International Journal of Research in Agricultural Sciences
Volume 1, Issue 3, ISSN (Online) : 2348 – 3997)

Determination of Inter Row Spacing and Seed Rate on Productivity of Finger Millet [*Eleusine Coracana* (L.) Gaertn.], At Jinka, Southern Ethiopia

Tekle Yoseph
Southern Agricultural Research Institute,
Jinka Agricultural Research Center, Jinka, Ethiopia

***Abstract* – A field experiment was undertaken at Jinka Agricultural Research Center to determine the effect of inter row spacing and seed rate on productivity of finger millet [Eleusine coracana (L.) Gaertn.], at Jinka. The experiment was conducted with four levels of inter row spacing (30, 45, 60 and 75 cm) and three levels of seed rate (5, 10 and 15 kg ha^{-1}). The treatments were arranged factorially and laid out in a randomized complete block design (RCBD) with three replications. Phenological and growth parameters such as yield and yield components, total biomass and harvest index were studied. The result showed that all phenological and growth parameters except finger length per plant were significantly affected by inter row spacing. As the inter row spacing wider there was increment on both plant height and tiller number per plant. Grain yield, 1000 seeds weight, total biomass and harvest index were very highly significantly affected by inter row spacing while number of fingers per ear was not significantly influenced by inter row spacing. The grain yield obtained from the inter row spacing of 45 cm (2.2488 t ha^{-1}) was higher by 35.39% compared to the inter row spacing of 75 cm (1.4528 t ha^{-1}). Seed rate had significantly affected all the growth and phenological parameters except days to maturity. The maximum number of tillers per plant and the highest finger length were noted from the seed rate of 5 kg ha$^{-1.}$ Seed rate had significantly affected yield components except number of fingers per ear. Seed rate had significant affected harvest index but it did not affect significantly total biomass. The highest grain yield (2.4693 t ha^{-1}) and the highest harvest index (0.367), obtained from the seed rate of 10 kg ha^{-1} were 42.64% and 41.47% increase over the seed rate of 15 kg ha^{-1}, respectively. There was significant interaction observed between inter row spacing and seed rate for all the studied parameters except number of fingers per ear. Therefore, it can be concluded from this result that the inter row spacing of 45 cm or the seed rate of 10 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.**

***Keywords* – Growth Parameters, Finger Millet, Inter Row Spacing, Phenological Parameters, Seed Rate, Yield Components, Yield.**

I. INTRODUCTION

Finger millet [*Eleusine coracana* (L.) Gaertn.] is an important traditional food crop in many parts of Africa and Asia. In Africa, it is extensively grown in Uganda, Tanzania, Ethiopia, Kenya, Rwanda, Burundi, Zimbabwe, Zambia and Malawi [1, 2]. It is the third most widely cultivated millets after pearl millet (*Pennisetum glaucum*) and foxtail millet (*Setaria italica*) in the semi-arid tropical and subtropical regions of the world [3]. Finger millet is the most important of the small millets grown for food and among the course cereals in India and it accounts 7% of the area with 11% of production [4]. In Ethiopia, finger millet occupies 4% of the total area allocated to cereals (nearly half a million hectares) each year and also contributes about 4% to the total annual cereal grain production in the country [5]. It is the 6th important crops after tef, wheat, maize, sorghum and barley. It comprises about 5% of the total land devoted to cereals. It is produced on 406,592 hectares of land, from which 599963 tons are obtained at national level. It is mainly grown in North Gondar, West Gojam, some parts of Tigray and West Wollega [6]. It is widely grown in the Amhara Region, it covers 198,835 hectares of land and giving 291775 ton in the region, which is 48.62% of the total national production [7]. Indigenous to eastern Africa, finger millet is widely produced in the cool high altitude areas in the region primarily as source of food and also for making traditional alcoholic beverages [8]. It is often valued as nutritious cereal by local people. Finger millet contains relatively higher concentration of calcium and dietary fiber than other cereals [9]. Finger millet production is common in southern Ethiopia especially South Omo Zone and Konso areas. In these areas, finger millet is a major crop for local consumption as supplementary to Teff and sorghum for 'injera', 'tella' and 'chaka'/'borde'. Information regarding finger millet is scarce on the agronomy and genetics of the crop [6]. Production of finger millet in the study area is mainly based under farmers practice since improved agronomic practice such as optimum seed rate and inter row spacing are lacking for the crop. Since no research attempts have been conducted in the target area on optimum seed rate and inter row spacing for finger millet. Therefore, to boost the production and productivity of finger millet in the target area; there is need to conduct a study on optimum seed rate and inter row spacing for finger millet production in the target area. To this end; this experiment is initiated with the following objectives.

