**System of Ragi Intensification: Impact of Seedling Age and Crop Geometry on Yield, Nutrient Uptake and Economics**

**Abstract**

Finger millet is called a drought-tolerant crop, owing to its capability to withstand water stress, nutritional stress and warming stress. A study was carried out at Agricultural and Horticultural Research Station, Honnavile to evaluate the performance of rainfed finger millet (Var. ML-365) in system of ragi intensification, SRI) of planting at different crop geometry (One to two seedlings per hill, guni method) during the *kharif* season in 2024-25. The experiment was assigned twelve treatments, laid out in a split-plot design with three replications. The treatments included: Main plots: 3 Age of seedlings; M1: 14 days old seedlings, M2: 21 days old seedlings, M3: 28 days old seedlings in ‘Guni’ method; Subplots: 4 planting geometries; S1: 20 × 20 cm, S2: 25 × 25 cm, S3: 30 × 30 cm, S4: 35× 35 cm and S5: 30 x 10 cm. Experimental data obtained were subjected to statistical analysis, adopting Fisher’s method of analysis of variance. The results showed that a number of ear heads, finger length and ear head weight were significantly higher in 28 DAT (Days after transplanting) compared to 14 & 21 DAT. The grain yield (3017 kg ha-1), straw yield (4801.20 kg ha-1) were significantly enhanced by 28 DAT compared to different age of transplanting combinations, but in the case of crop geometry, 35×35 cm recorded the highest grain yield (2718.67 kg ha-1) and straw yield (4222.67 kg ha-1). The nutrient uptake (N, P and K) and B-C ratio were also higher in the ‘guni’ method at 28 DAT and 35 × 35 cm spacing geometry, but N availability after the harvest of the crop was lower in 35 × 35 cm spacing compared to other planting geometries. Hence, it can be concluded that transplanting 28-day-old seedlings in the ‘guni’ method with 35 × 35 cm spacing performed better than mere transplanting of 14 & and 21-day-old seedlings in finger millet to achieve higher yield and straw yield.

**Keywords:** Economics, Finger millet, ‘Guni’ method, Plant Uptake, Yield attributes, Yield.

# INTRODUCTION

Finger millet (*Eleusine coracana*) is an [annual herbaceous plant](https://en.wikipedia.org/wiki/Annual_plant) widely grown as a [cereal](https://en.wikipedia.org/wiki/Cereal) crop in the [arid](https://en.wikipedia.org/wiki/Arid) and [semiarid](https://en.wikipedia.org/wiki/Semi-arid_climate) areas in [Africa](https://en.wikipedia.org/wiki/Africa) and [Asia](https://en.wikipedia.org/wiki/Asia). It is a [tetraploid](https://en.wikipedia.org/wiki/Tetraploid) and [self-pollinating](https://en.wikipedia.org/wiki/Self-pollination) species that probably evolved from its wild relative, *Eleusine africana*. Finger millet is native to the [Ethiopian](https://en.wikipedia.org/wiki/Ethiopian_Highlands) and [Ugandan](https://en.wikipedia.org/wiki/Uganda) highlands (Maharajan et al., 2022). Interesting crop characteristics of finger millet are the ability to withstand cultivation at altitudes over 2,000 metres (6,600 ft) above sea level, its high drought tolerance, and the long storage time of the grains (Patil et al., 2023). Finger millet is a staple grain in many parts of India, especially [Karnataka](https://en.wikipedia.org/wiki/Karnataka), where it is known as ragi. It is malted, and its grain is [ground](https://en.wikipedia.org/wiki/Mill_(grinding)) into [flour](https://en.wikipedia.org/wiki/Flour). Finger millet ensures a round the year food supply or even during a crop failure, which has earned it the popular name of "famine crop'' (Balachandrakumar & Devi, 2024; Bado et al., 2022).

