Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(1): 1420-1423
Received: 14-11-2020
Accepted: 18-12-2020

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

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DOI: https://doi.org/10.22271/phyto.2021.v10.i1t.13547

Abstract
The field experiment was conducted during *kharif* 2019 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.) on sandy loam soil. The experiment was conducted in Randomized Block Design consisting of 3 replications and 10 treatments comprising of three spacings (30 cm x 30 cm, 40 cm x 40 cm and 50 cm x 50 cm) and three fertilizer levels (50% RDF, 75% RDF and 100% RDF) which are compared with control plot. The results showed in growth attributing parameters *viz*., plant height (113.81 cm), number of leaves per hill (96.56), Leaf Area Index (11.26), number of tillers per hill (14.56), plant dry weight (101.80 g/hill), crop growth rate (13.03 g/m^2/day), relative growth rate (0.039 g/g/day) and grain yield (4571.32 kg/ha) were recorded maximum with spacing of 50 cm x 50 cm + 100% RDF.

Keywords: Finger millet, spacing, fertilizer levels, growth and yield

Introduction

Cereals and millets constitute a major component of diet consumed in developing countries like India. Finger millet is an important staple food in parts of eastern and central Africa and India. It is non-acid forming food and easy to digest. It is considered to be one of the least allergic and most digestible grains available and is a warming grain so it helps to heat the body in cold or rainy season. However, the use of finger millet is limited due to coarse nature of the grain. It has high fibre content and outer cover of the grain is thick, which makes its processing difficult and gives a poor sensory quality. Lack of adequate marketing avenues of these crops has also led to their rapid decline both in production and consumption (Pragya and Rita, 2012) [10]. In recent years there is a huge market for the ragi, as it has lots of health benefits especially for those who are diabetic due to its low glycemic index (Sarita, 2016) [15].

Crop geometry is an important factor for achieving higher production through better utilization of moisture and nutrients from the soil (root spread) and above ground (plant canopy) by harvesting maximum possible solar radiation which in turn better leads to better formation of photosynthates (Uphoff *et al*., 2011) [17]. It is also reported that finger millet yield can be increased to 3-4 tons/ha with square method of sowing as compared to 0.75-1.0 tons/ha in traditional farmers practice (Anitha, 2015) [1].

Nitrogen, phosphorus and potassium are the essential elements required for plant growth in relatively large amounts for better performance in crop growth (Dhhwayo and whhgwin, 1984) [3].

Ragi is a neglected millet crop for the last 20 years in Uttar Pradesh. The reason for replacement for ragi and other millets is because of its undesirable taste, low productivity and low monetary returns to farmer.

Materials and Methods

The experiment was conducted during the *kharif* season of 2019 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (U.P.). The Crop Research Farm is situated at 25.57^o N latitude, 87.19^o E longitude and at an altitude of 98 m above mean sea level. The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, phosphorus and low in potassium.

The experiment was laid out in Randomized Block Design. The treatments comprised of spacing and nutrient levels. There were 10 treatments and each replicated thrice. Treatments were randomly arranged in each replication, divided into thirty plots.

Seedlings were uprooted from nursery when they attained at an age of 20 days old. Two seedlings were transplanted in each hill. The recommended dose of fertilizers (RDF) used in the experiment are 60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha. Fifty percent of nitrogen and full dose of phosphorus and potassium were applied as basal dose in all plots. Whereas, remaining fifty percent of nitrogen as per the treatments was applied at 30 DAT. First irrigation is given immediately after transplanting and life-saving irrigation is given on third day after transplanting. Rest of the irrigations were occurred through rains. Weeding was done manually with the help of *khurpi* twice at 25 and 50 DAT to keep the plots free from weeds. Observations of plant height, number of leaves per hill, number of tillers per hill, dry weight**,** leaf area index**,** crop growth rate and relative growth rate were recorded at every 15 days interval. Data generated from the field experiments were subjected to the statistical analysis of variance appropriate to the experimental design. Seedlings were transplanted in the month of July on 27/07/2019 and harvested in mid-November on 17/11/2019.

Leaf Area Index

The leaf area index is defined as total leaf area (assimilatory source) per unit land area. It was calculated by dividing the leaf area per plant by the land area occupied by single plant (Sestak *et al*., 1971) [16].

