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Effect of Population Density and Row Spacing on Yield and Yield Components of Finger Millet (*Eleusine Coracana* L.) in Northwestern Ethiopia

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Abstract

Finger millet is one of the main grain crops grown in Northwestern Ethiopia and broadcasting is the dominant planting method of finger millet production in the country. The objective of the present study was to assess the effect of inter and intra row spacing and determine the appropriate spacing and population density in finger millet production. The experiment was conducted at Pawe agricultural research center in 2012 and 2013 cropping season. Five inter (20 cm, 30 cm, 40 cm, 50 cm and 60 cm) and three intra (10 cm, 15 cm and 20 cm) row spacing with one finger millet variety i.e. Baruda were used. The trial was laid down in Randomized Complete Block Design (RCBD) and replicated three times. Analysis of variance revealed a significant variation (P<0.05 and P<0.01) among treatments for all studied traits except finger length and lodging. The highest yield performance for two consecutive years i.e. 2012 and 2013 was recorded by treatment 20 cm × 10 cm with a yield of 6.67 ton/ha and 7.47 ton/ha respectively. Hence, the experiment was done in one location using one finger millet variety, so that further experiment using more than one location and finger millet variety is recommended to approve the result and used for future finger millet production.

Keywords: Finger millet; Population density; Row spacing

Introduction

Finger millet (*Eleusine coracana* L. Gaertn) is a widely grown cereal in semi-arid areas of east and southern Africa and south Asia. It is the primary food source for millions of people in tropical dry land regions. The crop also has excellent storability and nutritional qualities superior to that of rice and is on par with wheat [1]. The crop is also adapted to a wide range of tropical soils, ranging from red lateritic to sandy loams and black heavy vertisols [2]. It is estimated that some 10% of the world's 30 million tons of millet produced is finger millet [3]. Finger millet is used in various food preparations. It is usually converted into flour and made into cakes, bread and other bakery products. The sprouted seeds are also nutritious and easily digested. Millets are staple foods that supply a major portion of calories and protein to large segments of populations in the semi-arid tropical regions of Africa and Asia [4]. The grain may also be malted and a flour of the malted grain is used as a nourishing food for infants [5].

Generally the production of finger millet is still at subsistence level by small scale farmers and consumed as staple food and drink in most areas where the crop is grown. The crop has high impact on the poor farmers for food security and source of energy and protein for about 130 million people in sub-Saharan Africa [6]. The crop is important because it plays role in both the dietary needs and incomes of many rural households where it is grown. But still it is neglected and underutilized crop. Ethiopia is the center of diversity for finger millet also called Dagussa in Amharic mainly grown in north western and south western part of the country [7]. The crop is grown from sea level up to about 2400 m.a.s.l with a wide range of soil types and tolerates notable high rainfall and certain degree of alkalinity. Finger millet is one of the dominant staple cereal crops grown in Metekel zone of Benishangul Gumuz Regional State. In the region 21,311 ha of land is cultivated and a total of 426,554 quintals of finger millet was produced in 2018 [8].

It has no major storage pest problem and so can be stored cheaply for a long time provided it is dried well to low moisture content. Moreover, it has high nutritional value and excellent storage qualities [9]. These attributes combine to make finger millet a suitable crop for ensuring food security in drought prone areas of the countries that grows it. The straw is used as animal feed and for roof thatching. Broadcasting is the dominant practice done during planting of finger millet and other crops in the country. Row planting in general has many advantageous in contrast to broadcasting. Previous research work on plant population studies on finger millet indicated that most vigorous finger millet was observed when finger millet was planted at 20-30 cm spacing [10]. Planting finger millet in rows gives the highest grain yield as compared to broadcasting [10,11]. Row planting in general has many advantageous in contrast to broadcasting. Earlier research work on plant population density studies on finger millet indicated that most vigorous finger millet was observed when finger millet was planted at 20-30 cm spacing [10]. The previous work by Shinggu et al. and GRDC revealed that planting finger millet in rows gives the highest grain yield as compared to broadcasting [10,11]. As indicated by Anon, the major constraints of broadcasting in finger millet production in the field is weed management which leads to difficulty in crop management and as such requires high labour input from seed sowing to crop harvesting which further demands high production cost [12].

Similarly, the problems are faced in those farmers producing finger millet in Metekel zone. Predominantly the finger millet variety called baruda has not yet deffined spacing and population density to be used. Therefore, the present study was initiated with the objective to determine the recommended spacing and population density of baruda variety of finger millet. The variety Baruda, is released by Pawe agricultural research center in 2009.