Owing to its ability to adjust to different agro-climatic conditions and inherent ability to recover against temporary abiotic stress, without appreciable deterioration in grain quality for nutritional ability, it has been an indispensable part of the dryland farming system (Pandey et al., 2023). “Planting method varies among farmers according to their choice; leisure period, labour availability and wage rates, etc. The most practised method in finger millet is broadcasting and random transplanting. There is an uneven distribution of plants, which causes competition among plants for moisture and nutrients. Yield enhancement in finger millet is possible when cultivated with System of Crop Intensification (SCI), because there is less competition among plants and weeds, and plants can utilise below and above-ground resources efficiently” (Bhatta et al., 2017). “Guni or guli is the vernacular name in the Kannada language representing the idea of SCI in finger millet, also known as the scooping method. In ‘guli’ ragi cultivation, young millet seedlings 28 days old are transplanted into holes spaced 35 x 35 cm in a square grid pattern, two seedlings per hole. Guli ragi includes putting a handful of compost or manure into each hole along with the seedlings to boost soil fertility” (Adhikari *et al.,* 2018). Further, “when the plants are established in a square grid, inter-cultivation between rows is possible in perpendicular directions, not just between rows. It is similar to the SRI method of paddy cultivation called “System of Ragi Intensification”. In the wake of the attempts to popularise this concept and the surge in the interest of farmers, a need has arisen to generate scientific data to validate this concept” (Padesur S. et al., 2022).

Production volume of ragi across India, financial year 2024, Karnataka was the leading producer of ragi (finger millet) in India, with about 865 thousand metric tons. It was followed by the states of Tamil Nadu and Uttarakhand. Poor germination, often, is the result of inadequate moisture after sowing in low rainfall areas. Under these conditions, the adoption of a simple technique like seed hardening will not only improve germination and subsequent plant stand but also impart early seedling vigour and tolerance to drought. Hence, there is a need for the intensification of ragi in order to obtain a high yield. Therefore, the study aimed to evaluate the performance of rainfed finger millet (Var. ML-365) in the system of ragi intensification (SRI) of planting at different crop geometries.

**MATERIALS AND METHODS**

A field experiment was conducted Agricultural and Horticultural Research Station, Honnavile to evaluate the performance of rainfed finger millet (Var. ML-365) in system of ragi intensification, (SRI) of planting at different crop geometry (One to two seedlings per hill, guni method) during the *kharif* season in 2024-25 in split plot design with three replications. The soil of the experimental site was sandy clay loam in texture, neutral in reaction (pH 7.11), low in organic carbon (0.48 %) and available nitrogen (60 kg ha-1), medium in available phosphorus (30 kg ha-1) and available potassium (30 kg ha-1). Treatments included Main plots; Main plots: 3 Age of seedlings; M1: 14 days old seedlings, M2: 21 days old seedlings, M3: 28 days old seedlings in ‘Guni’ method; Subplots: 4 planting geometries; S1: 20 × 20 cm, S2: 25 × 25 cm, S3: 30 × 30 cm, S4: 35× 35 cm and S5: 30 x 10 cm in finger millet (Var. ML-365).

The experimental field was ploughed under dry conditions with a tractor-drawn disc plough, followed by ploughing with a cultivator, and the clods were broken with a rotovator. Finally, the field was uniformly levelled and laid out into experimental plots separated by buffer channels as per the treatments. Direct sowing was taken up as per the treatments on 20th August, 2024. The seeds were sown evenly on the beds. Powdered FYM was evenly sprinkled to cover the seeds, and watering was done in the evening hours. After 15 days, top dressing was done at 250 g of urea for every seed bed. Seedlings were ready for transplanting at 28 DAS. In M2 treatment, i.e., transplanting of the seedlings, was taken up in different geometries as per the treatments, @ 2-3 seedlings per hill on 20th August, 2024. For the ‘guni’ method, the individual plots were uniformly levelled and small gunis or scoops were formed manually using a spade at an intersect point of 30 cm × 10 cm, 30 cm × 30 cm, 45 cm × 45 cm and 60 cm × 60 cm spacing. A well-rotten FYM @ 1 kg/scoop as spot placement was spot-placed to the ‘guni’ planting method. On the same day, i.e., 12th August, 2019, transplanting of 25-day-old seedlings was done in the centre of the ‘guni’ @ 2-3 seedlings per hill. The row-to-row and plant-to-plant spacing were kept S1: 20 × 20 cm, S2: 25 × 25 cm, S3: 30 × 30 cm, S4: 35× 35 cm and S5: 30 x 10 cm as per the treatments. Recommended doses of N, P2O5 and K2O (40:30:25 kg ha-1) were applied in the form of urea, single super phosphate and muriate of potash. Half dose of N and full dose of P2O5 and K2O were applied as basal dose. The remaining quantity of nitrogen was applied to the soil in two equal splits at tillering and panicle emergence(Padesur S. et al., 2022).

