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Original Research Article

Determination of Seed Rate and Inter Row Spacing for Finger Millet Production (*Eleusine Coracana* Gaertn.) in North Western Ethiopia

Yayeh Bitew, Fekremariam Asargew

Agronomist, Adet Agricultural Research Centre, Amhara Agricultural Research Institute, P .O. Box 08, Bahir Dare, Ethiopia

Corresponding author: Yayeh Bitew

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ABSTRACT

Finger millet is one of the main crops grown in Northwestern Ethiopia. Broadcasting is the dominant planting method of finger millet production in the country. An experiment was conducted on the effect of seed rate and row spacing on the growth, yield and yield component of finger millet at Adete and Finoteselam research station during 2011-2012 cropping seasons. Four seed rates (10, 15, 20 and 25 kg/ha) and four row spacing (20, 30, 40 and 50 cm) were factorially combined. The experimental design was a completely randomized block with three replications. JMP5-SAS, computer software was used to compute the analysis of variance. Seed rate did not significantly affect plant height, number of heads, number of fingers, lodging, blast diseases, total dry biomass and grain yield of finger millet. Similarly, interaction between seed rate and row spacing had not significant effect on the yield and yield component of finger millet. On the other hand, row spacing significantly affect lodging and grain yield of finger millet. Thus, due to relative increment in yield components and reduction of lodging and blast diseases infestation, highest grain yield was recorded when finger millet was planted at 30 cm row spacing. Planting finger millet at the lowest seed rate (10kg/ha) at 30 cm row spacing gave the optimum grain yield of finger millet. However, when the farmers consider the straw yield as business, partial budget analysis showed that at the current cost of the grain and straw yield of finger millet, planting 25 kg/ha and 20 kg/ha seed rate of finger millet in 30 cm row spacing gave the first and second highest net benefit.

Key words: Finger millet, seed rate, row spacing.

INTRODUCTION

Finger millet (*Eleucine coracana* (L.) Gaertn.) is a staple cereal food crop for millions of people in the semi arid region of the world, particularly in Africa and India, and especially those who live by subsistence farming. [1] Ethiopia is the center of diversity for finger millet. [2] It is mainly grown in northern, north-western and south-western part of the country. It is grown from sea level up to about 2400 m a.s.l and grown in a wide range of soil types and tolerate notable high rainfall and certain degree of alkalinity. It is used in many forms for human food. The grain serves for preparation of both food and malt items. [3] Finger millet is one of the dominant cereal crops grown in the Amhara region specifically in West Gojam (77417 ha), South Gondar (31673 ha), North Gondar

(62441 ha) and Awi zone (54095 ha). [4] Finger millet is a more nutritious food than other cereals. [5,6] Even though, the area cultivated to finger millet using customary method increased by 5.7 % from 2008 to 2011, the research effort was very limited and lacked improved production packages for the production of the crop. Consequently, farmers used the traditional system of production and the yield was limited to 1507 kg/ha [4] though finger millet has high yield potential of 3000 kg/ha. [7]

Seeding rate and row spacing are tied together. If the population is too high, plants compete with each other and often lodge. If the population is too low, a producer is wasting growing space and lowering yield. [8] 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 20-30cm spacing and 10-15 kg seed rate per hectare. [1] Planting finger millet in rows gives the highest grain yield as compared to broadcasting. [1,9] The planting method for finger millet in the major producing areas of Ethiopia is broadcasting. One of the major constraints of broadcasting in finger millet production in the field is weed management [10] which leads to difficulty in crop management and as such requires high labour input from seed sowing to crop harvesting. Hence, determination of optimum seed rate and inter row spacing for finger millet is one area to be considered for raising productivity and production of finger millet in the region. This therefore calls for the present study aimed at determining the most suitable seed rate and row spacing that can give the optimum yield of finger millet in Ethiopia.

