass parameters observed in table 2.

Overall Performance and Statistical Significance

Statistical analysis indicated that most of the observed differences between the two establishment methods were significant, with low standard error (SE = 0.005–2.74), critical difference (CD 5% = 0.002–0.91), and coefficient of variation (CV = 0.04–12.97%). Overall, bulk seedling establishment recorded higher mean values for plant height, number of tillers, panicles per plant, and total biomass accumulation, while single seedling establishment showed superiority in plant girth, shoot dry weight, and number of fingers per panicle. These findings suggest that while bulk seedling planting promotes greater vegetative and reproductive output through enhanced competition and canopy development, single seedling establishment favors sturdier growth and improved assimilate partitioning per plant.

Table 1: Effect of salinity different growth parameters

S. No	plant height		Number of Tiller per plant		Number of panicle per plant		Number. Of finger per panicle	
	Single seedling	Bulk seedling	Single seedling	Bulkseedling	Single seedling	Bulk seedling	Single seedling	Bulk seedling
1	99.00 ± 0.57	103.20 ± 0.57	7.20 ± 0.57	10.20 ± 0.57	6.60 ± 0.57	7.40 ± 0.57	10.40 ± 0.57	9.20 ± 0.57
2	112.20 ± 0.57	108.60 ± 0.57	8.00 ± 0.57	8.00 ± 0.57	7.00 ± 0.57	8.40 ± 0.57	8.50 ± 0.57	8.60 ± 0.57
3	97.80 ± 0.57	99.80 ± 0.57	7.00 ± 0.57	10.20 ± 0.57	6.40 ± 0.57	7.80 ± 0.57	10.10 ± 0.57	9.00 ± 0.57
4	105.80 ± 0.57	107.80 ± 0.57	7.60 ± 0.57	8.00 ± 0.57	6.80 ± 0.57	6.80 ± 0.57	7.80 ± 0.57	9.00 ± 0.57
5	98.80 ± 0.57	98.60 ± 0.57	7.00 ± 0.57	7.40 ± 0.57	6.33 ± 0.88	6.20 ± 0.57	9.40 ± 0.57	8.80 ± 0.57
6	95.78 ± 0.57	103.80 ± 0.57	5.00 ± 0.57	6.00 ± 0.57	6.40 ± 0.57	5.60 ± 0.57	6.60 ± 0.57	8.20 ± 0.57
7	88.60 ± 0.57	98.60 ± 0.57	6.60 ± 0.57	7.20 ± 0.57	5.60 ± 0.57	6.00 ± 0.57	9.20 ± 0.57	8.80 ± 0.57
8	91.40 ± 0.57	100.00 ± 0.57	4.00 ± 0.57	6.00 ± 0.57	3.60 ± 0.57	4.00 ± 0.57	5.38 ± 0.57	5.90 ± 0.57
9	70.20 ± 0.57	90.70 ± 0.57	5.80 ± 0.57	6.80 ± 0.57	4.70 ± 0.49	5.50 ± 0.57	8.60 ± 0.57	8.50 ± 0.57
10	70.86 ± 0.88	86.80 ± 0.57	3.50 ± 0.57	4.50 ± 0.28	2.80 ± 0.57	2.00 ± 0.57	5.00 ± 0.57	4.60 ± 0.57
G. Mean	65.20	78.40	4.80	6.30	3.90	5.40	8.20	9.60
SE	0.30	0.12	0.006	0.47	1.26	0.005	0.01	0.004
CD5%	0.10	0.04	0.002	0.15	0.42	0.002	0.004	0.001
CD1%	0.14	0.06	0.003	0.22	0.59	0.002	0.006	0.002
CV	0.18	0.07	0.055	3.68	12.97	0.044	0.087	0.031

Table 2: Effect of salinity different growth parameters and physiological parameter