Sampling: “In order to record the yield parameters in each net plot, five representative plants were randomly selected and tagged. All the successive observations were recorded on the selected plants during the crop growth period. One row on either side of the plot and two plants on either end of each row were harvested as border rows. Besides this, one crop row was earmarked for periodical destructive sampling to estimate leaf area and dry matter production. The remaining plants in the plot were considered as the net plot, including five tagged plants which were harvested separately, and after recording yield was added to the net plot yield. The ear heads of finger millet in the net plot were harvested separately for each treatment at the harvest stage and dried separately. Then ear heads of each plot were threshed manually, winnowed and cleaned separately. The straw in each net plot was harvested separately and sun-dried. The grain and straw weights were recorded and converted to hectares” (Padesur S. et al., 2022). Experimental data obtained were subjected to statistical analysis adopting Fisher’s method of ‘analysis of variance’ as outlined by Gomez and Gomez (1984).

# RESULTS AND DISCUSSION

**Yield attributes:**

The yield attributes, like the number of ear heads per square meter, weight of ear head, and length of finger, were significantly influenced by establishment method and crop geometry. No. of ear heads per m2: Among the transplanting of different aged seedlings, A3 (28 days old) recorded the highest mean no. of ear heads per m2 (84.12). Among different crop geometries adopted in transplanting, S5 (30 cm × 10 cm) recorded the highest mean no. of ear heads per m2 (115.23). Among the different combinations, S5A3 (Transplanting of 28-day-old seedlings with 30 cm × 10 cm crop geometry) recorded the significantly higher number of ear heads (131.00), followed by S3A3 (Transplanting of 28-day-old seedlings with 30 cm × 30 cm crop geometry) (71.48). Minimum number of ear heads recorded in S1A1 (Transplanting of 14-day-old seedlings with 20 cm × 20 cm crop geometry) (50.00). (Table 1). Weight of ear heads: Among the transplanting of different aged seedlings, A3 (28 days old) recorded the highest mean weight of ear heads (6.97 g). Among different crop geometries adopted in transplanting, S4 (35 cm × 35 cm) recorded the highest mean weight of ear heads (9.72 g).

Higher weight of ear heads recorded in S4A3 (Transplanting of 28-day-old seedlings with 35 cm × 35 cm crop geometry) (9.72 g) followed by S3A3 (Transplanting of 28-day-old seedlings with 30 cm × 30 cm crop geometry) (7.64 g). Lower weight of ear heads recorded in S1A1 (Transplanting of 14-day-old seedlings with 20 cm × 20 cm crop geometry (2.79 g) (Table 1). Number of fingers per ear: Among the transplanting of different aged seedlings, A3 (28 days old) recorded the highest number of fingers per ear (4.79). Among different crop geometries adopted in transplanting, S4 (35 cm × 35 cm) recorded the higher mean number of fingers per ear (5.58). More number of fingers per ear heads recorded in S4A3 (Transplanting of 28 days old seedlings with 35 cm × 35 cm crop geometry) (5.58) followed by S5A3 (Transplanting of 28 days old seedlings with 30 cm × 10 cm crop geometry) (5.00 g). Lower weight of ear heads recorded in S1A1 (Transplanting of 14-day-old seedlings with 20 cm × 20 cm crop geometry (4.10) (Table 1). Length of finger (cm): Among the transplanting of different aged seedlings, A3 (28 days old) recorded the highest mean length of finger (4.73 cm). Among different crop geometries adopted in transplanting, S4 (35 cm × 35 cm) recorded the higher mean length of finger of 5.34 cm. Maximum length of fingers recorded in S4A3 (Transplanting of 28 days old seedlings with 35 cm × 35 cm crop geometry) (5.34 cm) followed by S3A3 (Transplanting of 28 days old seedlings with 30 cm × 30 cm crop geometry) (4.79 cm). Minimum length of fingers in ear heads recorded in S1A2 (Transplanting of 41-day-old seedlings with 20 cm × 20 cm crop geometry (3.89 cm) (Table 2).