MATERIALS AND METHODS

The experiment on the effect of seed rate and row spacing on yield and yield component of finger millet was conducted for three years, 2010-2012 at *Adete* and *Fenotselam* research stations in North western Ethiopia. The Former is located between$11^0 17'$ N latitude and 37^0 $43'$ E longitude with an altitude of 2240 m.a.s.l and the later is located between 37^0 $16'$ E latitude and10^0 $42'$ N longitude with an altitude of 1917 m.a.s.l. At *Adete* area the mean annual total rain fall is 1257mm, ranging between 860 mm and 1771 mm and the average annual temperature is ranging from 9^0C to 25.5^0C. At *Finoteselam* area the average monthly rain fall is ranging between 4 mm to 210 mm and the average monthly temperature is ranging from 8^0C to 17^0C. The rainfall and temperature during the experimental months are presented in Figures 1 and 2 below. The chemical characteristics of the soil at Adet are: total N (%), organic carbon (%), CEC, exchangeable K, available P and PH 0.8, 2.47, 37.97, 33.29, 1.98 and 5.17, respectively. Similarly, the chemical characteristics of the soil at Finoteslam are: total N (%), organic carbon (%), organic matter (%), available P and PH 0.02, 3.57, 6.164, 1.98 and 5.17, respectively. [11] The experimental designs were factorial randomized complete block design with three replications. Four seed rates (10, 15, 20 and 25 kg/ha) and four inter-row spacing (20, 30, 40 and 50 cm) were factorially combined. Seeds of the improved variety "Degu" were drilled at proposed row spacing and seed rate at both locations. The net plot size was 3m width by 5m length and the distance between each plot and replication were 0.5 m and 1m, respectively. Data for plant height, length of fingers, No of heads per m^2, fingers per $m^2$and biomass and grain yield in kg per hectare were collected from the proposed net plot size. Disease levels were determined by using the 0-9 score. [12] Lodging index was calculated using the formula developed by; [13]

$$\text{Lodging Index} = \frac{\sum(\text{lodging score x their respective \% of area lodged})}{5}$$

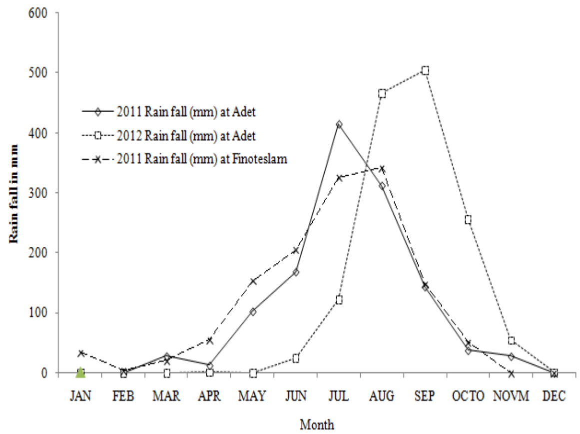

Figure 1: Rain fall (mm) distribution at the experimental sites during the experimental seasons.

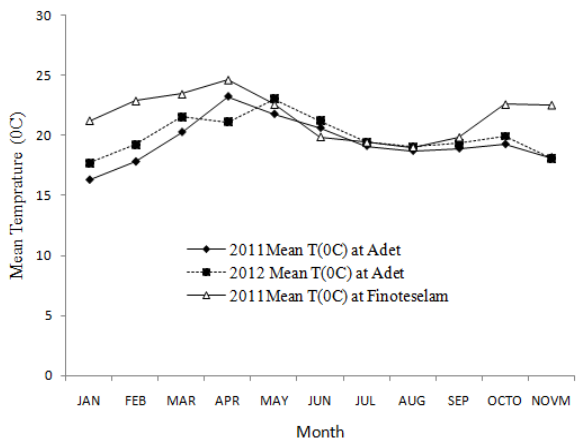

Figure 2: Mean temperature (^{0}C) at the experimental sites during the experimental seasons.

Data Analysis

The data's were subjected to analysis of variance using [14] computer software. Combined analysis of variance was made over the two locations and years for all agronomic traits. Diseases and lodging data were transformed using square root transformation method. In all the comparisons, the level of significance was set at α = 0.05. Mean comparison for the treatments were computed using Tukey HSD Test. The combined mean grain and straw yield data were adjusted down by 10 % and subjected to Partial budget analysis. [15] The marginal rate of return (MRR) was calculated for each non dominated treatment and minimum acceptable MRR of 100% was assumed.

RESULTS AND DISCUSSION

Results of combined analysis of variance across years and location showed that except for length of fingers at Adet, seed rate did not significantly affect (P>0.05) plant height, number of heads, number of fingers lodging, blast diseases, total dry biomass and grain yield of finger millet (Tables 1-3). The length of fingers was significantly longer at seed rate 15 kg as compared to seed rate 20 kg at *Adet* (Table 1). Similarly, except combined grain yield across years at *Adet* results of combined analysis of variance across years at each location (*Adet and Finoteslam*) and across location illustrated that interaction between seed rate and row spacing had no significant effect (P>0.05) on the yield and yield component of finger millet. The highest grain yield at *Adet* was recorded at 10 kg/ha seed rate and 30 cm row spacing (3235.98 kg/ha) while the lowest was recorded at 20 kg/ha seed rate and 20 cm row spacing (2862.63 kg/ha)) (Table 1).