Where,

LAI = Leaf Area Index

A = Total leaf area (cm^2)

P = Unit Land area (cm^2)

Crop Growth Rate ($g/m^2/day$)

It represents dry weight gained by a unit area of crop in a unit time and is expressed as $g/m^2/day$ (Brown, 1984) [2]. It was calculated with the help of following formula.

$$\text{Crop Growth Rate} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_1 = dry matter production per unit area at time t_1

W_2 = dry matter production per unit area at time t_2

t_1 = days to first sampling

t_2 = days to second sampling

Relative Growth Rate (g/g/ day)

RGR is a measure used to quantify the speed of plant growth. It is measured as the mass increase per above ground biomass per day. It is expressed as g/g/day. It was calculated with the help of following formula.

$$\text{Relative Growth Rate} = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

Where,

Ln = natural logarithm

W_1 = dry matter production per unit area at time t_1

W_2 = dry matter production per unit area at time t_2

t_1 = days to first sampling

t_2 = days to second sampling

Results and Discussion

Growth attributing parameters

Plant height (cm)

As seen in table 1. Among all treatments, plant height (113.81 cm) which was significantly higher in 50 cm x 50 cm + 100% RDF and at par values are found in the treatment with spacing of 50 cm x 50 cm + 75% RDF (112.18 cm), respectively. It is due to nitrogen, which promotes the vegetative growth thus, leading to increase in plant height. These results were similar with Rathore *et al.* (2006) [13] and Obeng *et al.* (2012) [8].

Number of leaves per hill

Spacing with 50 cm x 50 cm + 100% RDF was significantly higher in number of leaves per hill (96.56/hill) parameter and treatments with spacings of 50 cm x 50 cm + 75% RDF and 50 cm x 50 cm + 50% RDF (94.33 and 91.44/hill) which were found to be at par. Increased P uptake by the crops with N and P application attributed to their effect on the formation of active and prolific roots, resulting in increased foraging capacity of the plants. The results are in conformity with the findings of Vamshi *et al.* (2019) [18].

Leaf Area Index

Wider spacing (50 cm x50 cm) with 100% RDF found to be significantly most higher in LAI (11.26) over all other treatments. Wider spacing produced robust and healthy plants produced more number of leaves due to less competition between plants for light, water and increased fertilizer level automatically increased the nutrient availability finally helped to get more leaf area. To maintain higher leaf area there should be higher number of leaves which in turn depend on plant height and number of tillers. The results are in confirmative with the findings of Krishnamurthy (1988) [6].

Number of tillers per hill

Number of tillers per hill were significantly higher in 50 cm x 50 cm + 100% RDF (14.56/hill). Spacing of 50 cm x 50 cm + 75% RDF (13.67/hill) was found to be at par with 50 cm x 50 cm + 100% RDF.

There is higher number of tiller per plant in SCI method than other method because tillering was furnished under wider spacing as compared to closer spacing. Under wider spacing preferably square planting exerts less competitive pressure within plants in one hill and among plants in the field as a result tailoring was higher under wider spacing. The results are in conformity with the findings of Kewat *et al.* (2002) and Nayak *et al.* (2003). Better aeration at wider spacing resulted in healthy plant growth with more tillers. These results were in conformity with the findings of Prakasha *et al.* (2018).

Dry weight (g/hill)

Maximum dry weight (101.80 g/hill) is recorded in 50 cm x 50 cm + 100% RDF and at par values were noticed in the treatment of 50 cm x 50 cm + 75% RDF (99.90 g/hill).

Nitrogen application has been found to increase the growth, dry matter production and yield under dry/rainfed conditions (Hariprasanna, 2016). Better accumulation of dry matter in the form of shoot and root development has led to more uptake of potassium. Increased content and/or uptake of K due to increased nitrogen and potassium has been reported by Yadav *et al.* (2011).

Crop Growth Rate

From the table 2 at 90-105 DAT, significantly most maximum crop growth rate (13.03 g/m^2/day) was recorded in 50 cm x 50 cm + 100% RDF. However, rest of the treatments are not found at par values.

