

Effect of Crop Geometry and Age of Seedlings on Productivity and Nutrient Uptake of Finger Millet (*Eleusine coracana* L. Gaertn)

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ABSTRACT

Crop geometry is an important factor to achieve higher production by better utilization of resources and in turn higher production of photosynthates. The ideal crop geometry can assure healthy and uniform stand in the main field and ensure higher productivity. Proper age of seedlings has a tremendous influence on the tiller production, grain formation and other yield contributing characteristics. In view of the above, a field experiment was conducted during *kharif* season (June to October) of 2018 at Bagusala Farm (23°39' N latitude, 87°42' E longitude) of M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha to find out the effect of crop geometry and age of seedlings on yield attributing characters, yield and nutrient uptake of finger millet (cv. Vakula) in sandy loam soil. The experiment revealed that transplanting of 20 days old seedlings at 25 cm x 25 cm spacing registered superior performance in expression of yield attributes like effective tillers m⁻², number of grain ear head⁻¹, number of fingers ear head⁻¹, test weight and length of the fingers; grain and straw yield and nutrient uptake. It may be concluded that to obtain higher productivity of finger millet during *kharif* season in sandy loam soils of south Odisha, 20 days old seedlings may be transplanted with a spacing of 25 cm x 25 cm.

Highlights

- Transplanting of 20 days old seedlings with a spacing of 25 cm x 25 cm may be adopted to obtain higher productivity of finger millet
- A planting geometry of 25 cm x 25 cm spacing and 20 days old seedlings recorded greater nutrient uptake by finger millet

Keywords: Finger millet, crop geometry, age of seedling, yield attributes, yield, nutrient uptake

Finger millet (*Eleusine coracana* L. Gaertn) is an ecologically sound crops and not too vulnerable to risen temperature and climate change. As the crop requires very less moisture and nutrient demand, it has become a potential crop of resource poor areas. With respect to area and production in our country it has the pride of place in having the highest productivity among the millets (Seetharam

and Krishne Gowda 2007). The combined potential of millets as both resilient crops for resource-constrained farmers and as a nutritious foodstuff for growing populations, millets is slowly being rediscovered by the agricultural research and development community. Their potential for climate smart agriculture and enhanced nutrition is also underexploited. Due to these qualities it is now



considered as a nutritious cereal in the world of escalating malnourished population and it can play a major role in nutritional security (Affholder *et al.* 2013; Brahmachari *et al.* 2018; Mishra 2019).

In India finger millet is cultivated in an area of 1.27 million ha with a production of 2.61 million t and productivity is 1489 kg ha⁻¹. Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand, Uttaranchal, Maharashtra, and Gujarat are the leading states of India in finger millet cultivation. In Odisha the coverage of finger millet is in 1.66 lakh ha with a production of 1.61 lakh t (Agriculture Statistics at a Glance 2017). The average productivity of finger millet in Odisha (970 kg ha⁻¹) is far below from the national average. Improved varieties developed in India have the production potential of 4 t ha⁻¹ with proper agronomic management.

Actually, the crop is cultivated in marginal lands and fragile ecological conditions of the state. In south Odisha region, harsh and unfavorable climatic conditions coupled with poor soils make agricultural production system a gamble due to high risk of uncertainties during *kharif* season. Under such circumstances, it is a suitable crop to the resource poor farmers as it is an ecologically hardy crop. However, there is an urgent need to increase the productivity of finger millet as well as to achieve the maximum potential of the improved varieties. The productivity of finger millet is low due to adoption of local varieties and inferior quality seeds, poor crop stand under direct sowing, late transplanting and faulty management practices. Crop geometry is an important factor to achieve higher production by better utilization of moisture and nutrients from the soil (root spread) and above ground (plant canopy) by harvesting maximum possible solar radiation and in turn better photosynthates formation (Uphoff *et al.* 2011). The ideal crop geometry has to be adopted for getting optimum plant stand in the field which results in higher yield. It has been reported in Karnataka, the average yield of finger millet is more under square planting of young seedlings with single seedling hill⁻¹ (Kalaraju *et al.* 2011). Wider spacing was superior to narrow spacing in terms of enhanced grain and straw yield. Moreover, the ideal crop geometry can reduce the seed rate, healthy stand in the main field and ensure higher productivity. The age of seedlings is another important factor as

