



RESEARCH ARTICLE

Assessment of establishment techniques and varietal performance on yield and physiological traits of finger millet (*Eleusine coracana* L.)

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Abstract

Finger millet (*Eleusine coracana* L.) is an important climate-resilient nutri-cereal, known for its superior nutritional quality and adaptability to drought-prone environments. However, its productivity remains comparatively low due to inefficient crop establishment practices and varietal differences. The present study evaluated the effects of 3 crop establishment techniques and 4 finger millet varieties on physiological traits, growth and yield under field conditions. The location of this study carried out in SRMCAS college farm, Baburayanpettai, Chengalpattu district, India. The experimental design is split plot design. The findings revealed that improved establishment methods, particularly the System of Ragi Intensification (SRI) significantly enhanced plant growth, dry matter accumulation, chlorophyll content (SPAD), relative water content, membrane stability index and yield attributes compared to conventional direct sowing. Among the tested varieties, Paiyur 2 exhibited superior physiological performances and recorded the highest grain yield (1668 kg ha⁻¹), whereas PR 202 showed comparatively lower adaptability and productivity under the prevailing agro-climatic conditions. The combined effect of SRI and Paiyur 2 resulted in enhanced grain and straw yield through improved resource-use efficiency, better root development and superior photosynthetic activity. SRI recorded the highest grain yield (1797 kg ha⁻¹), while Paiyur 2 produced 1668 kg ha⁻¹, resulting in a 10.8–57.8 % yield advantage over other varieties. The study highlights the importance of integrating suitable crop establishment techniques with high-performing varieties to improve productivity, profitability and sustainability of finger millet cultivation thereby contributing to climate-resilient agriculture and nutritional security.

Keywords: nutritional security; physiological traits; resilient; sustainability; varietal performance

Introduction

Finger millet (*Eleusine coracana* L.) is an ancient cereal crop recognised for its nutritional richness, climate resilience and potential to support sustainable agriculture. The crop has gained renewed attention as consumers increasingly seek nutritious and environmentally sustainable food sources. It is uniquely rich in calcium (344 mg 100 g⁻¹), dietary fibre, iron and essential amino acids, making it a vital food security crop for millions of subsistence farmers in drought-prone environments. India contributes approximately 40 % of global finger millet production with Karnataka, Odisha, Tamil Nadu and Uttarakhand being major producing states (1). Despite its nutritional and ecological resilience, the national average yield of finger millet (approximately 1.8 t ha⁻¹) remains far below its genetic potential of 6 to 8 t ha⁻¹, primarily owing to suboptimal agronomic practices, poor root system development and inefficient water and nutrient utilisation.

Three principal cultivation methods are commonly practised for finger millet in India, namely System of Ragi

Intensification (SRI), conventional transplanting and direct sowing. The SRI approach, originally developed for paddy rice by Henri de Laulanié in Madagascar and later extended to other crops, is characterised by transplanting young seedlings at wider spacing, maintaining aerobic soil conditions through intermittent irrigation, incorporation of organic amendments and mechanical weeding to promote root proliferation and soil biological activity (2). Transplanted cultivation involves raising seedlings in a nursery and transplanting them at higher densities under conventional irrigation management. In direct sowing, seeds are planted directly into the prepared field without a nursery stage, offers labour economy but may compromise early establishment, root development and yield stability (3).

Growth attributes such as plant height and leaf area index (LAI) determine canopy light interception and biomass accumulation potential (4). Physiological parameters including SPAD chlorophyll meter reading (SCMR), root volume, membrane stability index (MSI) and relative water content (RWC) reflects the plants nutritional status, water use efficiency and cellular stress

tolerance (5). Yield attributes such as ear head length, number of fingers per ear head and 1000-grain weight contributes substantially to final grain and straw yield (6). Previous studies have largely examined crop establishment methods and finger millet varieties independently, without evaluating their interaction. In particular, the performance of SRI relative to conventional transplanting and direct sowing has rarely been tested across multiple varieties under uniform conditions, leaving the combined effect of establishment method and variety on growth and yield unclear. Although several studies have examined crop establishment methods or varietal performance individually, information on their interactive effects under the agro-climatic conditions of Tamil Nadu remains limited. Therefore, the present study was undertaken to evaluate the influence of different crop establishment techniques and finger millet varieties on growth, physiological traits and yield.

