**CURRENT FARM SCIENCE**
Volume 1 Issue 1 (July-Dec 2026) | e-ISSN: Applied | Page No: 25-35

# Effect of Crop Spacing and Nutrient Levels for Growth, Yield and Nutrient uptake of Transplanted Finger Millet (*Eleusine coracana* L.)

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**Article ID: CFS 002**

## Abstract

*The national average yield of finger millet remains far below its genetic potential, pointing to significant agronomic gaps that need to be addressed under irrigated conditions. The field experiment was carried out during rabi season (2025 – 2026) at SRMCAS, Tamil Nadu, India with main plot crop geometry as., 30 cm x 10 cm ($M_1$), 20 cm x 10 cm ($M_2$) and 10 cm x10 cm ($M_3$) with sub plot consisted nutrient level viz., 100% RDF @ basal ($S_1$), 50% RDF @ basal + 50% RDF at active tillering ($S_2$), 50% @ basal + 25% at active tillering + 25% at flowering ($S_3$), Control ($S_4$). Growth parameters (Plant Height, Dry Matter Production), physiological parameters (LAI, chlorophyll content - SPAD value) and yield attributes and yield were recorded at 20,40,60DAT and at harvest stage. The transplanted finger millet at 30 cm x 10 cm along with 50% RDF @ basal + 25% at active tillering + 25% at flowering was recorded significantly superior value across all growth, physiological and yield parameters. The plant height was recorded 78.0 cm at harvest, at 40 DAT leaf area index (3.7), at 60 DAT, total chlorophyll content (56.2) at 60 DAT. The treatment has produced higher yield of grain yield (1415kg/ha) and straw yield (2714kg/ha).*

**Keywords:** Finger millet; crop geometry; nutrient levels; split doses; yield

## INTRODUCTION

Finger millet (*Eleusine coracana*) is one the ancient nutri cereal millet under family *Poaceae*, domesticated in the highlands of East Africa and now cultivated widely across the arid and semi-arid tropics in Africa and Asia. At global level, finger millet production currently stands at 30.73 million tonnes, with India contributing approximately 37% of the total share, firmly establishing its position as the world's leading producers (Raturi et al 20260). In India, it

holds particular importance as a staple food crop, commonly known as ragi and grown across the states of AP, TN, Karnataka, Odisha and Uttarakhand. The crop is cultivated over an area of 1162 thousand hectares with a total production of 1692 thousand tons, and an average productivity of 1456 kg per hectare (India Stat.,2025). The grain is a rich source of calcium, iron, phosphorus, magnesium and dietary fiber, making it particularly significant for food and nutrition security among smallholder farming groups (Jayawardana et al., 2021).

Crop spacings are the fundamental agronomical management that determines the community utilizes the available resources of moisture, light and soil nutrients. The nutrient level is second critical in finger millet. The crop has a well-defined pattern of nutrient demand during various growth stages, and a single basal application of fertilizers, though convenient, is unable to match its demand pattern effectively (Kumar et al., 2022). Major nutrients (N, P & K) is the primary source of vegetative growth, promoting cell division, internodal elongation, leaf area development, and chlorophyll synthesis, supports energy transfer through ATP, accelerates root proliferation and seedling establishment after transplanting and plays an essential role in reproductive development, including pollen viability and grain filling, stomatal regulation, enzyme activation, phloem loading, and translocation of photosynthates from source leaves to developing ear heads (Reddy and Singh, 2021). Integrating organic and inorganic nutrient sources in a phased supply schedule significantly improved biomass, productive tillers per meter square, grain yield, and nitrogen use efficiency compared to single-dose chemical fertilizer application in finger millet (Padmaja et al., 2024).

The interaction between crop geometry and the timing of NPK application in transplanted finger millet has not been comprehensively evaluated, particularly under irrigated conditions, where the crop is increasingly finding a place as an alternative. Keeping this background, the present study was designed to evaluate the most productive combination of crop spacing with different nutrient levels in transplanted finger millet that improves growth, physiological parameters and yield attributes and yield ( Pandey et al., 2021).

