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Influence of Row Spacing and Seed Rate on Yield and Yield Components of Finger Millet at Assosa Zone in Benshagul Gumuze Region of Ethiopia

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Abstract
Information on the response of finger millet to row spacing and seed rate in the Assosa Zone is scanty. Field experiments were conducted at two locations, for two years at each location, to investigate the response of finger millet to row spacing and seed rate. Three seed rates (5, 15, 25 kg/ha) and four row spacing (20, 30, 40 and 50 cm) were studied in factorial combinations in a randomized complete block design (RCBD) with triplicates. The results revealed substantial responses of finger millet to the interaction of seed rate & row spacing on plant height ,number of finger per ear, total biomass and grain yield. The finger millet height($p<0.05$) ,number of finger per ear($p<0.05$), total biomass($p<0.01$) and grain yield($p<0.01$) increased significantly. Grain yield highly significantly increased ($p<0.01$) from 1499.3to 1926.8[a] kg ha^{-1} with decrease the seed rate from the broadcast (25) to 15 kg ha^{-1}. The highest grain yield of (1926.8 kg ha^{-1}) was obtained from the seed rate 15kg/ha@40cm row spacing. In addition to this; partial budget analysis showed that at the current cost of the grain and straw yield of finger millet, planting 15 kg/ha seed rate of finger millet in 40 cm row spacing gave the first highest net benefit. The magnitude of increase in grain yield over the broadcast due to application of 15 kg seed per hectare & 40 cm spacing between rows were 22.2 % (427.5 kg ha-1) (Table. 2). Therefore, it can be concluded that the row spacing of 40 cm and the seed rate of 15 kg ha^{-1} is advisable and could be appropriate for finger millet production in the test area even though further testing is required to put the recommendation on a strong basis.

1. 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. (Shinggu C.P., Dadari S.A., Shebayan, J.A, Adekpe, D.I., Mahadi, M.A, Mukhtar A. A and sala S.W., 2009.) Ethiopia is the center of diversity for finger millet. (Zonary, D., 1970.) 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.

Finger millet agronomy plays a great role in increasing and sustaining Finger millet production and productivity. Soil nutrient application rates, schedule of nitrogen fertilizer application, seed rate, and planting methods are among the major agronomic practices which limit Finger millet productivity and production.

Seed rate is the most important agronomic aspect which needs due attention. When the plant density exceeds an optimum level, competition among plants for light above ground and nutrients below ground becomes severe (Bloch et al, 2002). Consequently plant growth slows down and the grain yield decreases. However, very low plant density may not enable attainment of the yield plateau (Hay and Wolker, 1989; Daughtry et al, 1983). It is therefore necessary to determine the optimum density of plant population per unit area to obtain maximum yields. It is also quite important to address plant density with respect to soil fertility and millet variety (Baloch et al, 2002; Frizzel et al, 2005).

Finger millet planting methods (broadcasting, row planting) are also among the major factors limiting finger millet production. Finger millet row planting is reported to have better yielding advantage over broadcast planting. 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. Generating the appropriate spacing considering varietal differences in terms of tillering capacity, length of finger, number of finger and plant morphology is important in the case of row planting (Baloch et al, 2002). Given to the fact that finger millet is a recently cultivated crop in Benishangul Gumuz Region , there is great gap with regard to specific agronomic recommendations for the finger millet producing areas of the region. This urges that a lot has to be done on finger millet agronomic experiments so as to have appropriate finger millet crop management recommendations.

In order to increase and sustain finger millet production and productivity of the country, it would be important to do seed rate and row spacing in the finger millet growing areas of region. In view of this, the activity was initiated with the objective of determining the optimum seed rate and planting method for finger millet production and interaction effect of row spacing and seeding rate for millet production under rained conditions in the Nitisols.

2. Materials and Methods

2.1. Description of the Study Area

This experiment was conducted at Assosa Zone, Assosa woreda western Ethiopia in the main rainy season of 2012 up to 2014 consecutive years. The research sites are found in the altitude ranging between 1300-1470 m.a.s.l. with the minimum and maximum temperatures are 14.5 and 28.8 ºC, respectively and an average annual rainfall of 1358mm of which 1128.5mm were received between May and October during the cropping season.