it has a tremendous influence on the tiller dynamics, tiller production, grain formation and other yield contributing characteristics (Pasuquin *et al.*, 2008). Young seedlings are transplanted to preserve the potential for high tillering and extensive rooting ability than the aged seedlings. In view of the above observations a field experiment was conducted to find out the effect of crop geometry and age of seedlings on yield attributing traits, yield and nutrient uptake of finger millet.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* season (June to October) of 2018 at Bagusala Farm (23°39' N latitude, 87°42' E longitude) of M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Gajapati district, Odisha to evaluate the growth and productivity of finger millet as influenced by crop geometry and age of seedlings. The variety of finger millet was Vakula. In the experiment, three different crop geometries viz. 20 cm × 20 cm, 25 cm × 25 cm, 30 cm × 30 cm and three age of seedlings viz. 15, 20 and 25 days old were considered and the treatments were as follows. T₁: Transplanting of 15 days old seedlings at 20 cm × 20 cm, T₂: Transplanting of 15 days old seedlings at 25 cm × 25 cm, T₃: Transplanting of 15 days old seedlings at 30 cm × 30 cm, T₄: Transplanting of 20 days old seedlings at 20 cm × 20 cm, T₅: Transplanting of 20 days old seedlings at 25 cm × 25 cm, T₆: Transplanting of 20 days old seedlings at 30 cm × 30 cm, T₇: Transplanting of 25 days old seedlings at 20 cm × 20 cm, T₈: Transplanting of 25 days old seedlings at 25 cm × 25 cm, T₉: Transplanting of 25 days old seedlings at 30 cm × 30 cm. The raised nursery was prepared with a dimension of 4m length and 1.5 m width. Seed sowings was done at different dates to get respective aged seedlings (15, 20 and 25 days old) to transplant on same day. Soil of the experimental field was sandy loam in texture with following physic-chemical properties (Table 1).

Table 1: Chemical properties of experimental soil

pH	Organic C (%)	Available N (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
6.4	0.41	73.4	30.2	152.4

Field was laid out in Randomized Complete Block Design (RCBD) with three replications. The plot size was 4 m × 3 m. FYM at the rate of 5t ha⁻¹ was applied to all the experimental plots uniformly before final puddling and levelling. The applied recommended dose of N, P₂O₅ and K₂O was 40 Kg ha⁻¹, 20 Kg ha⁻¹ and 20 Kg ha⁻¹ respectively. Half dose of nitrogen and full dose of phosphorous and potassium were applied at basal application just before transplanting while the remaining half dose of nitrogen was applied after 21 days after transplanting. The crop received a total rainfall 1144 mm during the period of experimentation. Observations on yield attributing traits, grain and straw yields were recorded and chemical analysis was done by applying the standard procedure to obtain the nutrient uptake by finger millet. The data were analyzed statistically (Panse and Sukhatme 1985) and presented.

