

Effect of planting geometry and fertilizer levels on growth and yield of finger millet (*Eleusine coracana* L)

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ABSTRACT

The experiment was done on finger millet during the *zaid* season of 2021-22 at crop research farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (Uttar Pradesh). The treatments consisted of three planting geometry *viz.*, 20 cm × 20 cm, 25 cm × 25 cm and 30 cm × 30 cm and three NPK levels *viz.*, 75%, 100% and 125%. The experiment was conducted in randomized block design with nine numbers of treatments and replicated thrice. The results showed that treatment with 30 cm × 30 cm spacing at 125 % NPK /ha growth parameters *viz.*, maximum plant height (69.73 cm), number of tillers per plant (17.36 g/plant), dry weight per plant (7.36 g) while yield were recorded highest with treatment 20 cm × 20 cm spacing at 125 % NPK /ha. *viz.*, Grain yield (45.76 t/ha), Straw yield (4.33 t/ha) and harvest index (44.91) of finger millet at harvest. This may due to the highest plant population with close spacing treatment and higher number of heads/ m² as compare with wide spacing.

Introduction

Finger millet is commonly known as *ragi* or *mandua* or bird's foot millet [*Eleusine coracana* (L) Gaertn]. India has third rank in area and production. Finger millet having highest productivity among all small millets (Seetharam and Krishnegowda, 2007). It is primary food crop for majority of hilly regions of country. The crop is cultivated up to elevations of 3000 meters above mean sea level and utilized for both grain and fodder purposes. The crop is well adapted to very poor and marginal uplands where other crops cannot be grown successfully (AICSMIP, 2014). It is an annual herbaceous plant and contains a lot of protein, calcium, fiber, and energy. It is also rich in iron, essential amino acids (riboflavin, thiamine,

leucine, isoleucine and trypsin inhibitory factors) (Chethan and Malleshi, 2008). The average area, production and productivity of India in 2018-19 were 891, 1239 and 1390 respectively. In India, more than 50% area occupied by Karnataka, Maharashtra and Uttarakhand. If we look at the area and production of these three major growing states from 2007-08 to 2018-19, we will find that there has been a lot of volatility. The area and production of finger millet of Karnataka, Maharashtra in 2007-08 were (833 thousand hectare, 1497 MT) and (128 thousand hectare, 124 MT) respectively but in 2018-19 area and production of Karnataka and Maharashtra dropped to (527 thousand hectare, 678 MT) and (80 thousand hectare, 93 MT)

(Anonymous, 2020). The area and production of finger millet have decreased over the last three decades due to low market prices and lack of better cultivation practices *viz.*, fertilizer application, planting geometry etc due to which, the majority of farmers shifted to cash crops. Major constraint of low productivity and profitability in finger millet due to lower fertilizer dose and less fertilizer use efficiency. (Kalaraju *et al.*, 2011). A better crop geometry will result in a better harvest of moisture and nutrients from the soil (root spread) and from the plant canopy as well as better photosynthesis formation (Uphoff *et al.*, 2011). In Karnataka, the average yield of finger millet is reported more under square planting of young seedlings with single seedling hill (Kalaraju *et al.*, 2011). Nitrogen, phosphorous and potassium are the essential elements required for plant growth in relatively large amounts (Dhhwayo and Whhgwin, 1984). Nitrogen fertilizer is one of the most yield limiting nutrients for crop production and it is applied in large quantity for most annual crops (Huber and Thompson, 2007). Phosphorus plays an integral role in maintaining membrane structure, bimolecular synthesis, and high-energy molecule synthesis. As well as cell division, enzyme activation and inactivation, and carbohydrate metabolism (Razaq *et al.*, 2017). Potassium increases water use efficiency and transforms sugar into starch in the grain filling process (Srinivasa rao *et al.*, 2013).

Material and Methods

The present experiment was conducted at crop research farm, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj in *Zaid* season of 2021-22. The crop research farm is situated at 25°24'41.27" N latitude, 81°50'56" E longitude and 98 m altitude above the mean sea level. The experimental field located approximately 7 kilometers from Prayagraj city, near the River of Yamuna, on the left side of the Prayagraj-Rewa Road. There is a subtropical and semiarid climate in Prayagraj, with hot summers and pleasant winters. The area's average temperature is 46°C to 48°C, with temperatures seldom dropping below 3°C or 4°C. The relative humidity levels range from 45% to 92 %. In this location, it requires about 600-650 mm annual rainfall during crop period for optimum production. The soil chemistry analysis reveals



Figure: 1 General view of experimental field

sandy loam texture with a pH of 7.4 [Glass electrode pH meter (Jackson, 1973)], low amounts (0.32 percent) of organic carbon (Walkley and Black's rapid titration method (Piper, 1966), nitrogen [(188.3 kg/ha) Alkaline permanganate method (Subbiah and Asija, 1956)], phosphorus [(35.4 kg/ha) Olsen's colorimetric method (Olsen *et al.*, 1954)] and potassium [(87 kg/ha) Flame Photometer method (Jackson, 1958)]. The soil was electrically conductive and had an electrical conductivity of [(0.270 dS/m) Method No.4 USDA Hand Book No.16 (Richads, 1954)].