Objectives:-

- To determine the optimum inter row spacing for finger millet production in the study area
- To determine the optimum seed rate for finger millet production in the target area

Copyright © 2014 IJRAS, All right reserved

II. MATERIALS AND METHODS

2.1. Description of the Study Area

The experiment was conducted at research farm of Jinka Agricultural Research Center located 729 kms meters South West of the capital Addis Ababa at E 36^0 33' 02.7" Longitude and N 05^0 46' 52.0" Latitude and at an altitude of 1383 meters above sea level. The long term weather data for the center revealed that the maximum and minimum monthly average temperature of the main center is 27.55 ^{0}C and 16.55^{0}C respectively while the mean annual rainfall of the area is 1274.67 mm.

2.2. Treatments and Experimental Design

Treatments were made from a combination of two factors. Four levels of inter row spacing (30, 45, 60 and 75 cm) and three levels of seed rate (5, 10 and 15 kg ha^{-1}) were used. One variety of finger millet namely Tadese, was selected for the study based on its yielding potential. The experiment consisted of 12 treatments with a total of 36 plots. The field experiment was laid out in a randomized complete block design (RCBD) in factorial combinations the treatments with three replications.

2.3. Data Collection

Phenological Parameters

Phenological parameters such as days to emergence, days to heading and days to maturity were recorded. Days to emergence was recorded when 50% the plants per plot emerged while days to heading was recorded by counting the number of days after emergence when 50% of the plants per plot had the first open flower or open head. Days to maturity was recorded when 90% of fingers matured per plot.

Growth Parameters

At mid heading stages ten plants from each of the plots were selected randomly and uprooted carefully to determine crop growth parameters such as plant height and number of tillers. Dry matter was determined by drying the above ground parts of the five sampled plants at 70 oC for 48 hours in an air-ventilated oven.

Grain Yield, Yield Components, Total Biomass and Harvest Index

Harvesting was done from harvestable central rows for determination of grain yield. Grain yield was adjusted to 12.5% moisture content. Ten plants were randomly selected from the central rows to determine yield and yield components, which consisted of number of tillers per plant, number of fingers per ear and thousand seeds weight. Finger number per plant was determined by counting fingers of the ten randomly selected plants. Seed weight was determined by taking a random sample of 1000 seeds and adjusted them to 12.5% moisture content. Total biomass yield was measured from the middle harvestable rows when the plant reached harvest maturity. Harvest index was calculated as the ratio of seed yield to total above ground biomass yield.

2.4. Statistical Analysis

Analysis of variance was performed using the GLM procedure of SAS Statistical Software Version 9.1 [10]. Effects were considered significant in all statistical calculations if the P-values were < 0.05. Means were separated using Fisher's Least Significant Difference (LSD) test.

III. RESULTS AND DISCUSSION

The result of analysis of variance for mean squares exhibited that inter row spacing had significantly ($P \leq 0.01$) affected days to heading and number of tillers per plant; whereas it had affected significantly ($P \leq 0.001$) days to maturity and it also influenced significantly ($P \leq 0.05$) plant height. On the other hand, finger length was not affected significantly by inter row spacing (Table 1). The number of days to reach heading were 103. 444 and 97.556 for the inter row spacing of 60 cm and 30 cm, respectively (Table 2).

Seed rate had significantly ($P \leq 0.001$) affected number of tillers per plant and plant height, it also affected significantly ($P \leq 0.05$) days to heading and finger length; on the other hand, it had brought no significant effect on days to maturity (Table 1). The maximum (4.0583) and the minimum (2.3583) number of tillers per plant were noted from the seed rate of 5 kg ha-1 and 15 kg ha-1, respectively (Table 2). In this study, number of tillers increased as the seed rate gets decreased. This suggests that as the seed rate decreases, the effectiveness of the existing plant per hole to have maximum plant population gets increasing through increased tiller production per plant. The highest (92.533 cm) and the lowest (84.505 cm) plant height were obtained from the seed rate of 5 kg ha-1 and 15 kg ha-1, respectively (Table 2). The reason could possibly due to low competition for soil nutrients in low plant population from low seed rate that lead to enhanced plant growth. Inter row spacing and seed rate interacted significantly ($P \leq 0.01$) for days to heading and days to maturity, and also interacted significantly ($P \leq 0.001$) for plant height, number of tillers per plant and finger length (Table 1).