RESULTS AND DISCUSSION

Yield attributes

The result presented in Table 2 showed that the yield attributing traits were influenced by the crop geometry and age of seedling. Yield attributing characters viz., effective tillers m⁻², number of grain ear head⁻¹, number of fingers ear head⁻¹, test weight and length of the fingers were recorded the best with the treatment at T₅ (transplanting of 20 days old seedlings at 25 cm × 25 cm) and it significantly enhanced the values of above characters. The treatment T₅ (transplanting of 20 days old seedlings at 25 cm × 25 cm) being statistically at par with T₄ (transplanting of 20 days old seedlings at 20 cm × 20 cm) and T₈ (transplanting of 25 days old seedlings at 25 cm × 25 cm) recorded significantly more number of effective tillers m⁻² and number of grains ear head⁻¹ than all other treatments. In case of production of number of fingers ear head⁻¹, T₅ (transplanting of 20 days old seedlings at 25 cm × 25 cm) being statistically at par with T₆ (transplanting of 20 days old seedlings at 30 cm × 30 cm) established its significant superiority over all other treatments. But test weight of finger millet of T₅ (transplanting of 20 days old seedlings at 25 cm × 25 cm) was statistically at par with other treatments except T₁ (transplanting of 15 days old seedlings at 20 cm × 20 cm). However, the length of finger

of T₅ (transplanting of 20 days old seedlings at 25 cm × 25 cm) was statistically at par with all other treatments tried, except T₉ (transplanting of 25 days old seedlings at 30 cm × 30 cm). Treatment with a spacing of 25 cm × 25 cm and medium aged (20 days old) seedlings (T₅) might be provided optimum spacing and congenial microclimate to crop for effective utilization of available moisture, nutrient and its early adoption for better partitioning of photosynthates to reproductive parts there by recording better yield attributes. The results are in conformity with the findings of Roy *et al.* (2002), Kalaraju (2011), Rajesh (2011) and Suresh (2013).

Yield

The highest grain yield of finger millet (1482 kg ha⁻¹) was obtained with T₅ (transplanting of 20 days old seedlings at 25 cm × 25 cm) which was significant over all the other treatments (Table 2 and Fig. 1).

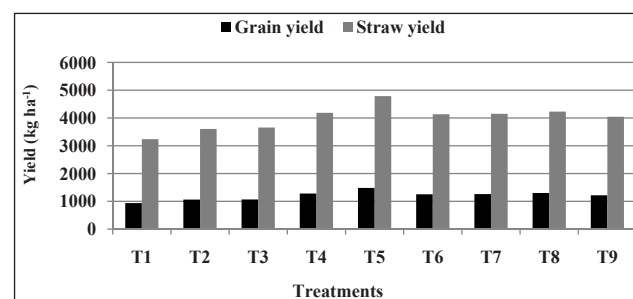


Fig. 1: Effect of crop geometry and age of seedlings on grain and straw yield of finger millet

The next best treatment was T₈ (transplanting of 25 days old seedlings at 25 cm × 25 cm) which was however, comparable with T₄ (transplanting of 20 days old seedlings at 20 cm × 20 cm), T₆ (transplanting of 20 days old seedlings at 30 cm × 30 cm), T₇ (transplanting of 25 days old seedlings at 20 cm × 20 cm) and T₉ (transplanting of 25 days old seedlings at 30 cm × 30 cm). The lowest grain yield (936 kg ha⁻¹) was recorded with T₁ (transplanting of 15 days old seedlings at 20 cm × 20 cm) which remained significantly inferior to all other treatments. Maximum grain yield was noted with T₅ (transplanting of 20 days old seedlings at 25 cm × 25 cm), probably because the treatment expressed comparatively more value of some yield attributing characters like effective tillers m⁻², number of grains per earhead⁻¹, number of fingers earhead⁻¹, test weight and length of the finger which are ultimately reflected into grain yield. The higher

Table 2: Effect of crop geometry and age of seedlings on yield attributes of finger millet