Materials and Methods

Experimental location and treatment details

The experiment was conducted at Agricultural College Farm, SRM College of Agricultural Sciences, Baburayanpettai, Chengalpattu district India during the Rabi season of, 2025-2026. The experimental site is situated at an altitude of 12.382082° N latitude, 79.734667° E longitude; 50 m above mean sea level. Composite soil samples collected from the experimental field were analysed for their physico-chemical characteristics. The soil of the experiment field was sandy loam in texture. The soil fertility status was low in available nitrogen (214.4 kg ha⁻¹), low in phosphorus (5.23 kg ha⁻¹) and medium in available potassium (144.2 kg ha⁻¹). The soil pH was 7.5, with an organic carbon content of 0.25. The data on maximum and minimum temperatures, relative humidity, sunshine hours and rainfall were collected from the Agro meteorological observatory at SRM College of Agricultural Sciences, Baburayanpettai, Chengalpattu. The weather conditions that prevailed during the cropping period from January to April 2026. During this period, the maximum and minimum temperatures ranged from 41.3 to 24 °C and 27 to 19.2 °C respectively. The total rainfall received was 10.66 mm over 3 rainy days. The relative humidity ranged from 99 to 82 % at 7:22 AM and from 79 to 33 % at 2:22 PM. Bright sunshine hours ranged from 9.3 to 4 hr per day, with a mean of 7.67 hr per day. The experiment was laid out in a split-plot design with three main plot treatment and four subplot treatments, replicated 3 times. Under SRI-based water management, finger millet was irrigated following the alternate wetting and drying (AWD) principle. After an initial irrigation for crop establishment, irrigation was applied whenever the soil approached mild moisture depletion, allowing the field to dry between successive irrigations without causing crop stress. Adequate soil moisture was maintained during critical growth stages such as tillering, panicle initiation, flowering and grain filling. This practice improved soil aeration, enhanced root growth and water-use efficiency and reduced irrigation water requirement while sustaining crop productivity. Crop establishment techniques were assigned to main plots, while varieties were allotted to subplots using randomisation procedures. The main plot includes 3 crop establishment techniques (E₁: Direct sown 22.5 × 10 cm, E₂: Transplanting 22.5 × 10 cm, E₃: System of Ragi Intensification 25 × 25 cm) and sub plots includes four finger millet varieties (V₁: CO 15, V₂: ATL 1, V₃: Paiyur 2, V₄: PR 202). The recommended dose of fertiliser was 60 kg N, 30 kg P₂O₅ and 30 kg K₂O ha⁻¹. Nitrogen was applied in

three equalised split doses to synchronise nutrient availability with crop demand. A total of 50 % of the recommended nitrogen was applied as a basal dose at transplanting, while the remaining nitrogen was top-dressed in 2 equal splits at 20 DAT (active tillering) and 40 DAT (panicle initiation). The entire quantity of phosphorus (30 kg ha⁻¹) and potassium (30 kg ha⁻¹) was applied through single super phosphate (SSP) and muriate of potash (MOP).

Seedlings for transplanted and SRI treatments were raised in a well-prepared nursery and transplanted at 22 days after sowing (7). Irrigation was provided one day before transplanting in order to ensure plant stand and on alternate days after transplanting until the proper establishment of the seedlings. Furthermore, irrigation was given at weekly intervals based on soil moisture conditions.