Table 1: Mean Square Values for Crop Phenology and Growth Parameters of Finger Millet at Jinka, in 2013.

Source	DF	Days to heading	Days to maturity	Tiller number ($plant^{-1}$)	Plant height (cm)	Finger Length (cm)
Replication (R)	2	2.6944ns	4.0833ns	0.3158^{ns}	0.253^{ns}	0.881ns
Inter Row (IR)	3	63.2963**	169.815***	5.3227**	52.039*	0.106ns
Seed Rate (SR)	2	40.1944*	53.083ns	8.6712***	216.1033***	1.943*
IR *SR	6	46.1574**	80.231**	5.5534***	167.497***	3.121***
Error	22	12.1489	17.1742	0.7611	0.253	0.419

*, ** and *** indicate significance at P< 0.05, P< 0.01 and P< 0.001, respectively and 'ns' indicate non significant

Copyright © 2014 IJRAS, All right reserved

Table 2: Crop Phenology and Growth Parameters of Finger Millet as Affected By Seed Rate and Inter Row Spacing at Jinka, in 2013

Source	Days to heading	Days to maturity	Tiller number (plant^{-1})	Plant height (cm)	Finger length (cm)
Treatments					
Inter Row Spacing (cm)					
30	97.556b	128.111bc	2.411b	89.267a	7.322a
45	103.00a	131.778b	3.1778b	89.089a	7.077a
60	100.444ab	126.889c	4.256a	84.644b	7.188a
75	103.4076	136.556a	3.011b	89.867a	7.111a
LSD 0.05	3.4076	4.0515	0.852	4.141	NS
Seed Rate (kg ha^{-1})					
5	100.083b	128.583b	4.0583a	92.533a	7.550a
10	103.167a	131.167ab	3.2258b	89.067b	6.750b
15	99.917b	132.750a	2.3583c	84.505c	7.225ab
LSD $_{0.05}$	2.951	3.5087	0.7387	3.587	0.548
CV (%)	3.45	3.17	27.14	4.80	9.02

Note: Means with the same letters within the columns are not significantly different at P <0.05.

Inter row spacing had significantly (P ≤ 0.001) affected grain yield and 1000 seeds weight; whereas, it had brought no significant effect on the number of fingers per ear (Table 3). Total biomass and harvest index were significantly (P ≤ 0.001) affected by inter row spacing (Table 3). The maximum (2.2488 t ha^{-1}) and the minimum (1.4528 t ha^{-1}) grain yield were recorded from the inter row spacing of 45 cm and 75 cm, respectively (Table 4). The highest grain yield obtained from the inter row spacing of 45 cm (2.2488 t ha^{-1}) was higher by 35.39% compared to the inter row spacing of 75 cm (1.4528 t ha^{-1}). In similar study, grain yield of 2858, 2224.5 and 2101 kg ha^{-1} were noted from the inter row spacing of 20, 25 and 30 cm, respectively [11]. The highest grain yield was recorded at the inter row spacing of 30 cm and 45 cm [11]. This could be attributed to better weed suppression due to narrow inter row spacing that inhibited weed competition with the crop.

Grain yield was significantly (P ≤ 0.001) affected by seed rate. Seed rate had significantly (P ≤ 0.05) affected 1000 seeds weight; on the other hand, it had brought no significant effect on the number of fingers per ear (Table 3). Seed rate was significantly (P ≤ 0.001) affected harvest index; whereas, it did not affect significantly total biomass (Table 3). The highest grain yield (2.4693 t ha^{-1}) was recorded from the seed rate of 10 kg ha^{-1}, whereas, the least grain yield (1.4165 t ha^{-1}) was noted from the seed rate of 15 kg ha^{-1} (Table 4). The maximum harvest index (0.367) was recorded from the seed rate of 10 kg ha^{-1} and the minimum harvest index (0.2148) was noted from the seed rate of 15 kg ha^{-1} (Table 4). Likewise, the grain yield of 2038, 2218.5 and 2262 kg ha^{-1} were recorded from the seed rate of 10, 15 and 20 kg ha^{-1}, respectively [11].

Also there was a significant (P ≤0.001) interaction effects of inter row spacing and seed rate were noted for grain yield, 1000 seeds weight, total biomass and harvest index; but the seed rate and inter row spacing did not interacted significantly for number of fingers per ear (Table 3).