Treatments	Yield attributes				
	Effective tillers m ⁻²	Number of grains ear head ⁻¹	Number of fingers ear head ⁻¹	Test weight (g)	Length of the finger (cm)
T ₁ Transplanting of 15 days old seedlings at 20 cm × 20 cm	20.6	1871	7.4	2.56	8.2
T ₂ Transplanting of 15 days old seedlings at 25 cm × 25 cm	22.1	1892	7.6	2.60	8.4
T ₃ Transplanting of 15 days old seedlings at 30 cm × 30 cm	21.7	1902	8.0	2.61	8.3
T ₄ Transplanting of 20 days old seedlings at 20 cm × 20 cm	28.6	2018	8.3	2.68	8.3
T ₅ Transplanting of 20 days old seedlings at 25 cm × 25 cm	28.8	2037	9.7	2.71	8.7
T ₆ Transplanting of 20 days old seedlings at 30 cm × 30 cm	25.2	1907	9.2	2.63	8.2
T ₇ Transplanting of 25 days old seedlings at 20 cm × 20 cm	24.9	1910	8.0	2.62	8.3
T ₈ Transplanting of 25 days old seedlings at 25cm × 25 cm	27.3	2008	8.2	2.69	8.2
T ₉ Transplanting of 25 days old seedlings at 30 cm × 30 cm	25.1	1912	8.5	2.62	8.0
SEm ±	0.60	37.81	0.25	0.06	0.19
CD (P=0.05)	1.80	112.1	0.75	0.18	0.58
CV (%)	5.7	6.3	9.0	5.7	7.1

grain yield might be due to enhanced stature of yield attributes, thus forming larger sink size coupled with efficient translocation of photosynthates to the sink was noticed under optimum planting pattern with transplanting of medium aged seedlings (T₅). Optimum planting pattern is the prerequisite for proper utilization of growth resources and ultimately to exploit the potential productivity of any crop. The results corroborate with the findings of Kalaraju *et al.* (2011), Rajesh (2011) and Prakasha *et al.* (2018).

Different crop geometries and age of seedlings resulted in significant effect on the straw yield of finger millet. Among different crop geometry and age of seedlings tried, T₅ (transplanting of 20 days old seedlings at 25 cm × 25 cm) produced significantly highest straw yield (4320 kg ha⁻¹) and it recorded significantly more straw yield than all other treatments.

The increase in straw yield was probably due to adoption of planting geometry with optimum spacing and medium aged seedling for better and uniform stand which enhanced higher dry matter

accumulation and this might be enhanced straw yield of finger millet. The results corroborate with the findings of Veeranna and Reddy (2010) and AICSMIP (2013). However, significant impact was not noticed in expression of harvest index.

Nutrient uptake

Crop geometries and age of seedlings have exerted significant influence on the N, P and K uptake by finger millet grain, straw and total uptake by the crop (Table 3 and Fig. 2).

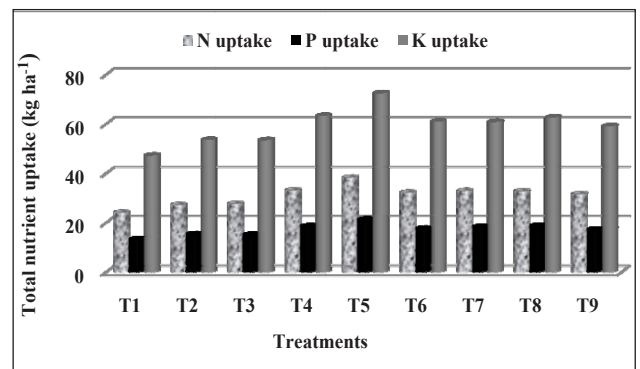


Fig. 2: Effect of crop geometry and age of seedlings on total nutrient uptake of finger millet

Table 3: Effect of crop geometry and age of seedlings on grain and straw yield and harvest index of finger millet

Treatments	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index
T ₁ Transplanting of 15 days old seedlings at 20 cm × 20 cm	936	3238	22.42
T ₂ Transplanting of 15 days old seedlings at 25 cm × 25 cm	1063	3603	22.78
T ₃ Transplanting of 15 days old seedlings at 30 cm × 30 cm	1069	3655	22.62
T ₄ Transplanting of 20 days old seedlings at 20 cm × 20 cm	1280	4185	23.42
T ₅ Transplanting of 20 days old seedlings at 25 cm × 25 cm	1482	4786	23.64
T ₆ Transplanting of 20 days old seedlings at 30 cm × 30 cm	1253	4134	23.25
T ₇ Transplanting of 25 days old seedlings at 20 cm × 20 cm	1262	4151	23.31
T ₈ Transplanting of 25 days old seedlings at 25 cm × 25 cm	1302	4231	23.53
T ₉ Transplanting of 25 days old seedlings at 30 cm × 30 cm	1218	4043	23.15
SEm±	32.2	76.4	0.7
CD (P=0.05)	96.4	229.3	2.1
CV (%)	6.8	6.2	NS