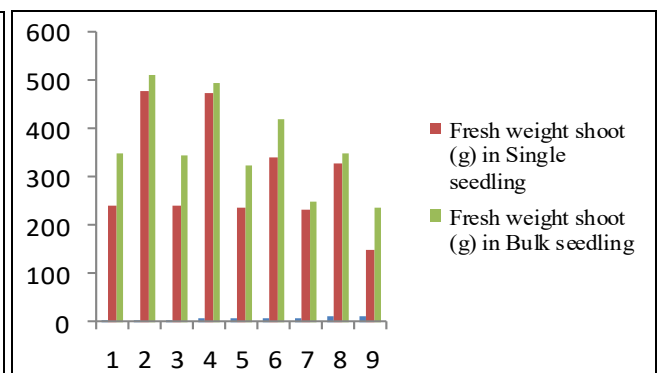
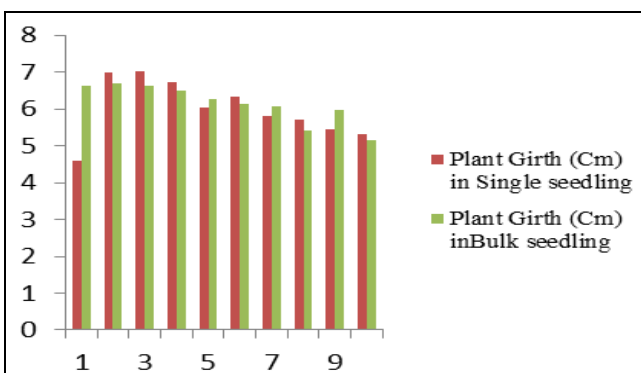
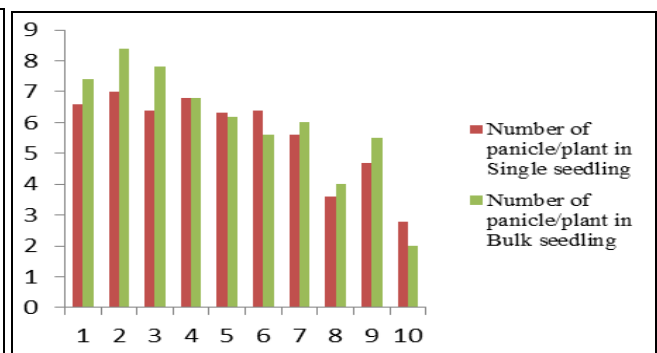
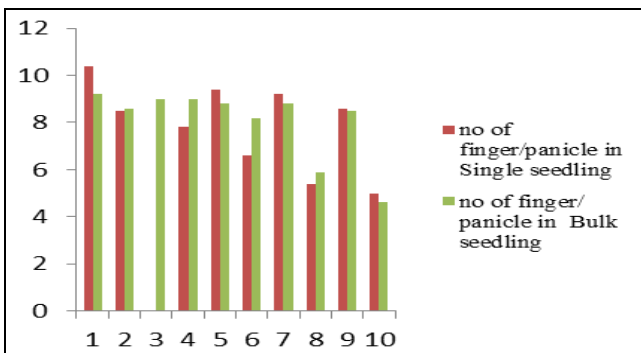
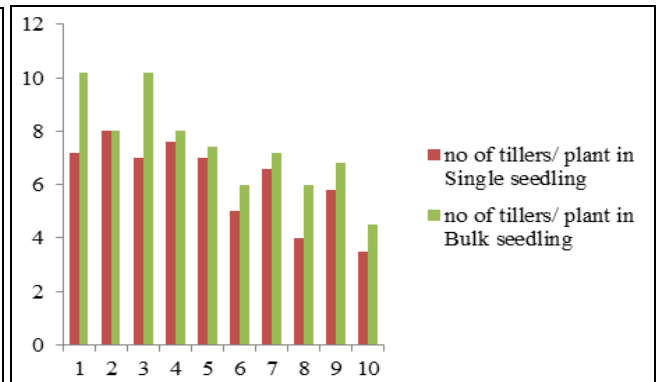
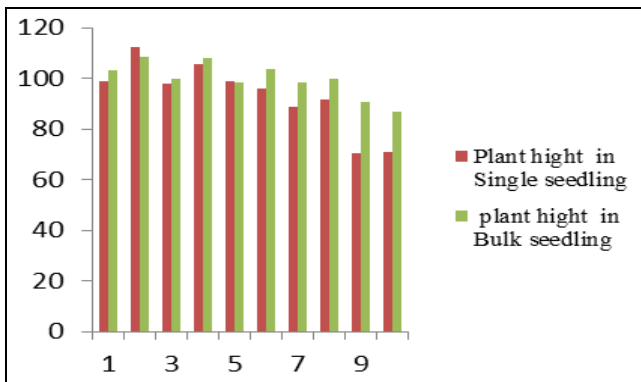
S. No	plant girth(cm)		Fresh weight shoot		Dry weight of shoot		Fresh weight root		bulk weight of root	
	Single seedling	Bulk seedling	Single seedling	Bulk seedling	Single seedling	Bulk seedling	Single seedling	Bulk seedling	Single seedling	Bulk seedling
1	4.60 ± 0.57	6.62 ± 0.57	478.00 ± 0.57	520.00 ± 0.57	105.16 ± 0.57	96.50 ± 0.28	69.00 ± 0.57	76.50 ± 0.57	25.43 ± 0.57	23.30 ± 0.57
2	7.00 ± 0.57	6.70 ± 1.15	240.00 ± 0.57	350.00 ± 0.28	77.20 ± 0.57	65.00 ± 0.28	26.67 ± 0.88	35.00 ± 0.57	24.50 ± 0.57	7.00 ± 0.57
3	7.02 ± 0.57	6.62 ± 0.57	477.50 ± 0.57	510.50 ± 0.57	104.30 ± 0.57	95.50 ± 0.57	68.80 ± 0.57	75.50 ± 0.57	24.50 ± 0.57	22.35 ± 0.57
4	6.72 ± 0.57	6.50 ± 0.57	239.50 ± 0.57	345.00 ± 0.57	77.00 ± 0.57	64.00 ± 0.57	26.50 ± 1.15	34.50 ± 0.57	22.35 ± 0.70	9.00 ± 0.28
5	6.02 ± 0.57	6.26 ± 1.15	475.60 ± 0.57	495.50 ± 0.28	103.20 ± 0.57	94.00 ± 0.28	68.40 ± 0.57	25.50 ± 0.57	24.53 ± 0.57	22.00 ± 0.57