The result of the Pearson correlation coefficient depicted that, days to maturity (r = 0.09749) and plant height (r = 0.03279) have a direct positive effect on grain yield (Table5). Days to heading (r = -0.13638) has a negative effect on grain yield. Similarly, finger millet grain yield per plant to be significantly negatively correlated to days to heading [12]. Number of fingers per ear (r = 0.36579*) and total biomass (r = 0.38575*) have a significant and positive association with grain yield whereas; tiller number per plant (r = 0.21957) has a direct positive association with grain yield (Table 5). Similar results were observed [13, 14]. From this result, it could be concluded that plant height, days to maturity and thousand seeds weights contributed to grain yield mainly by enhancing their high and positive indirect effect with biomass yield. Also grain yield per plant had strong positive association with finger number per ear [15]. On the other hand, days to heading, days to maturity, plant height and number of fingers per ear had showed negative direct effects on grain yield [16].Thousand seeds weight (r = 0.39836*) was positively and significantly correlated with grain yield whereas, harvest index (r = -0.16704) was negatively correlated with grain yield. Similar result was reported for biomass yield, who found that grain yield correlated positively with, biomass, and harvest index [17, 18]. Total biomass yield of finger millet showed strong and positive correlations with 1000 seeds weight (r = 0.69***) and grain yield (r = 0.39*). This indicates that high total above ground biomass would be important for maximum grain yield of finger millet.

Copyright © 2014 IJRAS, All right reserved

Table 3: Mean Square Values for Yield and Yield Components and Total Biomass in Finger Millet at Jinka, in 2013

Source	DF	Grain yield (t ha^{-1})	1000 Seeds Wt (gm)	Finger number (ear^{-1})	Total biomass (t ha^{-1})	Harvest Index
Replication (R)	2	0.4427ns	0.0133ns	0.5733^{ns}	0.1959^{ns}	0.0142**
Inter Row (IR)	3	1.3891***	1.7959***	0.3655ns	37.8258***	0 .0601***
Seed Rate (SR)	2	3.6886***	0.5025*	0.9733ns	0.6301ns	0.0769***
IR *SR	6	1.5189***	2.0584***	1.0533ns	14.0679***	0.0742***
Error	22	0.14160	0.1290	0.5527	0.3748	0.0022

*, ** and *** indicate significance at P< 0.05, P< 0.01 and P< 0.001, respectively and 'ns' indicate non significant

Table 4: Yield and Yield Components of Finger Millet as Affected By Seed Rate and Inter Row Spacing at Jinka, in 2013.

Source	Grain yield (t ha^{-1})	1000 Seeds Wt (gm)	Finger number (ear^{-1})	Total biomass (t ha^{-1})	Harvest Index
Treatments					
Inter Row Spacing (cm)					
30	2.1042a	13.1111b	5.2444a	6.8148b	0.331a
45	2.2488a	14.0556a	5.0667a	8.9733a	0.2657b
60	1.5639b	13.9222a	5.4444a	4.7219c	0.3446a
75	1.4528b	13.3778b	5.5111a	9.0185a	0.1655c
LSD 0.05	0.3679	0.3513	NS	0.5985	0.0467
Seed Rate (kg ha^{-1})					
5	1.6414b	13.3917b	5.2833a	7.5286a	0.2482b
10	2.4693a	13.6667ab	5.6176a	7.4997a	0.3670a
15	1.4165b	13.7917a	5.50500a	7.1181a	0.2148b
LSD $_{0.05}$	0.3186	0.3042	0.6295	NS	0.0404
CV (%)	20.42	2.63	13.98	8.29	17.25

Note: Means with the same letters within the columns are not significantly different at P <0.05.

Table 5. Pearson Correlation Coefficient for Nine Traits of the Improved Finger Millet Variety (Tadese), at Jinka, in 2013

Traits	**GYLD**	**BIMYLD**	**HI**	**TSW**	**PHT**	**TILN**	**DTH**	**DTM**	**FNM**
GYLD	1.00000	0.38575*	-0.16704	0.39836*	0.03279	0.21957	-0.13638	0.09749	0.36579*
		0.0201	0.3302	0.0161	0.8494	0.1982	0.4277	0.5716	0.0282
BIMYLD		1.00000	0.12930	0.69291***	-0.03012	0.25156	0.25334	-0.31142	0.09308
			0.4523	<.0001	0.8616	0.1389	0.1360	0.0645	0.5892
HI			1.00000	-0.53913***	0.22127	0.10600	-0.12463	-0.14138	-0.14812
				0.0007	0.1947	0.5383	0.4689	0.4108	0.3886
TSW				1.00000	-0.12540	0.07370	0.30460	-0.07124	0.25927
					0.4662	0.6692	0.0709	0.6797	0.1268
PHT					1.00000	-0.07636	0.14224	0.06887	-0.27036
						0.6580	0.4079	0.6898	0.1108
TILN						1.00000	-0.21166	-0.09244	0.01380
							0.2153	0.5918	0.9363
DT							1.00000	-0.00239	-0.16003
								0.9889	0.3512
FNM									1.00000