Test weight: There is not much difference in the test weight of grains of different treatment combinations (Table 2). Garin yield (kg ha-1): Among the transplanting of different aged seedlings, A3 (28 days old) recorded the highest mean yield of 3017.40 kg/ha. Among different crop geometries adopted in transplanting, S4 (35 cm × 35 cm) recorded the higher mean yield of 2718 kg/ha. Higher grain yield was recorded in S4A3 (Transplanting of 28-day-old seedlings with 35 cm × 35 cm crop geometry) (3541 kg ha-1) followed by S3A3 (Transplanting of 28-day-old seedlings with 30 cm × 30 cm crop geometry) (3003.00 kg ha-1). Lower grain yield was recorded in S2A1 (Transplanting of 21-day-old seedlings with 25 cm × 25 cm crop geometry (1589 kg ha-1) (Table 3). Straw yield (kg ha-1): Among the transplanting of different aged seedlings, A3 (28 days old) recorded the highest mean straw yield of 4801.20 kg/ha.

Among different crop geometries adopted in transplanting, S3 (30 cm × 30 cm) recorded the highest mean straw yield of 4363.67 kg/ha. Higher straw yield was recorded in S2A3 (Transplanting of 28-day-old seedlings with 25 cm × 25 cm crop geometry) (4971 kg ha-1), followed by S1A3 (Transplanting of 28-day-old seedlings with 20 cm × 20 cm crop geometry) (4971.00 kg ha-1). Lower straw yield was recorded in S1A1 (Transplanting of 14-day-old seedlings with 20 cm × 20 cm crop geometry (3230 kg ha-1) (Table 3). Harvest index: Among the transplanting of different aged seedlings, A3 (28 days old) recorded the highest mean HI of 0.39. Among different crop geometries adopted in transplanting, S4 (35 cm × 35 cm) recorded the higher mean HI of 0.39.The highest harvesting index was recorded in S4A3 (Transplanting of 28-day-old seedlings with 35 cm × 35 cm crop geometry) (0.42) followed by S5A3 (Transplanting of 28-day-old seedlings with 30 cm × 10 cm crop geometry) (0.40). Under an optimum spaced environment (45 cm × 45 cm), the number of productive tillers per unit area and weight of ear heads were higher on a per unit basis eventually which results in the production of higher grain yield at the end. These results are also in consonance with the findings of Uphoff (2002) in the SRI method of rice cultivation. Harvest index was also higher in the guni method and 45 × 45 cm spacing. Roy et al. (2002); Zhu et al. (2002) also reported that “planting of finger millet under wider spacing than closer spacing improved canopy photosynthesis, increased the percentage of productive tillers and ear head formation”. “In agreement higher number of fertile tillers were also found in closer spacing of rice” (Haque et al. 2025). Adhikari (2016) reported from Odisha that “improved varieties of finger millet produced 4.8 tonnes/ha under SCI/SFI management, while local varieties gave 4.2 tonnes/ha with these methods. The highest yield recorded was 6 tonnes/ha. On fertile soils, finger millet yields with SCI methods have been found to average 4.5–4.7 tonnes/ha, a four-fold increase over farmers’ usual yields”. In Nepal, also, SCI grain yield was 82% higher than with direct-seeding, and 25 % more than transplanting (Bhatta et al., 2017). Natarajan et al. (2019) from Tamil Nadu reported that “30 cm × 30 cm and 25 × 25 cm (wider spacing) were found to give better yields of finger millet in SCI compared to closer spacing, i.e., 20 cm × 20 cm”.