							1.15	0.57	0.57	0.57
6	6.34 ± 0.57	6.14 ± 0.57	235.00 ± 0.57	325.50 ± 0.86	75.30 ± 0.57	63.50 ± 0.28	25.63 ± 0.57	34.50 ± 0.57	21.06 ± 0.57	8.50 ± 0.57
7	5.82 ± 0.57	6.08 ± 0.57	340.50 ± 0.57	420.50 ± 0.57	93.23 ± 0.57	45.30 ± 0.57	26.40 ± 0.57	23.00 ± 0.57	15.70 ± 0.57	14.00 ± 0.28
8	5.70 ± 0.57	5.42 ± 0.57	230.00 ± 0.57	250.33 ± 0.44	71.30 ± 0.57	63.50 ± 3.25	13.10 ± 0.57	15.00 ± 0.57	8.50 ± 0.57	7.50 ± 0.57
9	5.44 ± 0.57	5.98 ± 0.57	330.00 ± 0.57	350.33 ± 0.43	92.06 ± 0.57	43.00 ± 0.57	18.10 ± 0.57	22.50 ± 0.57	15.30 ± 0.57	12.00 ± 0.57
10	5.32 ± 0.57	5.14 ± 0.57	150.33 ± 0.57	235.00 ± 0.28	43.50 ± 0.57	36.00 ± 0.57	6.20 ± 0.57	7.00 ± 0.57	3.00 ± 0.57	6.00 ± 0.57
G.Mean	6.00	6.20	319.64	376.07	84.22	66.53	35.08	34.00	18.29	13.09
SE	0.005	0.73	0.21	0.55	0.11	2.74	0.75	0.44	0.138	0.36
CD5%	0.002	0.24	0.07	0.18	0.03	0.91	0.25	0.14	0.046	0.12
CD1%	0.003	0.34	0.10	0.26	0.05	1.29	0.35	0.21	0.06	0.17
CV	0.052	6.86	0.04	0.08	0.07	2.38	1.24	0.74	0.43	1.60

Discussion

Significant differences were observed between single and bulk seedlings across all growth parameters. Bulk seedlings showed greater plant girth, shoot fresh and dry weights, and root biomass than single seedlings, indicating better resource utilization and vigor (Li et al., 2020; Singh et al., 2021) [20] present in table 1.2 and fig 1. The maximum plant girth (7.00 cm) and shoot fresh weight (520 g) were recorded in bulk seedlings, suggesting improved translocation efficiency and photosynthetic performance (Kumar et al., 2020; Zhao et al., 2021) [9, 16, 21]. Similarly,

root fresh and dry weights were higher in bulk seedlings, reflecting enhanced root proliferation and nutrient uptake (Ahmed et al., 2022; Huang et al., 2023) [1, 6]. Statistical analysis revealed significant variation ($p < 0.05$), confirming that higher seedling density positively influences morphological and physiological growth attributes (Devi et al., 2022; Patel et al., 2024) [4, 18]. These results indicate that bulk seedling establishment promotes vigorous plant architecture, improved biomass accumulation, and better adaptation to growth conditions (Ramesh et al., 2023; Gao et al., 2025) [5, 11, 19].