Observations and measurements

Growth parameters were recorded at 30 DAT, 60 DAT and at

Crop establishment techniques: Main plot treatments		
E ₁	:	Direct sown finger millet
E ₂	:	Transplanted finger millet
E ₃	:	System of Ragi Intensification
Varieties: Subplot treatments		
V ₁	:	CO 15
V ₂	:	ATL 1
V ₃	:	Paiyur 2
V ₄	:	PR 202

harvest. Plant height (cm) was measured from the soil surface to the tip of the tallest leaf, SPAD chlorophyll meter reading (SCMR) using a SPAD-502 meter on the fully expanded flag leaf, Membrane stability index (MSI)

$$MSI(\%) = \left[1 - \frac{C_1}{C_2} \right] \times 100$$

Where,

C₁ = Electrical conductivity (EC) of the leaf sample after incubating at 40 °C for 30 min.

C₂ = Electrical conductivity (EC) of the same sample after boiling at 100 °C for 10–15 min, followed by cooling to room temperature.

Relative water content (RWC) was recorded at growth 30, 60 DAT and harvest stages from freshly excised leaf laminae (8).

$$RWC(\%) = \frac{FW - DW}{TW - DW} \times 100$$

Where,

FW = Fresh weight of the leaf (g).

TW = Turgid weight of the leaf (g) after soaking in distilled water (usually for 4–6 hr or overnight at room temperature in the dark).

DW = Dry weight of the leaf (g) after oven drying at 70–80 °C until constant weight.

At harvest, ear head length (cm), number of fingers per ear head, 1000 grain weight (g), grain yield (g plot⁻¹) and straw yield (g plot⁻¹) were recorded from net plot area (9). Grain yield was adjusted to standard moisture content before conversion to kg ha⁻¹.

Statistical analysis

The data on various characters studied during the investigation were statistically analysed as per standard procedure. For significant results, the critical difference was worked out at 5 %

probability level to draw statistical conclusions. Wherever the treatment differences were found significant (F test), critical differences were worked out at 5 % probability level was worked out for comparison. Treatment differences which were not significant are denoted as "NS".

Results and Discussion

Plant height (cm)

Plant height, a fundamental indicator of vegetative vigour and canopy architecture, exhibited statistically significant variation across crop establishment techniques and varieties the observations were recorded at the active tillering stage (approximately 30 DAT), flowering stage (approximately 60 DAT) and harvest maturity. Among the crop establishment techniques, SRI (E₃) recorded significantly greater plant height at 30 DAT (46.32cm), 60 DAT (77.42 cm) and harvest (97.56 cm) compared with transplanting (E₂) and direct sowing (E₁) (Table 1). The lowest plant height was observed under direct sowing. The pronounced vegetative expression under SRI can be ascribed to the expansive root architecture fostered by alternating wetting and drying, coupled with reduced inter-plant rivalry at the wider 25 × 25 cm spacing, which collectively amplified nutrient and water acquisition, thereby accelerating internode elongation (10). At the varietal level, V₃ (Paiyur 2) recorded significantly greater plant height, attaining the maximum plant height of 95.89 cm at harvest, closely trailed by V₂ (ATL 1) at 89.42 cm, while V₄ (PR 202) remained the most diminutive at 78.43 cm, indicating a conspicuous genetic hierarchy in height expression. The interaction of E₃ (SRI) with V₃ (Paiyur 2) yielded the tallest canopy across all growth stages,

affirming that the architectural advantages of SRI are most effectively enhanced plant height when paired with inherently tall-statured genotypes. These observations resonate with the previous findings⁽¹¹⁾, who corroborated the height superiority of SRI-managed finger millet over conventional establishment systems.