## MATERIALS AND METHODS

A field experiment was laid out in split-plot design with 3 replication seasons of late *rabi* (2025-26) at SRM CAS, Tamil Nadu, India (12.38$^{o}$N lat. 79.73$^{o}$E long.). The experiment soil is clay loamy texture. 30 cm x 10 cm ($M_1$), 20 cm x 10 cm ($M_2$) and 10 cm x10 cm ($M_3$) with sub plot consisted nutrient level *viz.,* 100% RDF @ basal ($S_1$), 50% RDF @ basal + 50% RDF at

active tillering ($S_2$), 50% @ basal + 25% at active tillering + 25% at flowering ($S_3$), Control ($S_4$). Recommended Dose of Fertilizer (NPK- 60:30:30 kg/ha) with a variety (ATL-1) was used at seed rate of 4 kg/ha. As per the treatment seedlings were transplanted in an experimental field manually using two seedlings/hill at different row spacing. Biometric observations were recorded at 20, 40, 60 DAT and harvest stage. The experiment data were collected and subjected to statistical analysis following the methods of (Gomez and Gomez,1984).

## RESULTS AND DISCUSSION

The study of the effect of crop spacing, different nutrient levels with their interaction on biometric observations, yield attributes and yield in finger millet was a statistically significant difference and it is presented below.

### *Growth Parameters*

The plant height and dry matter production (DMP) were recorded in transplanted finger millet at 20, 40, 60 DAT and at harvest stage were significantly influenced (Tables 1 & 2). The spacing at 30 cm x 10 cm with 50% RDF @ basal + 25% at active tillering + 25% at flowering stage was recorded the taller plant height of 44.5, 67.7, 76.1 and 78.0 cm respectively and the higher dry matter production (DMP) of 1106.7, 3800, 8300 and 11683 kg/ha at 20, 40, 60 DAT and at harvest stage it might be less interplant competition for moisture, light and soil nutrients. The different time of application nutrients ensured timely nutrient availability (early vegetative growth and tillering stage). A similar finding was reported ( Aliveni et al 2025).

### *Physiological parameters*

The treatment ($M_1S_3$) 30 cm x 10 cm with 50% RDF @ basal + 25% at active tillering + 25% at flowering stage was recorded more leaf area index (1.4, 2.9, 3.7 and 2.8) and chlorophyll content with a SPAD value of 31.9, 53.0, 56.2, and 32.2 were recorded at 20, 40, 60 DAT, and at harvest stage (Table 3 & 4). It might be better light penetration where it supports leaf area expansion. This corroborates with the findings (Sai Aparna and Karthikeyan, 2023).

### *Yield attributes and Yield*

The yield attributes and yield namely, no. of fingers/ear head, grain & straw yield and harvest index were significantly influenced in transplanted finger millet (Table 5). The treatment $M_1S_3$ (30 cm x 10 cm with 50% RDF @ basal + 25% at active tillering stage + 25% at flowering stage) recorded the higher no. of fingers per ear head (6.3), grain yield (1415kg/ha) and straw yield (4330kg/ha). The higher grain yield under $M_1S_3$ (30 cm x 10 cm with 50% RDF @ basal +

25% at active tillering + 25% at flowering) was mainly due to better yield attributes viz., more productive tillers/plant, higher ear head number and weight, more finger count and better grain filling which together increased grain productivity per unit area. The 30 cm x 10 cm spacing achieved an effective balance between individual plant productivity and unit area plant population, ensuring that the advantage of wider spacing at the plant level translated into higher field-level yield rather than being offset by reduced plant density. The higher straw yield observed under $M_1S_3$ (30 cm x 10 cm with 50% RDF @ basal + 25% at active tillering + 25% at flowering stage) reflected vigorous vegetative growth sustained through all three NPK application stages taller plants, more leaf area index and higher dry matter production accumulation which lead to contribute to more biomass during harvest. The harvest index under $M_1S_3$ (30 cm x10 cm spacing with 50% RDF @ basal + 25% at active tillering + 25% at flowering stage) indicated that plants not only produced higher biomass but also converted more of it into grain yield. This may be due to the balanced NPK supply at different growth stages, especially at flowering, which improved grain filling and reduced excess vegetative growth. The phosphorus and potassium applied during the flowering stage helped to direct more photosynthates towards grain development, improving the harvest index. Similar findings reported by (Yadava et al., 2025).