**To work out the nutrient uptake of the effect of different ages of seedlings and plant geometry**

Higher nitrogen (109.20 kg ha-1), phosphorus (25.10 kg ha-1) and potassium (78.10 kg ha-1) uptake was evident from S4A3 (transplanting of 28-day-old seedlings with 35 cm × 35 cm crop geometry). On the other hand, the significantly lowest nitrogen uptake of 60.00 kg ha-1, phosphorus uptake of 11 kg ha-1 and potassium uptake of 40.10 kg ha-1 was recorded with the treatment combination of S1A1 (direct line sowing with 20 cm × 20 cm). There is not much difference in the pH, EC (d Sm-1), and Organic carbon (%) of different treatment combinations. The interaction effect between establishment method and crop geometry was not significant with respect to the weight of ear head (g), number of fingers per ear head, and the test weight of finger millet. Ahiwale et al. (2011) also found that “the finger millet crop established by transplanting at 20 cm × 15 cm spacing (Thomba method) produced higher ear weight and grain weight per ear”. Further, the present results are in consonance with those of Navale (2013).

**To work out the economics of the effect of different ages of seedlings and plant geometry**

Significantly higher gross returns (₹ 1,15,436.60 ha-1), net returns (₹ 71,701.60 ha-1) and B-C ratio (2.64) was recorded with S4A3 (transplanting of 28 days old seedlings with 35 cm × 35 cm crop geometry) followed by S3A3 (transplanting of 25 days old seedlings 30 cm × 30 cm crop geometry) treatment combination (Table 4). On the other hand, the significantly lowest monetary returns were recorded with the S1A1 combination (direct line sowing with 20 cm × 20 cm).

**Table 1: Yield attributes of finger millet as influenced by methods of establishment and crop geometry.**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Number of ear heads m-2** | | | | | **Weight of ear head (g)** | | | | **Number of fingers ear**  **head-1** | | | | |
| **Establishment method (A)** | | | | | | | | | | | | | |
| **Crop geometry (S)** | **A1:14 DAT** | **A2:21 DAT** | **A3:28 DAT** | **Mean** | **A1:14 DAT** | | **A2:21 DAT** | **A3:28 DAT** | **Mean** | | **A1:14 DAT** | **A2:21 DAT** | **A3:28 DAT** | **Mean** |
| **S1 (**20 × 20 cm) | 50.00 | 60.18 | 70.11 | **60.10** | 2.79 | | 3.18 | 2.89 | **2.95** | | 4.10 | 4.60 | 3.61 | **4.10** |
| **S2 (**25 × 25 cm) | 51.00 | 62.90 | 78.12 | **64.01** | 6.81 | | 5.58 | 6.10 | **6.16** | | 4.10 | 4.22 | 4.32 | **4.21** |
| **S3 (**30 × 30 cm) | 56.18 | 79.00 | 79.27 | **71.48** | 7.18 | | 7.62 | 8.00 | **7.60** | | 4.20 | 4.60 | 4.71 | **4.50** |
| **S4 (**35 × 35 cm) | 30.10 | 42.17 | 62.11 | **44.79** | 9.30 | | 10.15 | 9.72 | **9.72** | | 5.23 | 5.40 | 6.12 | **5.58** |
| **S5 (**30 × 10 cm) | 98.20 | 116.50 | 131.00 | **115.23** | 7.10 | | 7.70 | 8.12 | **7.64** | | 4.80 | 5.00 | 5.21 | **5.00** |
| **Mean** | **57.10** | **72.15** | **84.12** |  | **6.64** | | **6.85** | **6.97** |  | | **4.49** | **4.76** | **4.79** |  |
| **For comparison the mean of** | **SEm±** | | **CD(P=0.05)** | | **SEm±** | | | **CD(P=0.05)** | | | **SEm±** | | **CD(P=0.05)** | |
| Establishment method (A) | 0.19 | | 0.74 | | 0.00 | | | 0.02 | | | 0.00 | | 0.02 | |
| Crop geometry (S) | 1.08 | | 3.14 | | 0.12 | | | 0.35 | | | 0.08 | | 0.22 | |
| Sub plot (S) at same level of main plot (A) | 1.86 | | 5.44 | | 0.21 | | | 0.60 | | | 0.13 | | 0.38 | |
| Main plot (A) at same level of sub plot (S) | 0.42 | | 1.23 | | 0.14 | | | 0.40 | | | 0.11 | | 0.31 | |