Materials and Methods

Description of experimental site

The experiment was conducted in 2012 and 2013 cropping season at the experimental farm of Pawe agricultural research center in Metekel zone. Pawe Agricultural Research Center (PARC) is located in Benshangul Gumuz National Regional State which is about 575 km north-west of Addis Ababa at 36°25'E longitude, 11°12'N latitude and at an altitude of 1150 meters above sea level (masl). The area is characterized by hot humid conditions with mean maximum and minimum temperatures of 32°C and 16°C, respectively. The annual rainfall ranges from 1500 mm-1800 mm with long rainy season.

Experimental materials and design

The treatments used were five inter (20 cm, 30 cm, 40 cm, 50 cm and 60 cm) and three intra (10 cm, 15 cm and 20 cm) row spacing and a total of 15 treatments using one finger millet variety i.e. baruda (Table 1). The trial was laid down in Randomized Complete Block Design (RCBD) and replicated three times. Each plot has five rows with row length of 5 m. For plot management and data collection 1.5 m path was left between each block. Both urea and DAP fertilizer were applied at the recommended rate of 100 kg/ha. The whole DAP was applied at once during sowing whereas split application was done for urea. Fertilizer application was carried out 100 kg ha of DAP (Nitrogen=18% and Phosphate=46%) as a basal dose, and 100 kg ha^{-1} of urea (nitrogen=46%) as top dressing following the procedure described by Upadhyaya et al. Sowing was done by hand drilling at the seed rate of 6 kg/ha and thinning applied at the right time and the required number of population was maintained.

No.	Treatments	Variety/finger millet/
1	20 cm × 10 cm	Baruda
2	30 cm × 10 cm	Baruda
3	40 cm × 10 cm	Baruda
4	50 cm × 10 cm	Baruda
5	60 cm × 10 cm	Baruda
6	20 cm × 15 cm	Baruda
7	30 cm × 15 cm	Baruda
8	40 cm × 15 cm	Baruda
9	50 cm × 15 cm	Baruda
10	60 cm × 15 cm	Baruda
11	20 cm × 20 cm	Baruda
12	30 cm × 20 cm	Baruda
13	40 cm × 20 cm	Baruda
14	50 cm × 20 cm	Baruda
15	60 cm × 20 cm	Baruda

Table 1: List of treatments used in the experiment.

Data collected and data analysis

Agronomic data were collected on plot and plant basis which includes, plant height (cm), number of fingers per plant, number of tillers per plant, finger length (cm) were evaluated on five randomly taken plants from the middle three rows in each plot. On the other hand stand count at harvest, days to flowering, days to maturity, disease, lodging and grain yield (g) were taken in plot base and the grain yield (g) of the middle three rows in each plot was measured and converted to quintal per hectare for analysis. All the necessary agronomic data were collected and subjected for analysis using SAS software [13].

Result and Discussion

The combined analysis of variance mean squares of all agronomic traits across the two years showed significant variation ($p<0.05$) for plant height, number of tillers and number of fingers (Table 2). The plant height ranged from 106.16 cm to 120.83 cm (Table 3). The tallest was recorded by treatment 60 cm × 10 cm (120.83 cm) followed by treatment 40 cm × 10 cm (120.33 cm). The shortest was observed by treatment 60 cm × 20 cm (106.16 cm). The number of tillers, number of fingers and finger length are the main yield determinant parameters of finger millet. The highest number of tillers was observed by treatment 60 cm × 15 cm (7.0) and the lowest was recorded by 50 cm × 20 cm (5.16) (Table 2). In case of number of fingers the maximum was obtained from treatment 50 cm × 20 cm (9.66) and the minimum was from treatment 30 cm × 15 cm (8.0).

Sources of variation	Mean squares						
	Df	PHT	NOT	NOF	FL	LOD	GYD
Treatment	14	119^*	2.2^*	1.3^*	0.75^{NS}	1086.4	1376.6^{**}
Replication	2	820	1.2	1.8	0.67	717.5	83.09
Year	1	6084	32.4	413.8	4.01	23716	1.34
Error	72	121.2	2.2	1.7	1.5	683.5	123.5

Note: NS=Non-Significant, *=Significant at 0.05 probability level, **=Significant at 0.01 probability level. Df=Degree of Freedom, PHT=Plant Height, NOT=No. of Tillers, NOF=No. of Fingers, FL=Finger Length, LOD=Lodging, GYD=Grain yield.

Table 2: Analysis of variance for different agronomic traits.

In the present study significant variations were not showed among treatments for finger length. On the other hand, a highly significant variation ($p<0.01$) was observed among treatments in their grain yield (Table 2). The yield ranges from 2.41 ton/ha to 7.07 ton/ha and the highest yield was recorded by the treatment 20 cm × 10 cm (7.07 ton/ha) which is followed by 20 cm × 15 cm (6.56 ton/ha) whereas the lowest was obtained by treatments 60 cm × 15 cm (2.41 ton/ha) as indicated in (Table 3). Grain yield is the end result of many complex morphological and physiological processes occurring during the growth and development of crop [14].The highest yield performance for two consecutive years i.e. 2012 and 2013 was recorded by treatment 20 cm × 10 cm with a yield of 6.67 ton/ha and 7.47 ton/ha respectively (Table 4). Similar results were obtained in which narrow spacing (10 cm) gave a better yield and weed control than wider spacing [10].