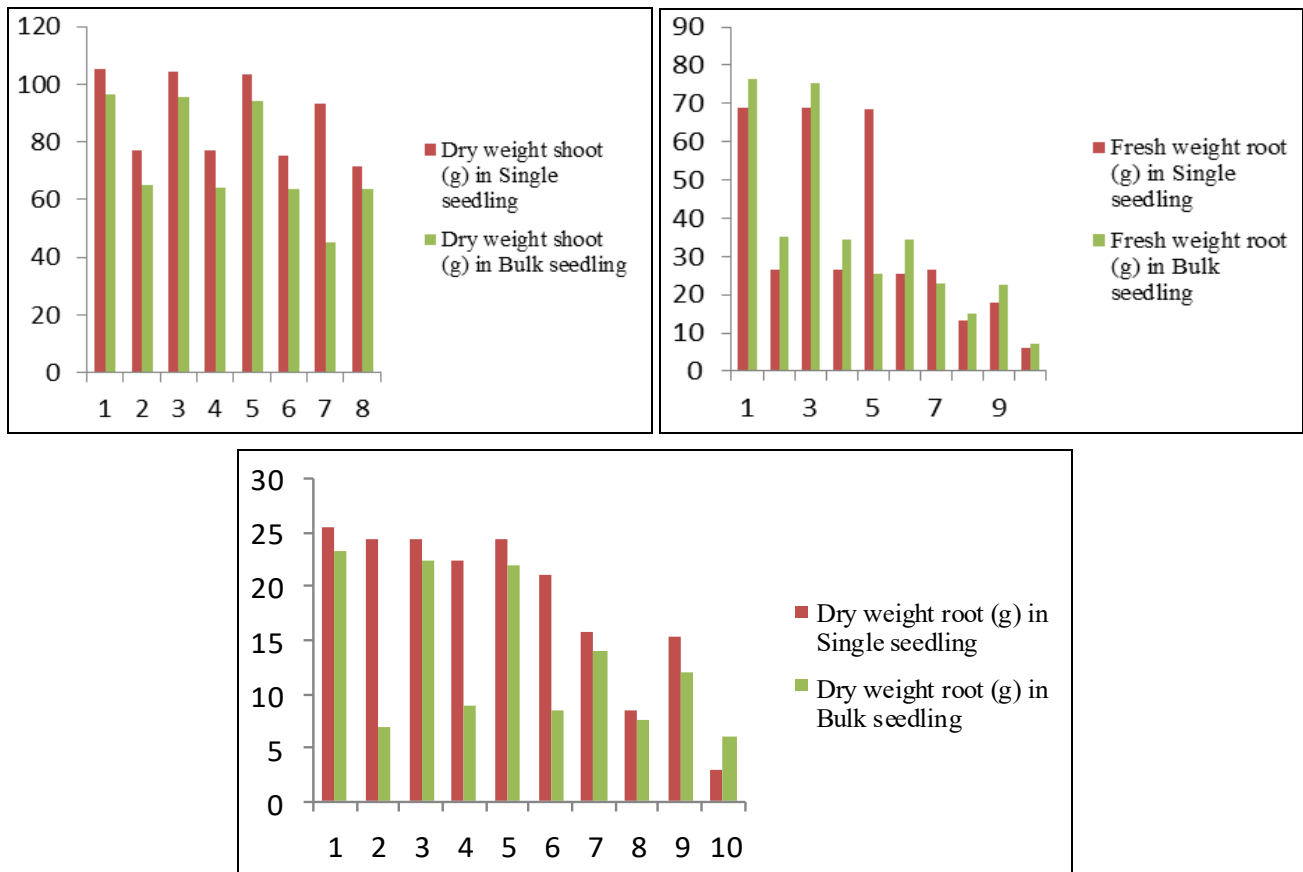


Fig 1: Effect on salinity different growth parameters

Summary

The comparative analysis of single and bulk seedlings revealed that bulk seedlings exhibited superior growth performance in terms of plant height, tiller number, panicle number, finger formation, plant girth, and biomass accumulation. Enhanced shoot and root weights in bulk seedlings indicate improved photosynthetic efficiency, nutrient uptake, and overall vigor evaluated the salinity tolerance of two finger millet varieties, CO 15 and CFMV1, under different NaCl concentrations (0, 50, 100, 150, and 200 mM) during the Kharif 2023–2024 season. Overall, CO 15 and CFMV1 showed differential responses to salinity, with CO 15 exhibiting relatively better tolerance under high NaCl concentrations, as evident from higher plant height, girth, and biomass compared to CFMV1. The results suggest that both genotype and planting method influence salinity tolerance in finger millet, which is critical for identifying salt-resilient varieties for saline-prone regions. Statistical analysis confirmed significant differences ($p < 0.05$) between treatments, demonstrating that bulk seedling establishment promotes better plant architecture, resource utilization, and yield potential. Overall, bulk seedling methods proved more effective for achieving higher growth and productivity in Pudukkottai district.

Author Contribution

This research work was project work carried out Shankar. S, Chinnaraja. V, Sarosan. A.M, Surya Ganesh.S, Mohamed sheik fareeth. S , Yokeshwaran. A of BSc. (Horns.) Agriculture Students of MTCA and P.Kanagamani ,Junior Research Fellow, TNAU under the Guidance of Dr. Ramya Balraj, Associate Professor (PBG), Mr. Sathyaraja,

Assistant professor (CS) and Dr.T.Shankar Assistant professor (Agronomy) give technical support , MTCA

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