**Table 2: Grain yield (kg ha-1), Straw yield (kg ha-1) and Harvest Index of finger millet as influenced by methods of establishment and crop geometry**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Grain yield (kg ha-1)** | | | | **Straw yield (kg ha-1)** | | | | | **Harvest Index** | | | | |
| **Establishment method (A)** | | | | | | | | | | | | | |
| **Crop geometry (S)** | **A1** | **A2** | **A3** | **Mean** | | **A1** | **A2** | **A3** | **Mean** | | **A1** | **A2** | **A3** | **Mean** |
| **S1** | 1957.00 | 2201.00 | 2548.00 | **2235.33** | | 3230.00 | 4255.00 | 4951.00 | **4145.33** | | 0.38 | 0.34 | 0.34 | 0.35 |
| **S2** | 1589.00 | 2400.00 | 2995.00 | **2328.00** | | 3241.00 | 4260.00 | 4971.00 | **4157.33** | | 0.33 | 0.36 | 0.38 | 0.36 |
| **S3** | 2018.00 | 2572.00 | 3003.00 | **2531.00** | | 4041.00 | 4373.00 | 4677.00 | **4363.67** | | 0.33 | 0.37 | 0.39 | 0.36 |
| **S4** | 1998.00 | 2617.00 | 3541.00 | **2718.67** | | 3330.00 | 4400.00 | 4938.00 | **4222.67** | | 0.38 | 0.37 | 0.42 | 0.39 |
| **S5** | 1600.00 | 2442.00 | 3000.00 | **2347.33** | | 3931.00 | 4125.00 | 4469.00 | **4175.00** | | 0.29 | 0.37 | 0.40 | 0.35 |
| **Mean** | **1832.40** | **2446.40** | **3017.40** |  | | **3554.60** | **4282.60** | **4801.20** |  | | 0.34 | 0.36 | 0.39 |  |
| **For comparison the mean of** | **SEm±** | | **CD(P=0.05)** | | | **SEm±** | | **CD(P=0.05)** | | | **SEm±** | | **CD(P=0.05)** | |
| Establishment method (A) | 6.56 | | 25.75 | | | 6.67 | | 26.19 | | | 0.00 | | 0.00 | |
| Crop geometry (S) | 39.57 | | 115.51 | | | 67.16 | | 196.01 | | | 0.01 | | 0.02 | |
| Sub plot (S) at same level of main plot (A) | 68.54 | | 200.07 | | | 116.32 | | 339.50 | | | 0.01 | | 0.03 | |
| Main plot (A) at same level of sub plot (S) | 2.62 | | 7.64 | | | 3.20 | | 9.35 | | | 0.03 | | 0.09 | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Nitrogen uptake (kg ha-1)** | | | | **Phosphorus uptake (kg ha-1)** | | | | **Potassium uptake (kg ha-1)** | | | |
| **Establishment method (A)** | | | | | | | | | | | |
| **Crop geometry (S)** | **A1** | **A2** | **A3** | **Mean** | **A1** | **A2** | **A3** | **Mean** | **A1** | **A2** | **A3** | **Mean** |
| **S1** | 60.00 | 84.10 | 94.00 | **79.37** | 11.00 | 11.10 | 10.90 | **11.00** | 40.10 | 55.20 | 58.30 | **51.20** |
| **S2** | 61.40 | 85.00 | 105.00 | **83.80** | 12.00 | 17.10 | 23.50 | **17.53** | 44.20 | 60.10 | 73.30 | **59.20** |
| **S3** | 75.20 | 88.20 | 100.10 | **87.83** | 13.10 | 16.20 | 19.80 | **16.37** | 54.00 | 61.90 | 69.80 | **61.90** |
| **S4** | 66.70 | 89.90 | 109.20 | **88.60** | 12.10 | 18.30 | 25.10 | **18.50** | 47.30 | 63.60 | 78.10 | **63.00** |
| **S5** | 69.50 | 77.60 | 95.30 | **80.80** | 12.80 | 14.10 | 17.20 | **14.70** | 50.10 | 56.20 | 60.10 | **55.47** |
| **Mean** | **66.56** | **84.96** | **100.72** |  | **12.20** | **15.36** | **19.30** |  | **47.14** | **59.40** | **67.92** |  |
| **For comparison the mean of** | **SEm±** | | **CD (P=0.05)** | | **SEm±** | | **CD (P=0.05)** | | **SEm±** | | **CD (P=0.05)** | |
| Establishment method (A) | 0.22 | | 0.85 | | 0.08 | | 0.30 | | 0.15 | | 0.58 | |
| Crop geometry (S) | 1.35 | | 3.95 | | 0.26 | | 0.75 | | 0.94 | | 2.73 | |
| Sub plot (S) at same level of main plot (A) | 2.34 | | 6.84 | | 0.45 | | 1.30 | | 1.62 | | 4.74 | |
| Main plot (A) at same level of sub plot (S) | 0.48 | | 1.40 | | 0.25 | | 0.72 | | 0.40 | | 1.16 | |