2.2. Treatments and Experimental Design

The fertilizer treatments considered in the study was consist of three seed rates (5, 15, 25 kg/ha) and four row spacing (20, 30, 40 and 50 cm). One additional plot of broadcast of finger millet seed at 25 kg/ha was considered as a standard check. The RCBD factorial with three replications of plot size of 5 m x 3.6 m was used. The trial was carried on research station and three farmers' field per location.. Urea and triple super phosphate was used as the source of N and P, respectively. Application of urea was in two split, while the entire rate of phosphorus was applied at sowing in band.

2.3. Soil Sampling

Soil samples were randomly collected from surface layer of the experimental field (i.e. 0-30 cm soil depth) to form composite before sowing and analyzed for the soil texture, pH, available P, total N, and OC (Organic Carbon). Besides, at harvesting, soil samples were also taken from each plot to determine the pH, total N, OC, and available P.

2.4. Laboratory Analyses

The soil samples were air-dried and ground to pass 2 and 0.5 mm sieves (for total N). All samples were analyzed following standard laboratory procedures. Organic carbon and total N contents of the soil were determined following the wet combustion method of Walkley and Black, and wet digestion procedure of Kjeldahl method, respectively. The available P content of the soil was determined following Olsen method. Soil texture was analyzed by Bouyoucos hydrometer method. The pH (1:2.5 solid: liquid ratio) of the soils was measured in water using pH meter with glass-calomel combination electrode.

2.5. Crop Management

The experimental land was well prepared. Each plot and block was separated by 1 m and 1.5m, respectively. Finger millet variety (Tadesse) was used for the experiment. Important agronomic practices like hoeing and weeding were uniformly applied to all experimental plots as often as required.

2.6. Plant Data Collection and Analysis

Central plants were used for data collection. Growth indicating parameters such as plant height, finger length, number of finger and grain yield was collected. The plant height (cm) was measured from the base of the plant to upper the top most leaves of the plant. The data was taken from ten randomly selected plants. The data was taken from ten randomly plants and the average value was computed. The grain yield from the middle was recorded and grain yield per hectare was calculated.

Analysis of variance was carried out for the yield studied following statistical procedures appropriate for the experimental design using SAS computer software. Whenever treatment effects was significant, the means were separated using the least significant difference (LSD) procedures test at 5 % level of significance. The combined mean grain and straw yield data were adjusted down by 10 % and subjected to Partial budget analysis. The marginal rate of return (MRR) was calculated for each non dominated treatment and minimum acceptable MRR of 100% was assumed (CIMMT, 1988).

3. Result and Discussion

3.1. Soil Physico-chemical Properties before Sowing

The textural classes of the soils were clayey, with varying proportions sand, silt and clay According to the rating of Landon (1991), the soil used for this study ranges from very strongly acidic (pH 4.29) to the neutral (pH 7.4) class indicating the possibility of Al toxicity and deficiency of certain plant nutrients. The exchangeable K of the soil before the application of the treatments ranges from 0.13 cmol(+) kg^{-1} to 0.42 cmol(+) kg^{-1}. All experimental soils had deficient to adequate K content. According to Landon (1991), available (Bray II extractable) soil P level of less than 10 ppm is rated as low, 11-31 ppm as medium and greater than 18 mg kg^{-1} is rated as high. Thus, most trial location had very low (bray II extractable) P (Table. 1). Following the rating of total N of > 1% as very high, 0.5 to 1% high, 0.2 to 0.5% medium, 0.1 to 0.2% low and < 0.1% as very low N status as indicated by Landon

(1991), the experimental soils qualify for very low total N. Similarly, the organic carbon (OC) content of the soil was also very low to low in accordance with Landon (1991), who categorized OC content as very low (< 2%), low (2- 4%), medium (4-10%), high (10-20%). The very low OC and low N content in the study area indicate low fertility status of the soil. This could be due to continuous cultivation and lack of incorporation of organic materials. (Table. 1)

Table 1. Chemical analysis of some parameters of soil prior to cropping.