Dry Matter Production (kg ha⁻¹)

Dry matter production, reflecting the cumulative photosynthetic efficiency and biomass accumulation capacity of the crop, manifested significant and progressive differences among crop establishment techniques and varieties across all growth stages (12). Among the crop establishment techniques, SRI (E₃) recorded significantly higher dry matter production at 30 DAT (1577 kg ha⁻¹), 60 DAT (4080 kg ha⁻¹) and harvest (7320 kg ha⁻¹) compared with transplanting (E₂) and direct sowing (E₁) (Table 2). The lowest DMP was observed under direct sowing. The higher biomass accumulation under SRI may be attributed to improved growth conditions and resource utilization (13). Among the varieties, V₃ (Paiyur 2) outpaced all others with the highest DMP of 1867, 3996 and 6947 kg ha⁻¹ across the three stages, registering a statistically significant edge over V₂ (ATL 1) (1699, 3692 and 6335 kg ha⁻¹) at all stages. V₄ (PR 202) recorded the lowest biomass accumulation (1213, 2744 and 4772 kg ha⁻¹), reflecting its inherent constraints in photosynthetic resource capture. The interaction of E₃ (SRI) with V₃ (Paiyur 2) produced the peak per-hectare DMP, while E₁ with V₄ consistently registered the minimum, confirming that biomass realisation is an outcome of the synergistic expression of both establishment environment and genotypic capacity. These findings are in agreement with an earlier report stating that enhanced biomass production in finger millet varieties exhibiting superior growth performance under

Table 1. Response of plant height (cm) as influenced by different crop establishment techniques and finger millet varieties

Treatments	30 DAT	60 DAT	At harvest
Crop establishment techniques			
E1	36.54	64.21	78.36
E2	41.36	75.41	89.63
E3	46.32	77.42	97.56
SEd	2.31	4.28	5.23
CD	5.42	8.31	10.17
Varieties			
V1	38.52	67.23	86.71
V2	43.26	74.12	89.42
V3	45.89	76.36	95.89
V4	32.54	61.25	78.43
SEd	2.01	3.18	3.05
CD	4.23	8.81	8.45
Interaction			
* SEd	4.57	6.46	8.54
CD	10.65	15.43	18.74

Table 2. Response of dry matter production on (kg ha⁻¹) as influenced by different crop establishment techniques and finger millet varieties

Treatments	30 DAT	60 DAT	At harvest
Crop establishment techniques			
E1	1297	3606	6179
E2	1471	3840	6768
E3	1577	4080	7320
SEd	55.24	145.81	301.41
CD	124.96	343.89	625.45
Varieties			
V1	1461	3188	5712
V2	1699	3692	6335
V3	1867	3996	6947
V4	1213	2744	4772
SEd	74.56	152.29	306.66
CD	168.03	307.58	609.85
Interaction			
* SEd	127.56	299.33	607.45
CD	291.36	653.47	1233.12

improved management practices (14).

SPAD Value (Chlorophyll content)

The SPAD chlorophyll meter reading, a non-destructive surrogate of leaf greenness and photosynthetic competence, was significantly modulated by crop establishment techniques and varieties at 30 and 60 DAT, while the differences converged to non-significance at harvest as the crop neared physiological maturity (15). Among the crop establishment techniques, SRI (E_3) recorded significantly higher SPAD values at 30 DAT (31.84) and 60 DAT (44.38) compared with transplanting (E_2) and direct sowing (E_1). The lowest SPAD values were observed under direct sowing (Table 3). The chlorophyll enrichment under SRI is mechanistically linked to the superior nitrogen mineralisation in well-aerated rhizosphere soils and the unhindered light penetration per plant at wider spacing, which synergistically stimulate chloroplast biogenesis and retard senescence-induced pigment degradation. The non-significant variation at harvest suggests a maturity-driven equalisation of chlorophyll pools across all treatments. At the varietal level, V_3 (Paiyur 2) and V_2 (ATL 1) stood on par, registering the uppermost SPAD values of 32.55 and 44.74 (V_3) and 31.33 and 43.21 (V_2) at 30 and 60 DAT, while V_4 persistently trailed with the lowest readings (25.63 and 35.25). The interaction of E_3 (SRI) with V_3 (Paiyur 2) achieved peak SPAD expression, whereas E_1 (direct sown) with V_4 (PR202) bottomed out across all stages, underscoring that photosynthetic enrichment under SRI is most effectively realised in genotypes with inherently robust chlorophyll biosynthetic capacity. These findings are consistent with an observation that significant varietal differences in growth and

physiological performance of finger millet (16).