**Table 3: Nutrient uptake (kg ha-1) of finger millet as influenced by method of establishment and crop geometry at harvest**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Gross returns (**₹**ha-1)** | | | | **Net returns (**₹ **ha-1)** | | | | **B:C ratio** | | | | |
| **Establishment method (A)** | | | | | | | | | | | | |
| **Crop geometry (S)** | **A1** | **A2** | **A3** | **Mean** | **A1** | **A2** | **A3** | **Mean** | **A1** | **A2** | **A3** | **Mean** |
| S1 | 63798.20 | 71752.6 | 83064.0 | **72871.87** | 28913.20 | 35016.60 | 39329.80 | **34419.87** | 1.83 | 1.95 | 1.90 | **1.89** |
| S2 | 51801.40 | 78240.0 | 97637.0 | **75892.80** | 16916.40 | 41504.00 | 53902.00 | **37440.80** | 1.48 | 2.13 | 2.23 | **1.95** |
| S3 | 65786.80 | 83847.2 | 97897.8 | **82510.60** | 30901.80 | 47111.20 | 54162.80 | **44058.60** | 1.89 | 2.28 | 2.24 | **2.14** |
| S4 | 65134.80 | 85314.2 | 115436.6 | **88628.53** | 30249.80 | 48578.20 | 71701.60 | **50176.53** | 1.87 | 2.32 | 2.64 | **2.28** |
| S5 | 52160.00 | 79609.2 | 97800.0 | **76523.07** | 17275.00 | 42873.20 | 54065.00 | **38071.07** | 1.50 | 2.17 | 2.24 | **1.97** |
| **Mean** | **59736.24** | **79752.6** | **98367.4** |  | 24851.24 | 43016.64 | 54632.24 |  | 1.71 | 2.17 | 2.25 |  |
| **For comparison the mean of** | SEm± | | CD (P=0.05) | | SEm± | | CD (P=0.05) | | SEm± | | CD (P=0.05) | | |
| Establishment method (A) | 306.70 | | 1204.26 | | 257.06 | | 1009.34 | | 0.01 | | 0.02 | | |
| Crop geometry (S) | 1275.97 | | 3724.29 | | 676.70 | | 1975.16 | | 0.03 | | 0.09 | | |
| Sub plot (S) at same level  of main plot (A) | 2210.04 | | 6450.66 | | 1172.09 | | 3421.07 | | 0.06 | | 0.16 | | |
| Main plot (A) at same level of sub plot (S) | 16.00 | | 46.70 | | 14.07 | | 41.07 | | 0.07 | | 0.22 | | |

**Table 4: Economics of finger millet as influenced by methods of establishment and crop geometry**

# CONCLUSION

From the present study, it can be concluded that transplanting of rainfed finger millet in system of ragi intensification (‘*guni’* method) at 35 cm × 35 cm spacing along with 28 days age old seedlings to led to enhanced yield, nutrient uptake and improved economics.