No.	Location/kebels	Analyzed materials	pH	CEC	OC (%)	N (%)	P	K
1	Amba 14	Soil	4.78	17.2	1.68	0.15	3.4	0.192
2	Megel 33	Soil	4.29	25.9	2.14	0.15	3.2	0.288
3	On station	Soil	5.22	29.02	2.49	0.17	3.4	0.42
4	Amba-12	Soil	7.4	25.84	2.48	0.168	7.5	0.13

3.2. Yield and yield components

3.2.1. Grain Yield

Grain yield is the end result of many complex morphological and physiological processes occurring during the growth and development of crop (Khan et al., 2008). Significant influence (P<0.001) on the grain yield of finger millet due to treatment application was recorded on trial locations. The maximum grain yield (1926.8 ha^{-1}) was obtained from application of 15 kg seed per hectare & 40 cm spacing between rows. Grain yield highly significantly increased (p<0.01) from 1499.3to 1926.8^{a} kg ha^{-1} with decrease the seed rate from the broadcast (25) to 15 kg ha^{-1}. This could mainly be attributed to increase panicle length and plant height might have increased grain yield indirectly by increasing the number of grain per panicle. The magnitude of increase in grain yield over the broadcast due to application of 15 kg seed per hectare & 40 cm spacing between rows were 22.2 % (427.5 kg ha-1) (Table. 2).

Table 2.Influence of seed rate and row spacing on growth and yield of finger millet.

Treatments (Seed rate by row spacing)	Plant height (cm)	No. of Finger per ear	Panicle length(cm)	Biomass yield (t/ha)	Grain Yield (kg/ha)
5kg/ha@20cm	89.59^{abc}	4.26^{bc}	5	3.475^{b}	1437.4^{de}
5kg/ha@30cm	84.52^{c}	4.87^{ab}	5.2	3.658.3^{b}	1364.3^{e}
5kg/ha@40cm	90.35^{abc}	4.92^{ab}	4.96	4.375^{b}	1422.9^{de}
5kg/ha@50cm	88.72^{abc}	4.89^{ab}	5.26	4.658.3^{b}	1552.4^{b-e}
15kg/ha@20cm	86.98^{abc}	5.08^{a}	5.1	3.800^{b}	1307.2^{e}
15kg/ha@30cm	84.68^{c}	4.52^{abc}	5.14	4.725^{b}	1395.1^{de}
15kg/ha@40cm	91.84^{ab}	5.79^{a}	5.05	**4.450^{b}**	1926.8^{a}
15kg/ha@50cm	92.97^{a}	4.82^{ab}	5.05	4.516.6^{b}	1692.3^{a-d}
25kg/ha@20cm	85.27^{bc}	4.39^{abc}	5.13	3.916.6^{b}	1534.2^{b-e}
25kg/ha@30cm	89.36^{abc}	5.01^{a}	5.37	3.808.3^{b}	1506.3^{c-e}
25kg/ha@40cm	90.71^{abc}	4.02^{c}	5.1	4.200^{b}	1773.5^{a-c}
25kg/ha@50cm	89.93^{abc}	4.53^{abc}	5.02	4.150^{b}	1828.5^{ab}
Broad cast (25kg/ha)	87.8^{abc}	4.34^{abc}	5.13	6.925^{a}	1499.3^{c-e}
LSD	6.8165	0.73	0.37	1.425	303.9
Sign.	*	*	Ns	**	**
CV	8.22	16.88	7.65	30.35	20.88

NB: - *= (p<0.05), ** = (p<0.01), Ns= non significant

3.2.2. Plant Height

Data regarding plant height showed that finger millet plant height was significantly influenced by treatment application. Application of 15 kg seed per hectare with 50 cm spacing between rows gave the tallest plant height which was 92.97 cm and followed by application of 15 kg seed per hectare with 40 cm spacing between rows which were 91.84 cm. The data revealed that shortest plant height was recorded from application of 5kg seed per hectare with 30 cm row spacing which was 84.52 cm. (Table 2)

3.2.3. Number of finger per ear, Biomass Yield and panicle length

Number of fingers shows that significantly influenced by Application treatment. The highest & lowest number of finger panicle was observed at 15 kg ha^{-1} seed rate at 40cm row spacing and 5 kg ha^{-1} seed rate at 20cm row spacing, respectively i.e. 5.79 & 4.26. Grain yield per plant had strong positive association with finger number per ear. Total biomass was significantly (P ≤ 0.001) affected by row spacing and seed rate (Table.2). The maximum (6.925 t ha^{-1}) and the minimum (3.475 t ha^{-1}) grain yield were recorded from the broad casting & row spacing of 20 cm with 5kg of seed rate, respectively (Table 2). While panicle length shows non significantly difference between the treatments. From this result, it could be concluded that plant height & number of finger per ear contributed to grain yield mainly by enhancing their high and positive direct & indirect effect with biomass yield.