In the present study, the combined analysis of the two years at Adet, showed that row spacing significantly affected (P<0.01) the plant height, blast diseases infestation, lodging index and grain yield (Table 1). Though, in combined of two years planting finger millet in 30 cm and 40 cm row spacing were on par with each other on grain yield, the highest mean lodging index and grain yield were observed when finger millet was planted in 20 cm (45.27%) and 30 cm (2883.77 kg/ha) row spacing whereas the lowest value were recorded in 50 cm (16.39 %) and 20 cm (2457.52 kg/ha) row spacing, respectively (Table 3). At *Adet* the highest and the lowest blast diseases were recorded at 20 cm (2.280 and 50 cm (1.58), respectively. On the other hand, at

Finoteslam except, grain yield and lodging, all other yield components as indicated in Table 2 were not significantly affected by row spacing. The highest and the lowest grain yield were recorded at 30 cm (2432.47 kg/ha) and 50 cm (2147.23 kg/ha), respectively. At *Fenoteslam*, row spacing of 20cm (7.44) and 50cm (3.63) gave the maximum and the minimum lodging of finger millet (Table 2). The combined analysis of the two location showed that 30cm row spacing (2883.77 kg/ha) give the maximum while 20cm (2457.52 kg/ha) give the minimum grain yield (Table 3). Similarly, row spacing of 20cm (6.4) and 50cm (3.2) gave the maximum and the minimum lodging of finger millet (Table 3).

Table 1 Combined main and interaction effects across two years (2011-2012) on the yield and yield component of finger millet at Adet research station.

Source of variations	PH	LF	N0H	N0F	LI	BD	TDB	GY
Effect of seed rate on the yield and yield component of finger millet								
10 kg/ha	99.29	11.67[a]	216.00	1443.75	3.50	1.78	8083.87	3136.96
15 kg/ha	99.27	11.10[b]	210.83	1379.17	3.45	1.78	8416.35	3095.43
20 kg/ha	99.45	11.26[ab]	202.92	1335.67	4.50	2.07	8495.05	2977.37
25 kg/ha	99.87	11.24[ab]	208.25	1399.92	4.48	2.05	8755.13	3022.66
Mean	99.47	11.32	209.50	1389.63	3.98	1.92	8437.60	3058.11
LSD (5%)	NS	*	NS	NS	NS	NS	NS	NS
Effect of row spacing on the yield and yield component of finger millet								
20 cm	95.72[b]	11.25	201.92	1321.08	5.35[a]	2.28[a]	8160.26	2747.88[b]
30 cm	99.12[ab]	11.36	210.83	1382.50	3.99[ab]	1.94[ab]	8795.14	3335.07[a]
40 cm	103.18[a]	11.43	213.58	1398.58	3.85[ab]	1.89[ab]	8470.00	3059.58[ab]
50 cm	99.87[ab]	11.27	211.67	1456.33	2.75[b]	1.58[b]	8325.00	3089.88[ab]
Mean	99.47	11.33	209.50	1389.62	3.99	1.92	8437.60	3058.10
LSD (5%)	**	NS	NS	NS	**	**	NS	**
Interaction between seed rate and row spacing								
Mean	99.47	11.32	209.50	1389.63	3.98	1.92	8437.59	3058.10
LSD (5%)	NS	NS	NS	NS	NS	NS	NS	*
CV (%)	5.6	4.5	25.7	11.8	48.5.0	9.9	11.9	10.4

Note: Means followed by the same letter in columns are not significantly different at 5% of probability level according to Tukey HSD Test. On the table PH , LF , N0H, N0F, LI, BD, TDB and GY refers to plant height in cm, Length of fingers in cm, number of heads per m^2, Number of fingers per m^2 , Lodging index in % (Square-root transformed), Blast diseases infestation (0-9 scale),Total dry biomass in kilogram/ha and Grain yield in kilogram/ha, respectively

Table 2 Combined main and interaction effects across two years (2011-2012) on the yield and yield component of finger millet at finoteslam research station