Relative water content (%)

Relative water content, a sensitive barometer of cellular turgor and hydration homeostasis under field conditions, was significantly differentiated across crop establishment techniques and varieties at all 3 growth stages (17). Among the crop establishment techniques, SRI (E_3) recorded significantly higher RWC at 30 DAT (67.36 %), 60DAT (78.54 %) and harvest (75.78 %) compared with transplanting (E_2) and direct sowing (E_1). The lowest RWC values were observed under direct sowing (Table 4). The higher RWC under SRI may be associated with improved moisture availability and root activity(18). The markedly lower RWC under direct sowing reflects the compounding effect of higher plant density on canopy-level transpirational demand. Among varieties, V_3 (Paiyur 2) maintained the highest RWC (66.53, 78.98 and 75.63 % at 30, 60 and at harvest), followed closely by V_2 (ATL 1) (65.24, 76.18 and 72.56 %) and V_4 (PR 202) recorded the lowest (50.56, 57.32 and 54.45 %), revealing a pronounced genotypic stratification in cellular water retention(19). The higher RWC recorded in Paiyur 2 and ATL 1 suggests better maintenance of plant water status under the prevailing environmental conditions. The interaction of E_3 (SRI) with V_3 (Paiyur 2) yielded the maximum RWC and E_1 with V_4 the minimum across all stages (20).

Membrane stability index (%)

Membrane stability index (MSI), an indicator of cell membrane integrity and stress tolerance, was significantly influenced by crop establishment techniques and varieties at all growth stages(21).

Table 3. Response to SPAD as influenced by different crop establishment techniques and finger millet varieties

Treatments	30 DAT	60 DAT	At harvest
Crop establishment techniques			
E1	26.12	38.16	35.23
E2	30.11	42.89	38.14
E3	31.84	44.38	41.63
SEd	0.71	1.36	0.84
CD	1.97	3.11	NS
Varieties			
V1	28.12	39.26	37.69
V2	31.33	43.21	40.21
V3	32.55	44.74	41.98
V4	25.63	35.25	35.36
SEd	1.37	1.98	0.98
CD	2.86	4.07	NS
Interaction			
* SEd	1.06	1.87	NS
CD	2.94	5.18	NS

Table 4. Response of relative water content (%) as influenced by different crop establishment techniques and finger millet varieties

Treatments	30 DAT	60 DAT	At harvest
Crop establishment techniques			
E1	53.32	64.56	61.23
E2	62.23	72.23	72.36
E3	67.36	78.54	75.78
SEd	2.16	3.01	4.03
CD	6.13	7.44	6.81
Varieties			
V1	58..21	69.21	65.23
V2	65.24	76.18	72.56
V3	66.53	78.98	75.63
V4	50.56	57.32	54.45
SEd	2.41	3.11	3.42
CD	5.83	6.34	6.93
Interaction			
* SEd	4.45	6.18	7.36
CD	11.84	13.91	13.54

Among the crop establishment techniques, SRI (E_3) recorded significantly higher MSI values at 30 DAT (47.34 %), 60 DAT (73.14 %) and harvest (60.58 %) compared with transplanting (E_2) and direct sowing (E_1) (Table 5). The lowest MSI values were observed under direct sowing. The maintenance of superior membrane integrity under SRI is underpinned by the optimum mineral nutrition particularly potassium and calcium, which are well-known membrane stabilisers rendered available through enhanced organic matter mineralisation in aerobic SRI soils, alongside the attenuation of oxidative stress facilitated by better light distribution at wider spacing (22). Among varieties, V_3 (Paiyur 2) and V_2 (ATL 1) were statistically on par at all stages, registering the topmost MSI values of 47.89, 73.69 and 61.37 % V_3 (Paiyur 2) and 45.59, 71.92 and 60.18 % V_2 (ATL1) respectively, while V_4 (PR 202) persistently occupied the lowest rung (39.71, 63.23 and 49.63 %). The genotypic superiority of V_3 (Paiyur 2) and V_2 (ATL1) in membrane stability is ascribed to their elevated antioxidant enzymatic activity and a more unsaturated fatty acid composition in membrane phospholipids, which confer greater fluidity and thermotolerance (23). The interaction of E_3 (SRI) with V_3 (Paiyur2) consistently delivered the highest MSI, while E_1 (Direct sown) with V_4 (PR202) recorded the lowest, confirming that membrane protection under SRI is a variety-contingent response. Similar improvements in physiological performance and stress-related traits under improved crop establishment methods as have been reported in finger millet (24).