Treatment	PHT	NOT	NOF	FL	LOD	GYD
20 × 10	115.66	5.83^{ab}	9.16^{ab}	14.83^{a}	51.67^{a}	7.07^{a}
30 × 10	118.16^{ab}	5.66^{ab}	9.16^{ab}	15.5^{a}	41.33^{abc}	6.126^{ab}
40 × 10	120.33^{a}	6.66^{ab}	8.5^{ab}	15.5^{a}	41.67^{abc}	3.32^{cd}
50 × 10	111.83^{ab}	6.66^{ab}	8.33^{ab}	15.5^{a}	43.33^{ab}	3.23^{cd}
60 × 10	120.83^{a}	5^{b}	8.16^{ab}	15.16^{a}	34.67^{abcd}	2.44^{cd}
20 × 15	114.33^{ab}	5.50^{ab}	8.83^{ab}	15.33^{a}	35^{abcd}	6.56^{a}
30 × 15	115.66^{ab}	5.83^{ab}	8^{b}	15.5^{a}	42.50^{abc}	3.40^{cd}
40 × 15	117^{ab}	5.50^{ab}	8.33^{ab}	14.83^{a}	25^{abcd}	3.22^{cd}
50 × 15	112.16^{ab}	6.5^{ab}	8.33^{ab}	15.66^{a}	20.83^{bcd}	3.27^{cd}
60 × 15	109.33^{ab}	7^{a}	9^{ab}	15.83^{a}	19.17^{bcd}	2.41^{d}
20 × 20	107.16^{b}	6.66^{ab}	8.66^{ab}	15.33^{a}	21.67^{abcd}	5.19^{b}
30 × 20	114.16^{ab}	6.33^{ab}	8.83^{ab}	15.5^{a}	16.67^{bcd}	3.725^{c}
40 × 20	110.16^{ab}	5.83^{ab}	8.33^{ab}	15.5^{a}	13^{cd}	3.38^{cd}
50 × 20	111^{ab}	5.16^{b}	9.66^{a}	15^{a}	14.17^{bcd}	2.71^{cd}
60 × 20	106.16^{b}	5.83^{ab}	9.33^{ab}	16.16^{a}	9.17^{d}	3.18^{cd}
Mean	113.6	6	8.74	15.4	28.65	4.02
CV	9.7	24.57	14.94	8.01	91.23	2.82
LSD (5%)	12.67	1.69	1.5	1.42	30.09	1.28

Note: PHT=Plant Height, NOT=No. of Tillers, NOF=No. of Fingers, FL=Finger Length, LOD=Lodging, GYD=Grain Yield

Table 3: Mean value of different agronomic traits.

However, the highest lodging was recorded by treatment 20 cm × 10 cm, which is the narrower row spacing, might be due to low plant strength due to nutrient competition and higher plant population. These imply that yield increases to optimal row spacing. Further increasing in row spacing from 30 cm to 40 cm, 50 cm and to 60 cm caused yield reduction. This result is in accordance with the results of GRDC who recommended that row spacing of 30 cm and closer plant to plant spacing helps in better establishment of finger millet. The research of Fawcett R.G and Auld et al. indicated a lower rate of yield loss in cereals with row space widening as plant populations increased [15,16].

Treatment	Yield (t/h)		
	2012	2013	Mean
20 × 10	6.67	7.47	7.07
30 × 10	6.25	5.98	6.12
40 × 10	3.61	3.03	3.32
50 × 10	3.46	2.99	3.23
60 × 10	2.33	2.56	2.44
20 × 15	6.78	6.33	6.56
30 × 15	3.31	3.49	3.4
40 × 15	2.87	3.57	3.22
50 × 15	3.23	3.32	3.27
60 × 15	2.03	2.79	2.41
20 × 20	7.07	5.6	6.33
30 × 20	3.83	3.6	3.72
40 × 20	3.87	2.89	3.38
50 × 20	2.96	2.46	2.71
60 × 20	3.4	2.96	3.18

Table 4: Mean grain yield of finger millet (Baruda variety) for two years (2012/2013).

Conclusion

In conclusion, the present study revealed and confirmed that the narrower spacing the higher yield was recorded in the two experimental years as well as the mean i.e. 20 cm × 10 cm, 20 cm × 15 cm and 20 cm × 20 cm. However, this result is applicable for only Baruda variety of finger millet. In fact the experiment was done in one location using one finger millet variety, so that further experiment using more than one location and finger millet variety is recommended to approve the result and used for future finger millet production.

Conflict of Interest

The author declares no conflict of interest.

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