Source of variations	PH	LF	N0H	N0F	LI	BD	TDB	GY
Effect of seed rate on the yield and yield component of finger millet								
10 kg/ha	108.10	12.69	181.11	1302.81	4.69	3.10	10376.8	2330.83
15 kg/ha	112.04	12.22	172.56	1238.21	4.97	3.10	10782.6	2283.59
20 kg/ha	118.27	12.62	169.87	1221.73	5.96	3.10	10042.0	2277.74
25 kg/ha	114.41	12.92	174.44	1247.97	6.37	3.10	10461.4	2255.93
Mean	113.21	12.61	174.49	1252.68	5.49	3.10	10415.70	2287.02
LSD (5%)	NS	NS	NS	NS	NS	NS	NS	NS
Effect of row spacing on the yield and yield component of finger millet								
20 cm	117.25	12.89	170.25	1218.29	7.44[a]	3.21	9834.8	2167.15[b]
30 cm	114.73	12.55	174.83	1252.01	5.15[ab]	3.05	10156.7	2432.47[a]
40 cm	114.16	12.55	186.09	1328.64	5.78[ab]	3.05	10545.9	2401.25[a]
50 cm	106.69	12.46	166.79	1211.77	3.63[b]	3.09	11125.4	2147.23[b]
Mean	113.21	12.61	174.49	1252.68	5.50	3.10	10415.70	2287.03
LSD (5%)	NS	NS	NS	NS	*	NS	NS	*
Interaction between seed rate and row spacing								
Mean	113.21	12.61	174.49	1252.68	5.50	3.10	10415.69	2287.02
LSD (5%)	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	10.2	6.2	14.8	13.6	46.7	6.4	11.4	13.5

Note: Means followed by the same letter in columns are not significantly different at 5% of probability level according to Tukey HSD Test. On the table PH , LF , N0H, N0F, LI, BD, TDB and GY refers to plant height in cm, Length of fingers in cm, number of heads per m^2, Number of fingers per m^2 , Lodging index in % (Square-root transformed), Blast diseases infestation (0-9 scale),Total dry biomass in kilogram/ha and Grain yield in kilogram/ha, respectively.

Table 3 Combined main and interaction effects across two locations and years on the yield and yield component of finger millet

Source of variations	PH	LF	N0H	N0F	LI	BD	TDB	GY
Effect of seed rate on the yield and yield component of finger millet								
10 kg/ha	103.69	12.19	198.55	1373.28	4.095	2.44	9230.32	2733.89
15 kg/ha	105.65	11.66	191.69	1308.69	4.21	2.44	9599.47	2689.51
20 kg/ha	108.86	11.94	186.39	1278.70	5.23	2.59	9268.50	2627.56
25 kg/ha	107.14	12.08	191.35	1323.94	5.425	2.58	9608.28	2639.29
Mean	106.33	11.97	191.99	1321.15	4.74	2.51	9426.64	2672.56
LSD (5%)	NS	NS	NS	NS	NS	NS	NS	NS
Effect of row spacing on the yield and yield component of finger millet								
20 cm	106.49	12.06	186.09	1269.69	6.395^{a}	2.75	8997.51	2457.52^{b}
30 cm	106.92	11.95	192.83	1317.26	4.57^{ab}	2.50	9475.90	2883.77^{a}
40 cm	108.67	11.99	199.84	1363.61	4.815^{ab}	2.47	9507.95	2730.42^{a}
50 cm	103.28	11.86	189.23	1334.05	3.19^{b}	2.33	9725.20	2618.55^{ab}
Mean	106.34	11.97	192.0	1321.15	4.7425	2.51	9426.64	2672.57
LSD (5%)	NS	NS	NS	NS	*	NS	NS	**
Interaction between seed rate and row spacing								
Mean	106.34	11.97	191.99	1321.15	4.74	2.51	9426.65	2672.56
LSD (5%)	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	5.6	4.2	10.9	8.9	48.5.0	9.9	8.2	9.3

Note: Means followed by the same letter in columns are not significantly different at 5% of probability level according to Tukey HSD Test. On the table PH , LF , N0H, N0F, LI, BD, TDB and GY refers to plant height in cm, Length of fingers in cm, number of heads per m^2, Number of fingers per m^2 , Lodging index in % (Square-root transformed), Blast diseases infestation (0-9 scale),Total dry biomass in kilogram/ha and Grain yield in kilogram/ha, respectively.