**Nutrient uptake**

Nutrient uptake in crops viz., nitrogen, phosphorus and potassium uptake were significantly influenced with crop spacing, nutrient levels with their interaction at different stages (Table 6). Among crop spacing treatments, $M_1$ recorded higher nutrient uptake, while $M_3$ recorded the lowest. Among nutrient management practices, $S_3$ recorded the higher uptake of N, P, K, indicating improved nutrient levels acquisition under split application. The interaction effect was significant, with $M_1S_3$ consistently recording higher nutrient uptake. Nitrogen uptake under $M_1S_3$ was 33.9 and 67.5 kg/ha at 20 and 40 DAT, while phosphorus uptake was 17.6 and 29.3 kg/ha. Potassium uptake under $M_1S_3$ reached 44.2 and 80.0 kg/ha at 20 and 40 DAT. The higher nutrient uptake under $M_1S_3$ may be associated with better root and shoot growth, greater dry matter accumulation and improved nutrient availability through split fertilizer application. The synchronisation of nutrient supply with crop demand during active tillering and flowering likely enhanced nutrient acquisition and utilisation by the crop (Chavan et al., 2019; Kumar et al., 2025).

## CONCLUSION

The results from the field experiment clearly mention that plant spacing and different levels of nutrients on finger millet are determinants of the growth and productivity. Transplanting of finger millet at 30 cm x 10 cm decreases interplant competition for moisture, solar light, crop spacing and nutrients and enhances vegetative growth, higher tillers and ear head compared to closer spacing. Based on these findings, transplanting finger millet at 30 cm x 10 cm and applying NPK as 50% RDF @ basal + 25% at active tillering + 25% at flowering stage is recommended as an agronomic package for achieving higher productivity under irrigated conditions.

**Declarations and statements**

**Acknowledgements**

The present study was supported by the Department of Agronomy, SRMCAS, SRMIST, Baburayanpettai, Tamil Nadu, India for providing access to research field and laboratory facilities, as well as for their financial support in cultivating the crop successfully. I am also thankful to the chairperson and advisory committee for their invaluable guidance and support throughout this research work.

**Disclaimers**

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**Conflict of interest**

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

**Funding statement**

This research received no external funding

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**Table 1. Effect of crop geometry and nutrient management practices on plant height (cm) in finger millet**

| Treatment | 20 DAT | 40 DAT | 60 DAT | At Harvest |
|---|---|---|---|---|

| | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | 44.2 | 44.1 | 43.4 | 43.9 | 64.7 | 65.9 | 61.0 | 63.9 | 72.0 | 73.0 | 71.7 | 72.2 | 75.5 | 74.0 | 73.3 | 74.3 |
| $S_2$ | 44.6 | 44.3 | 43.9 | 44.3 | 68.3 | 67.4 | 61.0 | 65.6 | 76.3 | 75.0 | 72.0 | 74.4 | 78.0 | 76.5 | 72.5 | 75.7 |
| $S_3$ | 45.2 | 44.4 | 44.0 | 44.5 | 71.7 | 68.2 | 63.3 | 67.7 | 81.0 | 77.0 | 70.3 | 76.1 | 83.0 | 78.0 | 73.0 | 78.0 |
| $S_4$ | 43.50 | 42.60 | 41.5 | 42.5 | 59.7 | 59.3 | 56.0 | 58.3 | 70.0 | 70.0 | 61.0 | 67.0 | 72.7 | 72.7 | 62.5 | 69.3 |
| Mean | 44.4 | 43.9 | 43.2 | | 66.1 | 65.2 | 60.3 | | 74.8 | 73.8 | 68.8 | | 77.3 | 75.3 | 70.3 | |
| | M | S | M X S | S X M | M | S | M X S | S X M | M | S | M X S | S X M | M | S | M X S | S X M |
| SEd | 1.2 | 2.2 | 3.1 | 3.1 | 0.4 | 0.7 | 0.9 | 0.9 | 0.8 | 0.9 | 1.3 | 1.3 | 0.8 | 1.2 | 1.7 | 1.7 |
| CD (p=0.05) | NS | NS | NS | NS | 1.2 | 1.5 | 1.8 | 1.8 | 2.4 | 2.2 | 2.6 | 2.6 | 2.2 | 2.9 | 3.4 | 3.4 |