Yield Parameters and Yield

The differences in growth and physiological parameters were reflected in yield and yield attributes. Among crop establishment techniques, E_3 (SRI) decisively outperformed the other methods, recording the highest grain yield (1797 kg ha⁻¹) and straw yield (3108 kg ha⁻¹), followed by E_2 (transplanted) 1696 and 2952 kg ha⁻¹ and E_1 (direct sown) 1563 and 2719 kg ha⁻¹ as tabulated in Table 6. This yield ascendancy of SRI, despite a relatively lower plant population, was a manifestation of its ability to maximise individual plant productivity through enhanced tiller production, improved source-sink relationships and superior physiological status, collectively channelling greater assimilate flux into grain filling. The number of fingers per ear head, a critical determinant of spikelet fertility and sink size, was significantly higher under E_3 (SRI) is 6.53, progressively declining under E_2 (transplanted) 5.82 and E_1 (direct sown) is 4.19, confirming the multiplicative reproductive advantage of SRI. Ear head length and 1000-grain weight, however, did not exhibit significant variation among establishment methods, indicating that

individual grain development was not materially altered by the mode of crop establishment (25). At the varietal level, V_3 (Paiyur 2) registered the highest grain yield (1668 kg ha⁻¹) and straw yield (2920 kg ha⁻¹), statistically on par with V_2 (ATL 1) (1605 and 2777 kg ha⁻¹), as the yield margin between the 2 fell within the significance threshold. V_4 (PR 202) yielded the lowest grain (1157 kg ha⁻¹) and straw output (2002 kg ha⁻¹). The number of fingers per ear head followed the same varietal order Paiyur V_3 (6.54) > ATL1 V_2 (6.15) > CO15 V_1 (5.67) > PR202 V_4 (5.11) with significant differences, corroborating that yield superiority in finger millet is principally governed by ear prolificacy rather than individual grain or ear head dimensions (26–29). The interactions $E_3 \times V_3$ and $E_3 \times V_2$ produced superior yield performance compared with other treatment combinations, suggesting that Paiyur 2 and ATL 1 responded favourably to SRI management. These findings are in strong consonance with the similar report revealing significant yield gains under SRI-based crop establishment when combined with superior finger millet genotypes.

Conclusion

Based on the results of the study, Paiyur 2 performed better than the other tested varieties, while SRI emerged as the most effective crop establishment techniques for improving finger millet productivity. ATL 1 also demonstrates potential performance under SRI and remained statistically comparable with Paiyur 2 for several growth and yield parameters (Fig 1). The study demonstrated that different crop establishment techniques and varieties significantly influenced the growth and yield of finger millet (*Eleusine coracana* L.). Improved methods such as transplanting and SRI produced higher yields and better economic returns compared to direct sowing (27). Among the varieties, Paiyur 2 (V_3) performed best under the local conditions, while PR 202 (V_4) showed lower adaptability and yield performance. The adoption of suitable establishment techniques benefits farmers through increased income, better resource-use efficiency and improved drought tolerance. The integration of improved crop establishment methods with superior-performing varieties can contribute to enhanced finger millet productivity and support climate-resilient crop production systems.