3.3. Economic data collection and analysis

Table . Partial budgets for an experiment on finger millet seed rate and row spacing

Treatments (Seed rate by row spacing)	Adjusted grain yield (kg/ha)	Gross Income (ETB/ha)	Adjusted straw yield (kg/ha)	Gross Income (ETB/ha)	Total Gross Income (GY+SY) (ETB/ha)	Total Variable cost	Net benefit	Dominance	MRR (%)
5kg/ha@20cm	1437.4	12936.6	3475.0	1737.5	14674.1	1250	13424.1		
5kg/ha@30cm	1364.3	12278.7	3658.3	1829.2	14107.9	1050	13057.9	D	
5kg/ha@40cm	1422.9	12806.1	4375.0	2187.5	14993.6	850	14143.6	D	
5kg/ha@50cm	1552.4	13971.6	4658.3	2329.2	16300.8	650	15650.8		370.0
15kg/ha@20cm	1307.2	11764.8	3800.0	1900.0	13664.8	1350	12314.8	D	
15kg/ha@30cm	1395.1	12555.9	4725.0	2362.5	14918.4	1150	13768.4	D	
15kg/ha@40cm	1926.8	17341.2	4450.0	2225.0	19566.2	950	18616.2		990.0
15kg/ha@50cm	1692.3	15230.7	4516.7	2258.3	17489.0	750	16739.0		940.0
25kg/ha@20cm	1534.2	13807.8	3416.7	1708.3	15516.1	1450	14066.1	D	
25kg/ha@30cm	1506.3	13556.7	3808.3	1904.2	15460.9	1250	14210.9	D	
25kg/ha@40cm	1773.5	15961.5	4200.0	2100.0	18061.5	1050	17011.5		90.0
25kg/ha@50cm	1828.5	16456.5	4150.0	2075.0	18531.5	850	17681.5		340.0
Broad cast (25kg/ha)	1499.3	13493.7	6925.0	3462.5	16956.2	1450	15506.2	D	

Note: Price of finger millet= Birr 9/kg, Price of finger millet straw= Birr 0.50/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 8 days/ha, respectively and labour cost/ man day= Birr 25

Economic analysis was performed to investigate the economic feasibility of the treatments (fertilizer rates). A partial budget, dominance and marginal analysis were used. The average yield was adjusted downwards to reflect the difference between the experimental plot yield and the yield farmers were expecting from the same treatment. The average open market price (Birr kg^{-1}) for finger millet was used for analysis. (Table 3)

4. CONCLUSION

Growing finger millet by using optimum inter row spacing and seed rate could make an important contribution to increase agricultural production and productivity in areas like Assosa where there is low practice of using improved agronomic practices. To this end, applying optimum row spacing and seed rate could be one of the alternatives to improve productivity by small farmers. However, the agronomic management regarding inter row spacing and seed rate is not yet studied in the area. Thus, this research work is initiated to investigate the impact of inter row spacing and seed rate on the performance of finger millet.

The result also showed that all the yield and yield components were significantly affected by seed rate and row spacing except panicle length. The highest grain yield of (1926.8 kg ha^{-1}) was obtained from the seed rate 15kg/ha@40cm row spacing. In addition to this; partial budget analysis showed that at the current cost of the grain and straw yield of finger millet, planting 15 kg/ha seed rate of finger millet in 40 cm row spacing gave the first highest net benefit. Therefore, it can be concluded that the row spacing of 40 cm and the seed rate of 15 kg ha^{-1} is advisable and could be appropriate for finger millet production in the test area even though further testing is required to put the recommendation on a strong basis.

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