DAT- Days After Transplanting; *Significant at P ≤ 0.05; NS- Non-Significant P ≤ 0.05

**Table 2. Effect of crop geometry and nutrient management practices on dry matter production (kg/ha) in finger millet**

| reatmen | ) DAT | | | | ) DAT | | | | ) DAT | | | | t Harvest | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | ean | 1 | 2 | 3 | ean | 1 | 2 | 3 | ean | 1 | 2 | 3 | ean |
| | 080 | 090 | 075 | 081. | 400 | 300 | 00 | 267 | 000 | 300 | 500 | 300 | 500 | 350 | 100 | 317 |
| | 00 | 10 | 085 | 098. | 700 | 550 | 200 | 483 | 300 | 00 | 700 | 033 | 800 | 600 | 200 | 533 |
| | 20 | 05 | 095 | 06. | 50 | 300 | 450 | 300 | 550 | 350 | 000 | 300 | 2000 | 750 | 300 | 683 |

| | )50 | )40 | )20 | )36. | )00 | 350 | 300 | 350 | 550 | 500 | 350 | 467 | 100 | 050 | )950 | 033 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ean | )87 | )86 | )69 | | 538 | 375 | 38 | | 25 | )38 | 538 | | 600 | 438 | 138 | |
| | | | X | X M | | | X | X | | | X | X | | | X | X |
| Ed | 7.0 | 5.6 | ).4 | ).4 | 5 | 5 | 20 | 20 | 0 | )5 | 40 | 40 | 20 | 0 | 50 | 50 |
| D =0.05) | S | S | S | S | 30 | 50 | 00 | 00 | 20 | 00 | 50 | 50 | 50 | 20 | 30 | 30 |

DAT- Days After Transplanting; *Significant at P ≤ 0.05; NS- Non-Significant P ≤ 0.05

**Table 3. Effect of crop geometry and nutrient management practices on leaf area index in finger millet**

| | 20 DAT | | | | 40 DAT | | | | 60 DAT | | | | At Harvest | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean |
| $S_1$ | 1.3 | 1.3 | 1.3 | 1.3 | 2.6 | 2.5 | 2.2 | 2.4 | 3.2 | 3.2 | 2.7 | 3.0 | 2.7 | 2.7 | 2.7 | 2.7 |
| $S_2$ | 1.4 | 1.4 | 1.3 | 1.3 | 3.0 | 2.8 | 2.2 | 2.6 | 3.9 | 3.6 | 2.8 | 3.4 | 2.8 | 2.7 | 2.7 | 2.7 |
| $S_3$ | 1.4 | 1.4 | 1.3 | 1.4 | 3.4 | 2.9 | 2.4 | 2.9 | 4.3 | 3.8 | 3.0 | 3.7 | 2.8 | 2.8 | 2.7 | 2.8 |
| $S_4$ | 1.3 | 1.3 | 1.25 | 1.3 | 1.9 | 1.9 | 1.6 | 1.8 | 2.45 | 2.4 | 2.0 | 2.3 | 2.7 | 2.8 | 2.7 | 2.7 |
| Mean | 1.3 | 1.3 | 1.3 | | 2.7 | 2.5 | 2.1 | | 3.5 | 3.2 | 2.6 | | 2.7 | 2.7 | 2.7 | |
| | M | S | M X S | S X M | M | S | M X S | S X M | M | S | M X S | S X M | M | S | M X S | S X M |
| Sed | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| CD (p=0.05) | NS | NS | NS | NS | 0.2 | 0.2 | 0.3 | 0.3 | 0.2 | 0.3 | 0.3 | 0.3 | NS | NS | NS | NS |