Table 4: Effect of crop geometry and age of seedlings on total nutrient uptake of finger millet

Treatments	Nutrient uptake (Kg ha ⁻¹)								
	N uptake			P uptake			K uptake		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T ₁ Transplanting of 15 days old seedlings at 20 cm × 20 cm	12.64	11.33	23.97	2.53	10.68	13.21	3.08	44.04	47.12
T ₂ Transplanting of 15 days old seedlings at 25 cm × 25 cm	14.46	12.61	27.07	2.98	12.25	15.23	3.72	49.72	53.44
T ₃ Transplanting of 15 days old seedlings at 30 cm × 30 cm	14.43	13.15	27.58	2.99	12.06	15.05	3.63	49.71	53.34
T ₄ Transplanting of 20 days old seedlings at 20 cm × 20 cm	17.54	15.45	32.99	3.84	14.65	18.49	4.60	58.59	63.19
T ₅ Transplanting of 20 days old seedlings at 25 cm × 25 cm	20.45	17.71	38.16	4.44	16.75	21.19	5.33	67.01	72.34
T ₆ Transplanting of 20 days old seedlings at 30 cm × 30 cm	17.17	14.89	32.06	3.51	14.05	17.56	4.26	56.63	60.89
T ₇ Transplanting of 25 days old seedlings at 20 cm × 20 cm	17.41	15.36	32.77	3.66	14.53	18.19	4.29	56.45	60.74
T ₈ Transplanting of 25 days old seedlings at 25 cm × 25 cm	17.84	14.80	32.64	3.77	14.82	18.59	4.56	57.96	62.52
T ₉ Transplanting of 25 days old seedlings at 30 cm × 30 cm	16.93	14.55	31.48	3.41	13.74	17.15	4.02	54.98	59.00
SEm ±	0.66	0.51	0.74	0.22	0.33	0.57	0.27	1.72	1.83
CD (P=0.05)	1.97	1.54	2.22	0.65	1.01	1.72	0.82	5.14	5.48
CV (%)	10.2	11.6	6.8	16.0	8.0	10.3	14.8	6.3	6.1

The highest nutrient uptake by the crop was recorded in T₅ (transplanting of 20 days old seedlings at 25 cm × 25 cm) which was significantly superior to all other treatments tried. The lowest nutrient uptake was recorded with T₁ (transplanting of 15 days old seedlings at 20 cm × 20 cm). The uptake of nutrients differed significantly among the treatments because of significant variation in grain and straw yield. The higher uptake of nutrients by grain and straw as well as total uptake of nutrients by the crop was obtained with the treatment T₅ (transplanting of 20 days old seedlings at 25 cm × 25 cm) as the treatment well exhibited yield attributes and more of grain and straw yield. Such results were probably

due to the impact of favorable environment and less competition among plants by optimum spacing and moderate age of seedling that assured better crop establishment. The results are in conformity with the findings of Rajesh (2011), Avasthe *et al.* (2012), Sri Devi and Chellamuthu (2012).

CONCLUSION

The results of the field experiment conclude that finger millet may be grown in sandy loam soils of South Odisha maintaining a spacing of 25 cm × 25 cm with 20 days old seedlings to obtain more productivity and higher nutrient uptake by the crop.



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DECLARATION

The content is based on the research work carried out by the first author for partial fulfillment of M.Sc. Ag.(Agronomy) degree and there is no conflict of interest among the authors.

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