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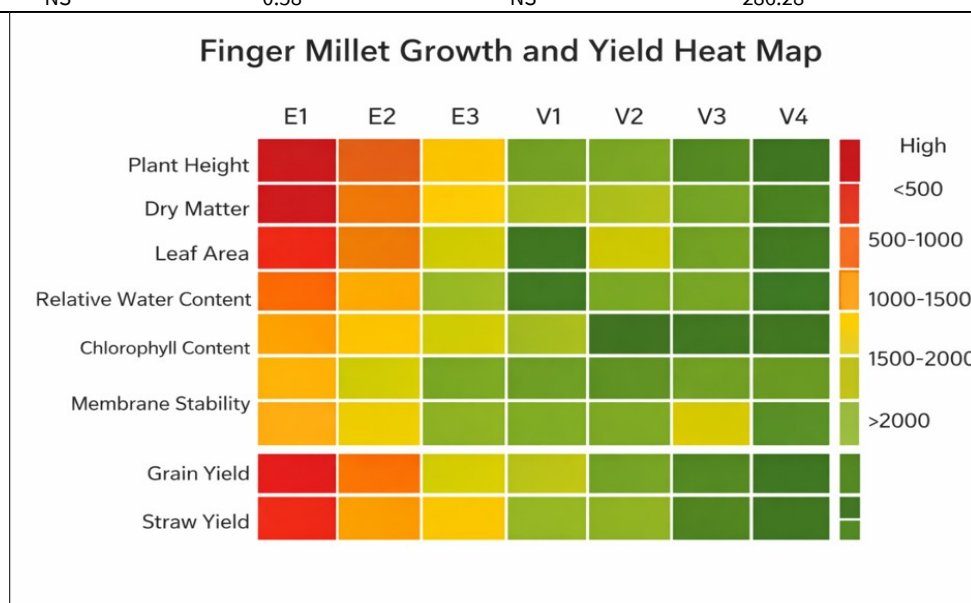
I thank chairperson and advisory committee who supported me in this study and helped to prepare this article. The authors sincerely

Table 5. Response of membrane stability index (%) as influenced by different crop establishment techniques and finger millet varieties

Treatments	30 DAT	60 DAT	At harvest
Crop establishment techniques			
E1	41.23	65.46	53.36
E2	46.23	71.56	58.85
E3	47.34	73.14	60.58
SEd	1.28	3.22	2.37
CD	3.55	6.94	5.81
Varieties			
V1	42.48	66.16	55.58
V2	45.59	71.92	60.18
V3	47.89	73.69	61.37
V4	39.71	63.23	49.63
SEd	1.72	3.07	2.24
CD	3.94	6.96	5.72
Interaction			
* SEd	3.05	6.32	4.65
CD	7.53	13.93	11.59

Table 6. Response of Yield attributes as influenced by different crop establishment techniques and finger millet varieties

Treatments	Ear head length (cm)	Number of fingers per ear head	1000-grain weight (g)	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
Crop establishment techniques					
E1	11.37	4.19	2.11	1563	2719
E2	12.18	5.82	2.78	1696	2952
E3	12.72	6.53	3.03	1797	3108
SEd	0.80	0.36	0.25	43.77	124.09
CD	NS	0.74	NS	121.53	258.48
Varieties					
V1	12.21	5.67	2.01	1461	2442
V2	12.75	6.15	2.72	1605	2777
V3	13.33	6.54	3.06	1668	2920
V4	11.52	5.11	2.47	1157	2002
SEd	0.52	0.21	0.31	59.67	103.45
CD	1.44	0.53	0.86	165.29	286.56
Interaction					
* SEd	NS	0.21	NS	103.35	226.51
CD	NS	0.58	NS	286.28	546.23

**Fig. 1.** Finger millet growth and yield heat map.

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Authors' contributions

DD, JR, RA and NR designed the study, performed the statistical analysis and participated in drafting the manuscript. The authors also contributed equally to the interpretation of results and revision of the manuscript for intellectual content. The research work was framed under the guidance by my chairperson, documented with the support of the advisory committee members and the statistical analysis was carried out by the author. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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