Three replications of the experiment were done in an experimental design with randomized block design and nine treatments *viz.*, T₁- 20 cm × 20cm spacing at 75 % NPK /ha, T₂- 20 cm × 20cm spacing at 100 % NPK /ha, T₃- 20 cm × 20cm spacing at 125 % NPK /ha T₄- 25 cm × 25cm spacing at 75 % NPK /ha, T₅- 25 cm × 25cm spacing at 100 % NPK /ha, T₆- 25 cm × 25cm spacing at 125 % NPK /ha, T₇- 30 cm × 30cm spacing at 75 % NPK /ha, T₈- 30 cm × 30cm spacing at 100 % NPK /ha, T₉- 30 cm × 30cm spacing at 125 % NPK /ha. In order to meet the nitrogen, phosphorus, and potassium requirements, urea, DAP, and MOP were used as nutrient sources. The recommended dose of fertilizer *viz.*, N, P₂O₅ and K₂O (50:40:25) was applied respectively. Nitrogen was given in two split, half of nitrogen and entire quantity of phosphorus and potassium applied as basal dose and remaining half quantity of nitrogen applied as top dressing. Observation recorded as plant height, number of tillers, total dry weight, crop growth rate, relative growth rate, grain yield, straw yield and harvest index. The F test was

Table I- Effect of planting geometry and fertilizer levels on growth of finger millet at harvest

Treatments	Plant height (cm)	Total tillers/ hill	Plant dry weight (g/plant)
1. 20 cm × 20 cm at 75% NPK/ha	89.25	7.07	18.73
2. 20 cm × 20 cm at 100% NPK /ha	92.34	7.74	20.88
3. 20 cm × 20 cm at 125% NPK/ha	94.98	8.87	21.12
4. 25 cm × 25 cm at 75% NPK/ha	90.44	8.07	19.77
5. 25 cm × 25 cm at 100% NPK/ha	93.13	8.80	21.58
6. 25 cm × 25 cm at 125% NPK/ha	98.44	9.39	22.17
7. 30 cm × 30 cm at 75% NPK/ha	91.69	8.48	20.47
8. 30 cm × 30 cm at 100% NPK/ha	96.57	9.40	22.72
9. 30 cm × 30 cm at 125% NPK/ha	101.23	10.27	23.11
F test	S	S	S
S. EM ±	2.28	0.49	0.82
CD (P = 0.05)	6.85	1.47	2.47

Table II- Effect of planting geometry and fertilizer levels on yield attributes and yield of finger millet

Treatment	Productive Tillers/ hill	No. of fingers /earhead	No. of grains /earhead	Length of Finger (cm)	Test Weight (g)
1. 20 cm × 20 cm at 75% NPK/ha	5.56	4.57	1633	7.50	2.27
2. 20 cm × 20 cm at 100% NPK /ha	6.37	4.93	1692	8.01	2.19
3. 20 cm × 20 cm at 125% NPK/ha	7.21	5.67	1839	9.09	2.11
4. 25 cm × 25 cm at 75% NPK/ha	6.00	4.87	1638	7.80	2.68
5. 25 cm × 25 cm at 100% NPK/ha	7.78	5.07	1713	8.40	2.57
6. 25 cm × 25 cm at 125% NPK/ha	8.25	6.10	1878	9.50	2.19
7. 30 cm × 30 cm at 75% NPK/ha	7.03	4.90	1687	7.93	2.92
8. 30 cm × 30 cm at 100% NPK/ha	8.79	5.33	1821	8.62	2.84
9. 30 cm × 30 cm at 125% NPK/ha	9.10	6.51	1908	9.73	2.71
F test	S	S	S	S	NS
SEm±	0.30	0.33	64.89	0.45	0.35
CD(p=0.05)	0.92	1.00	194.5	1.35	-

Table III- Effect of planting geometry and fertilizer levels on growth of finger millet

