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Influence of planting geometry and fertilizer levels on economics of finger millet (*Eleusine coracana* L)

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Abstract
During the zaid season of 2021-22, the experiment was conducted on finger millet at the crop research farm of Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (Uttar Pradesh). There were three planting geometry treatments: 20 cm x 20 cm, 25 cm x 25 cm, and 30 cm x 30 cm, as well as three NPK levels: 75 percent, 100 percent, and 125 percent. The study used a randomized block design with nine different treatments and was replicate three times. I have studied with objective to work out the economics of treatment combinations. The results showed that gross return (105180.85 INR/ha), net return (74326.63 INR/ha) and B: C ratio (2.41) were recorded significant with spacing 20 cm × 20 cm along with application of 125% NPK /ha (T_3). Therefore it is concluded that spacing 20 cm × 20 cm spacing at 125% NPK /ha (T_3) this could be attributed to the larger plant population and number of heads per m2 with close spacing compared to broad spacing. Therefore proved to be an economically viable option to the farmer for getting higher profit.

Keywords: Spacing, Gross return, Net return, B: C ratio, Fertilizer, Geometry

Introduction

Ragi and mandua are other names for the finger millet [*Eleusine coracana* (L) *Gaertn*]. India is ranked third in terms of area and production. Finger millet has the best productivity of all small millets (Seetharamand Krishnegowda, 2007) [15]. In the majority of the country's hilly regions, it is the most common food crop. The crop thrives in extremely poor and marginal uplands where other crops fail (AICSMIP, 2014) [2].

It is an herbaceous annual plant that is high in protein, calcium, fibre, and energy. Iron and necessary amino acids are also abundant (riboflavin, thiamine, leucine etc) (Chethan and Malleshi, 2008) [3].When we compare the acreage and production of these three key growing states from 2007-08 to 2018-19, we can see a lot of variation. In 2007-08, the area and production of finger millet in Karnataka and Maharashtra were (833 thousand hectares, 1497 MT) and (128 thousand hectares, 124 MT) respectively, but in 2018-19, the area and production of finger millet in Karnataka and Maharashtra were (527 thousand hectares, 678 MT) and (527 thousand hectares, 678 MT) respectively (80 thousand hectare, 93 MT) (Anonymous, 2020) [1].

Due to low market pricing and a lack of superior agricultural practices such as fertilizer application and planting geometry, the acreage and production of finger millet have fallen during the last three decades, and the majority of farmers have migrated to cash crops. Finger millet has a major constraint of low production and profitability due to reduced fertilizer dose and fertilizer usage efficiency (Kalaraju *et al.*, 2011) [9]. A better crop geometry will result in greater moisture and nutrient harvesting from the soil and the plant canopy, as well as improved photosynthetic production (Uphoff *et al.*, 2011) [18]. In Karnataka, Ragi yields are higher when young seedlings are planted in squares with a single seedling hill (Kalaraju *et al.*, 2011) [9]. The key elements nitrogen, phosphorous, and for plant growth, potassium is necessary in quite large concentrations (Dhhwayo and Whhgwin, 1984) [4]. One of the most yield-limiting elements in crop cultivation is nitrogen fertilizer and for most annual crops, it is used in large quantities (Huber and Thompson, 2007) [6]. Phosphorus is required for membrane construction, bimolecular synthesis, and the creation of high-energy molecules. Cell division, enzyme activation and inactivation, and glucose metabolism are all examples of biological processes (Razaq *et al.*, 2017) [13]. In the grain filling process, potassium boosts water efficiency and converts sugar to starch (Srinivasarao *et al.*, 2013) [16].

Methodology

The trial took place during the *Zaid* season (2021-2022) at Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj. The crop research farm is located at 25o24'41.27" north latitude, 81°50'56" east longitude, and 98 meters above sea level. The experimental field is about 7 kilometers from Prayagraj city, along the Yamuna River, on the Prayagraj- Rewa Road's left side.