Relative Growth Rate

At 90-105 DAT, highest relative growth rate (0.039 g/g/day) was observed in 50 cm x 50 cm + 100% RDF and lowest relative growth rate (0.015 g/g/day) was noticed in 25 cm x 15 cm + 100% RDF.

Yield attributing parameters

Grain yield

However, maximum grain yield (4571.32 kg/ha) was found to be significantly higher in treatment with wider spacing of 50 cm x 50 cm + 100% RDF. Treatments 50 cm x 50 cm + 75% RDF, 50 cm x 50 cm + 50% RDF and 40 cm x 40 cm + 100% RDF (4472.76, 4470.60 and 4133.30 kg/ha) were found to be at par with the treatment 50 cm x 50 cm + 100% RDF.

Synthesis, accumulation and translocation of photosynthates depend upon efficient photosynthetic structure, extent of translocation into sink (grains) and also plant growth and development during early stages of crop growth. The production and translocation of synthesized photosynthates depends upon mineral nutrition supplied. These results are in accordance with the findings of Puttaswamy and Krishnamurthy (1975) [12], Pandushastry (1977) [9] and Reddy (1974) [14].

Table 1: Effect of square planting and fertilizer levels on growth attributing parameters of finger millet

Treatments	At harvest				
	Plant height (cm)	Number of leaves/hill	Leaf Area Index	Number of tillers/hill	Dry weight (g/hill)
30 cm x 30 cm + 50% RDF	95.06	54.22	4.07	8.11	68.13
30 cm x 30 cm + 75% RDF	96.98	62.22	4.19	8.78	72.66
30 cm x 30 cm + 100% RDF	97.02	70.33	5.12	10.11	77.56
40 cm x 40 cm + 50% RDF	100.10	79.00	5.69	10.22	81.52
40 cm x 40 cm + 75% RDF	101.96	87.00	5.73	10.89	85.82
40 cm x 40 cm + 100% RDF	104.89	87.22	6.11	11.89	89.93
50 cm x 50 cm + 50% RDF	108.04	91.44	7.07	12.56	94.47
50 cm x 50 cm + 75% RDF	112.18	94.33	8.08	13.67	99.90
50 cm x 50 cm + 100% RDF	113.81	96.56	11.26	14.56	101.80
25 cm x 15 cm + 100% RDF	90.04	54.00	3.88	6.33	50.87
F-test	S	S	S	S	S
S.Em±	0.85	2.84	0.33	0.39	1.68
CD (P=0.05)	2.53	8.44	0.99	1.16	5.00

Table 2: Effect of square planting and fertilizer levels on CGR, RGR and grain yield of finger millet

Treatments	90-105 DAT	90-105 DAT	At harvest
	CGR (g/m^2/day)	RGR (g/g/day)	Grain yield (kg/ha)
30 cm x 30 cm + 50% RDF	7.47	0.016	2967.64
30 cm x 30 cm + 75% RDF	7.58	0.018	3013.68
30 cm x 30 cm + 100% RDF	7.98	0.021	3370.09
40 cm x 40 cm + 50% RDF	8.17	0.022	3446.19
40 cm x 40 cm + 75% RDF	8.61	0.024	3608.61
40 cm x 40 cm + 100% RDF	8.75	0.028	4133.30
50 cm x 50 cm + 50% RDF	9.45	0.031	4470.60
50 cm x 50 cm + 75% RDF	9.63	0.037	4472.76
50 cm x 50 cm + 100% RDF	13.03	0.039	4571.32
25 cm x 15 cm + 100% RDF	6.29	0.015	2727.04
F-test	S	NS	S
S.Em±	0.92	0.008	163.29
CD (P=0.05)	2.74	-	495.15

Conclusion

It is concluded that the treatment combination of spacing 50 cm x 50 cm with 100% RDF was found to be the best for obtaining maximum plant height, number of leaves per hill, Leaf Area Index, number of tillers per hill, plant dry weight, crop growth rate, relative growth rate and grain yield.

Although the experimentation is based on one season, further research is needed to confirm the findings and it's recommendation.

Acknowledgement

I express gratitude to my advisor and all the faculty members for constant support and guidance to carry out the research work.

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