Treatments	Grain Yield (t/ha)	Straw Yield (t/ha)	Harvest Index (%)
1. 20 cm × 20 cm at 75% NPK/ha	2.45	4.93	33.19
2. 20 cm × 20 cm at 100% NPK /ha	2.74	5.49	33.29
3. 20 cm × 20 cm at 125% NPK/ha	3.32	5.58	37.30
4. 25 cm × 25 cm at 75% NPK/ha	2.31	4.87	32.17
5. 25 cm × 25 cm at 100% NPK/ha	2.62	5.30	33.08
6. 25 cm × 25 cm at 125% NPK/ha	3.10	5.50	36.04
7. 30 cm × 30 cm at 75% NPK/ha	2.19	4.67	31.92
8. 30 cm × 30 cm at 100% NPK/ha	2.54	5.06	33.42
9. 30 cm × 30 cm at 125% NPK/ha	3.03	5.28	36.46
F test	S	S	NS
S. EM (±)	0.11	0.24	4.62
CD (P = 0.05)	0.35	0.74	-

used to test for the significance of the overall difference among treatments using the experimental data analyzed statistically by analysis of variance (ANOVA) prescribed for the design, and the conclusion was drawn at a 5% probability level. Economics of treatments was also worked out (Gomez and Gomez, 1984).

Results and Discussion

I. Growth parameters at harvest

A. Plant height (cm)

In the present observation plant height is shown in (table 1). It is a most important growth attributing character which increases with crop age. In all treatment combinations, significant differences were observed at harvest. The highest plant height (101.23 cm) was found in treatment with the application of 125% NPK + 30 cm x 30 cm (T₉), which was significantly superior among all treatments, except treatment with application 100% NPK + 30 cm x 30 cm (T₈) and 125%NPK+ 25cm x 25cm . The lowest number of tillers (7.07) was associated with 75% NPK at 20 cm x 20 cm (T₁). Higher availability of nutrients to the plant at higher NPK levels and wider spacing resulted in good growth and development of auxiliary buds leading to higher number of tillers. Similar results were reported by Prakasha *et al.*, (2018). As a result of planting in a square format at a wider spacing, there is less competition between plants in a hill and in the field, resulting in more efficient tailoring. The results found by Kewat *et al.*,(2002) and Nayak *et al.*,(2003).

a wider spacing resulted in reduced plant competition, increased solar radiation absorption, photosynthesis, and nutrient supply, which leads to the robust growth of transplanted finger millet. This was evidenced by Prakasha *et al.*, (2018).

B. Number of tillers/ hill

Data related to total number tillers is shown in (table 1). It was recorded at harvest. The maximum number of tillers (10.27) was found in treatment with the application of 125% NPK + 30 cm x 30 cm (T₉), which was significantly superior among all treatments, except treatment with application 100% NPK + 30 cm x 30 cm (T₈) and 125%NPK+ 25cm x 25cm . The lowest number of tillers (7.07) was associated with 75% NPK at 20 cm x 20 cm (T₁). Higher availability of nutrients to the plant at higher NPK levels and wider spacing resulted in good growth and development of auxiliary buds leading to higher number of tillers. Similar results were reported by Prakasha *et al.*, (2018). As a result of planting in a square format at a wider spacing, there is less competition between plants in a hill and in the field, resulting in more efficient tailoring. The results found by Kewat *et al.*,(2002) and Nayak *et al.*,(2003).