Prayagraj has a subtropical and semiarid climate, with hot summers and mild winters. The mean temperature in the area is 46°C to 48°C, with temperatures rarely falling below 3°C or 4°C. The relative humidity values vary between 45 and 92 percent. For optimum production in this region, 600-650 mm of yearly rainfall is required during the crop period. The soil chemistry analysis reveals a sandy loam texture with a pH of 7.4 [Glass electrode pH meter (Jackson, 1973)] [7], low amounts (0.32 percent) of organic carbon (Walkley and Black's) rapid titration method (Piper,1966) [11], nitrogen [(188.3 kg/ha) Alkaline permanganate method (Subbiah and Asija, 1956)] [17], and phosphorus [(35.4 kg/ha) Olsen's [(87 kg/ha) Flame Photometer technique (Jackson, 1958)] and potassium [(0.270 dS/m) Method No.4 USDA Hand Book No.16 (Richads, 1954)] [14].

The soil was electrically conductive.T_1- 20 cm 20cm spacing at 75 percent NPK /ha, T_2- 20 cm 20 cm spacing at 100 percent NPK /ha, T_3- 20 cm 20cm spacing at 125 percent NPK /ha were the three replications of the experiment in an experimental design with randomized block design and nine treatments. T_4- 25 cm /ha spacing at 75 percent NPK, T_5- 25 cm /ha spacing at 100 percent NPK, T_6- 25 cm /ha spacing at 125 percent NPK, T_7- 30 cm /ha spacing at 75 percent NPK, T_8- 30 cm /ha spacing at 100 percent NPK, T_9- 30 cm /ha spacing at 125 percent NPK Urea, DAP, and Muriate of potash were used as nutrition stream to meet the NPK requirements. The recommended fertilizer doses were administered, namely N, P2O5, and K2O (50:40:25). Half of the nitrogen, along with the entire amount of P and K, were administered as a basal dose, and the other half was placed as a top dressing. Plant height, number of tillers, total dry weight, crop growth rate, relative growth rate, grain yield, straw yield, and harvest index were all recorded as observations. Using experimental data examined statistically by analysis of variance (ANOVA) recommended for the design, the F test was performed to test for the significance of the overall difference among treatments, and the conclusion was drawn at a 5% probability level. Treatment costs were also calculated (Gomez and Gomez, 1984) [5].

Results and Discussion

1. Economics

1.1 Cost of cultivation (INR/ ha)

Costs of cultivation of finger millet were altered to a noticeable extent by different planting geometry and fertilizer levels (Table 1).

The highest costs of cultivation (30854.60 INR/ha) were recorded with 20 cm x 20 cm + 125% (T_3) than another treatment due to high seed rate and fertilizer levels. The lowest costs of cultivation (29171.80 INR/ha) were recorded with 30 cm x 30 cm + 75% (T_7) due to lowest fertilizer levels and seed rate.

1.2 Gross return (INR/ ha)

Gross returns of finger millet were altered to a noticeable extent by different planting geometry and fertilizer levels (Table 1).

The best gross returns (105180.85) were recorded with 20 cm x 20 cm + 125% (T_3) which was remarkably more than with another treatment. The next best treatment was 25 cm x 25 cm + 125% (T_6) after that 30 cm x 30 cm + 125% (T_9) were recorded (98500.00 INR/ha) and (96180.63 INR/ha) respectively. The lowest gross return (70370.85 INR/ha) was recorded with 30 cm x 30 cm + 75% (T_7) because grain and straw yields are poor. When compared to wider spacing, recommended spacing produced greater grain and straw yields of 3.32 t/ha and 5.58 t/ha, respectively, resulting in higher gross Khafi *et al*. (2000) [8].

1.3 Net return (INR/ ha)

Net return of finger millet was altered to a noticeable extent by different planting geometry and fertilizer levels (Table 1).