DAT- Days After Transplanting; *Significant at P ≤ 0.05; NS- Non-Significant P ≤ 0.05

**Table 4. Effect of crop geometry and nutrient management practices on chlorophyll content (SPAD value) in finger millet**

| reatmen | ) DAT | | | | ) DAT | | | | ) DAT | | | | t Harvest | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | ean | 1 | 2 | 3 | ean | 1 | 2 | 3 | ean | 1 | 2 | 3 | ean |
| | .5 | .2 | 0.9 | .2 | 3.5 | 3.5 | 2.5 | 5.5 | .8 | .8 | 6.7 | 0.1 | .8 | .8 | .3 | .6 |
| | 2.0 | .8 | .1 | .6 | 5.3 | 2.0 | 2.5 | 9.9 | 7.3 | 4.6 | 7.0 | 3.0 | 2.2 | 2.0 | .3 | .8 |
| | 2.4 | 2.1 | .3 | .9 | 0.1 | 5.8 | 4.0 | 3.0 | 2.7 | 7.7 | 3.4 | 5.2 | 2.9 | 2.2 | .5 | 2.2 |
| | 0.0 | 0.99 | 7.84 | 9.3 | 0.5 | 0.5 | 5.0 | 3.0 | 3.38 | 3.0 | 5.33 | 0.9 | 0.9 | 0.9 | 0.5 | 0.8 |
| ean | .5 | .3 | 0.3 | | 0.6 | 0.0 | .0 | | 3.8 | .8 | 4.6 | | 2.0 | .7 | .2 | |
| | | | | X S | X M | | | X S | X M | | | X S | X | | | X S | X M |
| Ed | 4 | 2 | | 7 | 7 | 5 | 4 | 9 | 9 | 7 | 5 | 7 | 7 | 4 | 2 | 7 | 7 |
| D =0.05) | S | S | | S | S | 4 | 2 | 7 | 7 | 2 | 2 | 4 | 4 | S | S | S | S |

DAT- Days After Transplanting; *Significant at P ≤ 0.05; NS- Non-Significant P ≤ 0.05

**Table 5. Effect of crop geometry and nutrient management practices on yield attributes and yield in finger millet**

| Treatment | Number of finger/head | | | | Grain yield (kg/ha) | | | | Straw yield (kg/ha) | | | | Harvest index | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean |
| $S_1$ | 5.3 | 5.4 | 4.9 | 5.2 | 1285 | 1260 | 1090 | 1212 | 4050 | 3980 | 3520 | 3850 | 0.24 | 0.24 | 0.24 | 0.24 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_2$ | 6.2 | 6.0 | 4.8 | 5.7 | 1490 | 1385 | 1110 | 1328 | 4480 | 4283 | 3600 | 4121 | 0.25 | 0.24 | 0.24 | 0.24 |
| $S_3$ | 7.5 | 6.3 | 5.1 | 6.3 | 1600 | 1460 | 1185 | 1415 | 4750 | 4420 | 3820 | 4330 | 0.25 | 0.25 | 0.25 | 0.25 |
| $S_4$ | 4.04 | 3.9 | 3.4 | 3.8 | 1015 | 995 | 945 | 985 | 3180 | 3120 | 3010 | 3100 | 0.24 | 0.24 | 0.24 | 0.24 |
| Mean | 5.8 | 5.4 | 4.5 | | 1348 | 1275 | 1082 | | 4115 | 3951 | 3485 | | 0.25 | 0.24 | 0.24 | |
| | M | S | M X S | S X M | M | S | M X S | S X M | M | S | M X S | S X M | M | S | M X S | S X M |
| SEd | 0.2 | 0.2 | 0.3 | 0.3 | 21.9 | 46.2 | 65.3 | 65.3 | 28.1 | 38.4 | 54.3 | 54.3 | 0.01 | 0.01 | 0.01 | 0.01 |
| CD (p=0.05) | 0.5 | 0.6 | 0.7 | 0.7 | 63.9 | 108.5 | 126.8 | 126.8 | 82.1 | 90.2 | 105.5 | 105.5 | NS | NS | NS | NS |