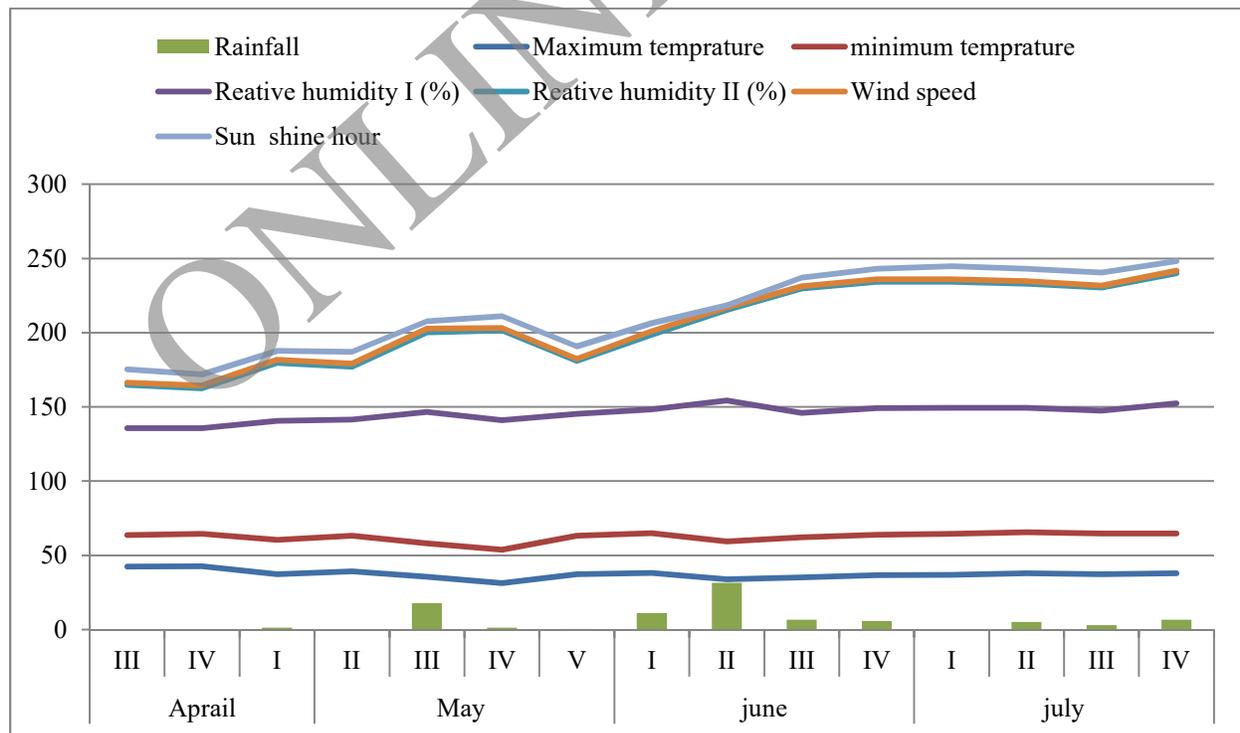


Figure: 2 Mean weekly weather parameters and total rainfall during the cropping season Zaid 2021

C. Dry matter Production (g)/ plant

The production of dry matter consistently increased with age of plant from seedling to vegetative stage, after this stage it starts decreasing in vegetative part of plant and accumulating in grains. It shown in (Table 1). Finger millet has the highest (23.11 g/plant) estimated dry matter production at harvest was found in treatment with the application of 125% NPK + 30 cm x 30 cm (T₉), which was significantly superior among all treatments except all spacing combinations of 100% and 125%NPK, respectively. Primary nutrients like nitrogen, phosphorus and potassium showed significant effect on dry matter producing characteristics like-number of tillers, leaves, length of leaves etc. wide spacing helps in better solar radiation penetrations and interception to plant. So, it results better dry matter accumulation in plant parts Prakesha *et al.*, (2018).

II. Yield Attribute

A. Productive tillers/hill

In tillering crops, productive tillers play important role to deciding crop yield. The number of productive tillers/ hill found during research is given in (Table 2). Planting geometry and different fertilizer levels statistically influenced the number of productive tillers/ hill in finger millet. Data recorded at harvest, maximum number of productive tillers/ hills (9.10) was recorded with application 125% NPK + 30 cm x 30 cm (T₉), which was significantly superior among all treatments, except treatment with application 100% NPK + 30 cm x 30 cm (T₈) and 125%NPK + 25 cm x 25cm (T₆). The minimum productive tillers/ hill (5.56) were produced with 75% NPK + 20 cm x 20 cm (T₁). Vijay *et al.*, (2019) reported that yield attributing factor like productive tillers (7.3) found maximum in wide plant spacing and highest fertilizer levels.

B. Number of fingers/ earhead

Number of finger/ earhead differed significantly due to planting geometry and different fertilizer levels (Table 2). Among the different planting geometry and fertilizer levels, the highest number of fingers/ earhead (6.51) was recorded with 125% NPK + 30 cm x 30 cm (T₉), which was at par with all spacings of 125% NPK. The lowest number of fingers/ earhead (4.57) was produced with 75 % NPK + 20 cm x 20 cm (T₁). Kumar *et al.*, (2019)

reported that yield attributing traits were significantly influenced by the crop geometry and fertilizer levels, where yield attributing characters *viz.*, number of fingers/ ear head was recorded the maximum with transplanting of seedlings at 50 cm ×50 cm + 100% RDF.