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

# REFERENCES

Adhikari, P., Araya, H., Aruna, G., Balamatti, A., Banerjee, S., Baskaran, P., and Verma, A. (2018). System of crop intensification for more productive, resource- conserving, climate-resilient, and sustainable agriculture: Experience with diverse crops in varying agroecologies. International journal of agricultural sustainability, 16(1): 1-28.

Ahiwale, P. H., Chavan, L. S. and Jagtap, D. N. (2011). Effect of establishment methods and nutrient management on yield attributes and yield of finger millet (Eleusine coracana G.). Advanced Research Journal of Crop Improvement, 2(2): 247-250.

Bhatta, L. R., Subedi, R., Joshi, P., and Gurung, S. B. (2017). Effect of Crop Establishment Methods and Varieties on Tillering Habit, Growth Rate and Yield of Finger- Millet. Agricultural Research and Technology: Open Access Journal, 47(3): 367-371.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research. John Willey and Sons Publishers, New York. Pp: 97-107.

Haque MA, Bhuyan MI, Jahiruddin M (2025) Impacts of plant spacing and nitrogen on wet season rice yield in the non-saline coast of Bangladesh. International Journal of Plant Production. https://doi.org/10.1007/s42106-025-00345-3

Natarajan, S., Ganapathy, M., Arivazhagan, K. and Srinivasu,V. (2019). Effect of spacing and nutrient sources on system of finger millet (Eleusine coracana) intensification. Indian Journal of Agronomy, 64(1): 98-102.

Navale, H. (2013). Influence of spacing and method of planting on seed yield and quality of foxtail millet (Setaria italica) varieties. M.Sc. thesis, University of Agricultural Sciences, Dharwad, Karnataka.

Roy, N. R., Chakraborty, T., Sounda, G. and Maitra, S. (2002). Growth and yield attributes of finger millet as influenced by plant population and different levels of nitrogen and phosphorus. Indian Agriculturist, 46(1&2): 65-71.

Uphoff, N. (2002). Opportunities for raising yields by changing management practices: the system of rice intensification in Madagascar. Agro-ecological innovations: increasing food production with participatory development. 145-61.

Maharajan, T., Ceasar, S. A., & Ajeesh Krishna, T. P. (2022). Finger millet (Eleusine coracana (L.) Gaertn): Nutritional importance and nutrient transporters. *Critical Reviews in Plant Sciences*, *41*(1), 1-31.

Patil, P., Singh, S. P., & Patel, P. (2023). Functional properties and health benefits of finger millet (Eleusine coracana L.): A review. *The Journal of Phytopharmacology*, *12*(3), 196-202.

Balachandrakumar, V., and S. Devi. 2024. “Enhancing Ragi Yield: The Effect of Organic Seed Priming”. *International Journal of Plant & Soil Science* 36 (7):901-7.

Pandey, M., Awasthi, H. R., Subedi, R., & Joshi, K. (2023). Crop intensification practices for better finger millet growth. *Reviews in Food and Agriculture*, *4*(2), 71-77.

Bado, B. V., Bationo, A., Whitbread, A., Tabo, R., & Manzo, M. L. S. (2022). Improving the productivity of millet based cropping systems in the West African Sahel: Experiences from a long-term experiment in Niger. *Agriculture, Ecosystems & Environment*, *335*, 107992.

Padesur S., Bhimireddy P., Hussain S. A., & K. P. C. R. (2022). ‘Guni’ Method (System of Ragi Intensification) for Enhanced Yield, Nutrient Uptake and Economics in Finger Millet. Biological Forum – An International Journal, 14(2): 320-326