Table 4 partial budgets for an experiment on finger millet seed rate and drill row planting

Treatments (Seed rate by row spacing)	Adjusted grain yield (kg/ha)	GGB (Eth. birr/ha)	Adjusted straw yield (kg/ha)	GSB (Eth. birr/ha)	TGFB (Eth. birr/ha)	TVC (Eth.birr)	NB (Eth.birr)	MRR (%)
10kg/ha@50cm	2434.86	24348.6	9512.64	23781.6	48130.2	160	47970.2	
10kg/ha@40cm	2703.87	27038.7	12059.1	30147.75	57186.45	180	57006.45	4510
10kg/ha@30cm	2680.56	26805.6	12425.67	31064.18	57869.78	200	57669.78	3316
15kg/ha@50cm	2624.31	26243.1	10748.16	26870.4	53113.5	210	52903.5	D
10kg/ha@20cm	2339.46	23394.6	12233.61	30584.03	53978.63	220	53758.63	D
15kg/ha@40cm	2442.78	24427.8	12306.24	30765.6	55193.4	230	54963.4	D
15kg/ha@30cm	2514.24	25142.4	14373.27	35933.18	61075.58	250	60825.58	6311
20kg/ha@50cm	2501.46	25014.6	11898.54	29746.35	54760.95	260	54500.95	D
15kg/ha@20cm	2381.22	23812.2	13437.99	33594.98	57407.18	270	57137.18	D
20kg/ha@40cm	2542.41	25424.1	12276.63	30691.58	56115.68	280	55835.68	D
20kg/ha@30cm	2544.93	25449.3	14892.57	37231.43	62680.73	300	62380.73	3110
25kg/ha@50cm	2303.64	23036.4	12426.39	31065.98	54102.38	310	53792.38	D
20kg/ha@20cm	2115.63	21156.3	12947.85	32369.63	53525.93	320	53205.93	D
25kg/ha@40cm	2402.64	24026.4	12801.33	32003.33	56029.73	330	55699.73	D
25kg/ha@30cm	2807.73	28077.3	14479.74	36199.35	64276.65	350	63926.65	3091
25kg/ha@20cm	2253.96	22539.6	13259.52	33148.8	55688.4	370	55318.4	D

Note: GGB, GSB, TGFB, TVC, NB and MRR indicates: Gross grain yield benefit, Gross straw yield benefit, Total Gross field benefit, Total variable cost, Net benefit and Marginal rate of return, respectively. Price of finger millet= Birr 10/kg, Price of finger millet straw= Birr 2.50/kg, Seed cost of finger millet = Birr 10/kg (Average of 2013 and 2014), man power needed for 20 cm, 30cm, 40 cm and 50 cm row planting of finger millet = 6, 5, 4 and 3 man days/ha, respectively and labour cost/ man day= Birr 20

As planting finger millet from 20 cm to 30 cm row spacing the grain yield increased by 14.8 % in the combined of location (Table 3). This might be due to relative increment in yield components and reduction of lodging and blast diseases infestation. Highest gain yield in 30 cm as compared to narrow spacing (20 cm) could be also due to fewer nutrients, less light competition among the same plant in narrow spacing. [16] The highest lodging and biomass at narrower row spacing might be due to low plant strength due to nutrient competition and higher plant population, respectively. Further increase in row spacing from 30 cm to 40 cm and 50 cm caused 5.3 % and 9.2 % yield reduction, respectively (Table 3). These imply there could be optimal row spacing, suggesting increasing row spacing could increase grain yield initially, reach an optimum and further increases in row spacing would reduce yield. [17,18] This result is in accordance with the results of, [9] who recommended that row spacing of 30 cm and closer plant to plant spacing helps in better establishment of finger millet. The research of [19,20] indicated a lower rate of yield loss in cereals with row space widening as plant populations increased. In contrary, [1] reported narrow spacing (10 cm) gave a better yield and weed control than wider spacing.

However, when farmers consider the straw yield as business, according to partial budget analysis as indicated in Table 4, the first and the second highest net benefit were obtained from 25 kg/ha and 20 kg/ha seed rate of finger millet were planted in 30 cm row spacing, respectively.

CONCLUSION

The present study revealed that seed rate did not significantly affect plant height, number of heads, number of fingers lodging, blast diseases, total dry biomass and grain yield of finger millet. Similarly, interaction between seed rate and row spacing had not significant effect on the yield and yield component of finger millet. On the other hand, row spacing significantly affect lodging and grain yield of finger millet. Hence, due to relative increment in yield components and reduction of lodging and blast diseases infestation, highest grain yield was recorded when finger millet was planted at 30 cm row spacing. Planting finger millet at the lowest seed rate (10kg/ha) at 30 cm row spacing gave the optimum biological yield. However, when we consider the straw yield as business, partial budget analysis showed that at the current cost of the grain and straw yield of finger millet, planting 25 kg/ha and 20 kg/ha seed rate of finger millet in 30 cm row spacing gave the first and second highest net benefit.

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