C. Number of grains/ earhead

Number of grains/ finger differed significantly due to planting geometry and different fertilizer levels (Table 2). The maximum number of grains/ finger (1908) was recorded with 125% NPK + 30 cm x 30 cm (T₉), which was statistically superior over other treatments, however, at par with all spacing of 125% NPK and 100% NPK+ 30 cm x 30 cm. The minimum number of grains/ finger (1633) was produced with 75% NPK + 20 cm x 20 cm (T₁). A planted area of 30 cm x 30 cm + 125% of NPK provides a favorable microclimate for crops to effectively utilize available nutrients and moisture, and early adoption of this practice results in the partitioning of photosynthesis to reproductive parts, resulting in greater productivity. Similarly, Prakasha *et al.*, (2018) reported that different nutrient levels and spacing *i.e.*, 60 cm x 60 cm + 100% RDF found maximum number of grains/ earhead.

D. Length of finger (cm)

Length of finger differed significantly due to planting geometry and different fertilizer levels (Table 2). The maximum finger length (9.73 cm) was recorded with 30 cm x 30 cm + 125 % (T₉) which was statistically superior to all other treatments except all other spacings of 125% NPK and 25 cm x 25 cm and 30 cm x 30 cm of 100% NPK. The lowest finger length (7.50 cm) was recorded with 20 cm x 20 cm + 75 % NPK (T₁). This may be to increase in plant spacing and level of fertilizer increases the length of finger millet.

E. Test weight (g)

The results from the data revealed that no significant difference exists between the treatments on test weight (Table 2). However, the maximum test weight (2.92 g) was recorded with 30 cm x 30 cm + 75 % (T₇) and the lowest test weight (2.11 g) was recorded with 20 cm x 20 cm + 125 % (T₃). It's not affected by planting geometry and fertilizer levels because weight of seed highly influenced by genetic characters of variety.

III. Yield

A. Grain yield(t/ha)

Planting geometry and fertilizer levels played significant role increasing the grain yield of finger millet shown in (Table 3). The maximum grain yield (3.32 t/ha) was obtained with 20 cm x 20 cm + 125 % (T₃). This was statistically superior over the all other treatments. Another best treatment was 25 cm x 25 cm + 125 % (T₆) was recorded (3.10 t/ha) followed by 30 cm x 30 cm + 125 % (T₉) was recorded (3.03 t/ha). The lowest grain yield (2.19 t/ha) was recorded with 30 cm x 30 cm + 75 % (T₇). The closer spacing was most likely to have resulted in more heads and grains, as there were more plants, as opposed to a wider spacing. According to Shinggu *et al.*, (2012) narrow spacing suppresses weeds and eventually leads to increased yields. Similar results were also reported by Shinggu and Gani (2016) reported that closer inter-row spacing produced a higher number of panicles and higher grain yield at 15 cm inter-row space compared to over 20 cm; this was attributed to higher panicle numbers according to the researchers. Wider plant spacing yielded lower grain yields because total plant number per unit area was much lower than closer planting. To exploit the potential productivity of any crop, the optimal planting pattern is critical for maximizing growth resources.

B. Straw yield (t/ha)

Straw yield directly influenced by planting geometry and fertilizer level shown in (Table 3). The maximum straw yield (5.58 t/ha) was obtained with 20 cm x 20 cm + 125 % (T₃). This was statistically superior over the all other treatments. Another best treatment was found with 25 cm x 25 cm + 125 % (T₆) recorded (5.50 t/ha) followed by 20 cm x 20 cm + 100 % (T₂) was recorded (5.49 t/ha). The lowest straw yield (4.93 t/ha) was recorded with 20 cm x 20 cm + 75 % (T₁). In finger

millet, higher NPK level and higher plant population were likely to lead to maximum dry matter production in stems, leaves, and roots. Furthermore, positive effects are shown on leaf area index, which contributed to increased straw yield. Similar findings were reported by (Rajesh, 2011) and Kalaraju *et al.*, (2011).

C. Harvest index (%)

The results from the data revealed that significant difference did not exist between the treatments on test weight (Table 3). However, the maximum harvest index (37.30) was recorded with 30 cm x 30 cm + 75 % (T₇) and the minimum harvest index (27.42) was recorded with 30 cm x 30 cm + 125 % (T₉).

Conclusion

Optimum planting geometry and fertilizer levels shows great effect on growth and yield of finger millet. In view of the obtained results from the experiment, application of 125% NPK at 20 cm × 20 cm (T₃) produces maximum grain yield and straw yield. So, application of 125% NPK at 20 cm × 20 cm (T₃) is economically viable to the farmer. Only one season of experimentation has been conducted, so recommendations require further confirmation.

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Conflict of interest

The authors declare that they have no conflict of interest.

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