*Significant at P ≤ 0.05; NS- Non-Significant P ≤ 0.05

**Table 6. Effect of crop geometry and nutrient management on nutrient uptake in finger millet**

| Treatments | Nitrogen (kg/ha) | | | | | | | | Phosphorus (kg/ha) | | | | | | | | Potassium (kg/ha) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20DAT | | | | 40DAT | | | | 20DAT | | | | 40DAT | | | | 20DAT | | | | 40DAT | | | |
| | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean | $M_1$ | $M_2$ | $M_3$ | Mean |
| $S_1$ | 29 | 29 | 25 | 28.1 | 57 | 56 | 48 | 29.4 | 15 | 14 | 13 | 14.5 | 24 | 24 | 22 | 15.0 | 38 | 38 | 36 | 37.9 | 68 | 67 | 60 | 65.6 |

| | .4 | .2 | .6 | | .0 | .0 | .2 | | .0 | .8 | .6 | | .9 | .5 | .5 | | .9 | .8 | .1 | | .4 | .9 | .5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_2$ | 32.1 | 31.0 | 25.4 | 29.5 | 63.0 | 60.7 | 46.9 | 32.1 | 16.4 | 15.9 | 13.3 | 15.2 | 27.2 | 26.4 | 22.0 | 16.4 | 42.3 | 41.1 | 35.7 | 39.7 | 75.1 | 72.6 | 59.2 | 69.0 |
| $S_3$ | 33.9 | 31.9 | 27.2 | 31.0 | 67.5 | 62.5 | 51.3 | 33.9 | 17.6 | 16.3 | 14.2 | 16.0 | 29.3 | 27.0 | 23.4 | 17.6 | 44.2 | 42.0 | 37.4 | 41.2 | 80.0 | 74.8 | 63.7 | 72.8 |
| $S_4$ | 23.8 | 23.2 | 20.9 | 22.6 | 42.9 | 41.5 | 36.3 | 23.8 | 12.4 | 12.1 | 11.2 | 11.9 | 20.7 | 20.1 | 18.4 | 12.4 | 33.5 | 33.1 | 31.6 | 32.7 | 52.9 | 51.8 | 46.5 | 50.4 |
| Mean | 29.8 | 28.8 | 24.8 | | 57.6 | 55.2 | 45.7 | 29.8 | 15.4 | 14.8 | 13.1 | | 25.5 | 24.5 | 21.6 | 15.4 | 39.7 | 38.8 | 35.2 | | 69.1 | 66.8 | 57.5 | |
| | M | S | M × S | S × M | M | S | M × S | M | M | S | M × S | S × M | M | S | M × S | M | M | S | M × S | S × M | M | S | M × S | S × M |
| SE(d) | 0.63 | 0.77 | 1.33 | 1.33 | 2.78 | 1.23 | 2.14 | 0.63 | 0.37 | 0.43 | 0.75 | 0.75 | 0.80 | 1.06 | 1.84 | 0.37 | 1.98 | 1.24 | 2.14 | 2.14 | 2.57 | 1.96 | 3.40 | 3.40 |
| CD P=0.05) | 1.74 | 1.61 | 2.79 | 2.79 | 7.71 | 2.59 | 4.49 | 1.74 | 1.03 | 0.91 | 1.57 | 1.57 | 2.21 | 2.23 | 3.87 | 1.03 | 5.50 | 2.60 | 4.51 | 4.51 | 7.13 | 4.13 | 7.15 | 7.15 |