The highest net returns (74326.63 INR/ha) were recorded with 20 cm x 20 cm + 125% (T_3) which was remarkably more than with the all other treatment. The next best treatment was 25 cm x 25 cm + 125% (T_6) after that 30 cm x 30 cm + 125% (T_9) were recorded (67756.33 INR/ha) (65517.74 INR/ha) respectively. The lowest net return (41199.82 INR/ha) was recorded with 30 cm x 30 cm + 75% (T_7) because grain and straw yields are poor. Grain and straw yield directly influenced the net return of crop. Due to high fertilizer rate and optimum plant geometry shows superior produce attributional characters like number of finger, productive tillers, length of finger, number of grains per finger etc as well as vegetative growth like plant height, number of tillers, number of leaves, leaf area index etc of plant. Similar results found by Mudalagiriyappa *et al.,* (2015) [10].

1.4 B: C Ratio

Benefit cost ratio of finger millet were altered to a noticeable extent by different planting geometry and fertilizer levels (Table 1).

The best B: C (2.41) was recorded with 20 cm x 20 cm + 125% (T_3) which was remarkably more than with another treatment. The next best treatment was 25 cm x 25 cm + 125% (T_6) after that 30 cm x 30 cm + 125% (T_9) were recorded (2.20) (2.13) respectively. The lowest B: C (1.68) was recorded with 20 cm x 20 cm + 75% (T_1) because grain and straw yields are poor. This might be due to optimum plant population maintained in a unit area and less cost of cultivation resulted in more profit in finger millet. Similar result by (rajesh, 2011) [12].

Table 1: Effect of planting geometry and fertilizer levels on Economics of finger millet

	Treatments	Cost of cultivation (INR/ ha)	Gross return (INR/ ha)	Net return (INR/ ha)	B:C ratio
1.	20 cm × 20 cm at 75% NPK/ha	29363.30	78430.20	49066.31	1.68
2.	20 cm × 20 cm at 100% NPK /ha	30284.20	87690.80	57405.67	1.90
3.	20 cm × 20 cm at 125% NPK/ha	30854.60	105180.85	74326.63	2.41
4.	25 cm × 25 cm at 75% NPK/ha	29253.70	74170.61	44916.90	1.53
5.	25 cm × 25 cm at 100% NPK/ha	30174.90	83900.28	53725.54	1.78
6.	25 cm × 25 cm at 125% NPK/ha	30744.70	98500.00	67756.33	2.20
7.	30 cm × 30 cm at 75% NPK/ha	29171.80	70370.85	41199.82	1.41
8.	30 cm × 30 cm at 100% NPK/ha	30092.20	81260.57	51168.44	1.70
9.	30 cm × 30 cm at 125% NPK/ha	30662.10	96180.63	65517.74	2.13

Table 2: Analysis of soil (0-15 cm depth) is presented

S. No.	Soil characteristics	values	Method
Mechanical analysis			
a	Sand	60.00%	Bouyoucos hydrometer method
b	Silt	25.6%	
c	Clay	14.4%	
d	Soil texture	Sandy loam	
Physical properties			
a	Bulk density	1.45 g/cm^3	Core sampler method (baver *et al*., 1976)
b	Particle density	2.63 g/cm^2	Pycnometer
c	Moisture at field capacity (%)	14.00	Field method (piper, 1966) [11]
Chemical analysis of soil			
a	pH	7.4	Glass electrode pH meter (Jackson, 1973) [7]
b	EC	0.27 dS/m	Method No.4 USDA Hand Book No.16 (Richads, 1954) [14]
c	Organic carbon	0.32%	Walkley and Black's rapid titration method (Piper, 1950)
d	Available nitrogen	188.3 kg/ ha	Alkaline permanganate method (Subbiah and Asija, 1956) [17]
e	Available phosphorus	34.5 kg/ ha	Olsen's colorimetric method (Olsen *et al*., 1954)
f	Available potassium	87 kg/ ha	Flame Photometer method (Jackson, 1958)

Fig 1: general view of experimental site

Conclusion
The economics of finger millet production are greatly influenced by optimal planting geometry and fertilizer levels. Based on the results of the trial, a 125 percent NPK application at 20 cm x 20 cm (T_3) gives the highest gross return, net return and B: C ratio. As a result, the farmer may afford to apply 125 percent NPK at 20 cm x 20 cm (T_3). Because only one season of trial has been completed, recommendations must be confirmed.

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