KEY: DTH=days to heading, DTM= days to maturity, TILN=Tiller number, PHT= plant height (cm), FNM= finger number, TSW=thousand seeds Weight (gram), GYLD=grain yield per (t ha^{-1}), BIMYLD, HI= harvest index, *= significant, **= highly significant and ***= very highly significant

Copyright © 2014 IJRAS, All right reserved

IV. SUMMARY AND 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 Jinka where there is low practice of using improved agronomic practices. To this end, applying optimum inter 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.

Study on inter row spacing and seed rate was conducted at Jinka under rain fed conditions in 2013. The objectives of the study were to determine the optimums inter row spacing and seed rate that will improve finger millet production. The experiment was carried out using a randomized complete block design (RCBD) with three replications at Jinka in 2013. The treatments involved were four levels inter row spacing (30, 45, 60 and 75 cm) and three levels of seed rate (5, 10 and 15 kg ha^{-1}). According to the result of analysis of variance, all the phenological and growth parameters except finger length per plant were significantly affected by inter row spacing. All the yield and yield components were significantly affected by inter row spacing except number of fingers per ear. The maximum grain yield (2.2488 t ha^{-1}) was obtained from the inter row spacing of 45 cm. All the phenological and growth parameters were significantly affected by seed rate except days to maturity. The maximum number of tillers per plant and the highest finger length were noted from the seed rate of 5 kg $ha^{-1.}$ The result also showed that all the yield and yield components were significantly affected by seed rate except number of fingers per ear. The highest grain yield of (2.4693 t ha^{-1}) was obtained from the seed rate of 10 kg ha^{-1}. Therefore, it can be concluded that the inter row spacing of 45 cm or the seed rate of 10 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.

REFERENCES

[1] FAO, 1998. The state of *ex situ* conservation. In: The state of world's plant genetic resources for food and agriculture. Rome, Italy: Food and Agriculture Organization of the United Nations.

[2] Upadhyaya, H.D., C.L.L. Gowda and D.V Sastry, 2008. Plant genetic resources management: collection, characterization, conservation and utilization. Journal of SAT Agricultural Res.,6: 1-16.

[3] Redy V. G., H. D. Upadhyaya, C. L. L. Gowda and S. Singh, "Characterization of Eastern African Finger Millet Germplasm for Qualitative Quantitative Characters at ICRISAT," *Journal of SAT Agricultural Research*, Vol. 7, 2009.

[4] Seetharam, A., 1995. Coarse cereals: Yawning productivity gaps. The Hindu Survey of Indian Agric., 51-56.

[5] Central Statistical Agency (CSA) 2010. "Agricultural Sample Survey," Report on Area and Production of Crops (Pri-vate Peasant Holdings, Meher Season), Statistical Bulle-tin 446, Addis Ababa.

[6] Adugna A., Tesfaye T., Erenso D., Taye T., Feyera M., Wasihun L. Alemu T., Haileselassie K., Andualem W., Chemeda D. 2011. Genotype-by-Environment Interaction and Yield Stability Analysis in Finger Millet (*Elucine coracana* L. Gaertn) in Ethiopia. *American Journal of Plant Sciences*, 2, 408-415

[7] CSA (2008). Agricultural sample survey report on area and production for major crops (Private Peasant holdings meher season).The FDRE Statistical Bulletin 439, Vol.1. Addis Ababa, Ethiopia.

[8] ICRISAT and FAO, "The World Sorghum and Millet Economies: Facts, Trends and Outlook," ICRISAT, An-dhra Pradesh, 1996.

[9] Wondimu A. and F. T., "Utilization of Teff in the Ethiopian Diet," In: H. Tefera, G. Belay and M. Sorrells, Eds., *Proceedings of the International Workshop on Tef Genetics and Improvement*, Debre Zeit, 2001.

[10] SAS (2007) Statistical Analysis Systems SAS/STAT user's guide Version 9.1 Cary NC: SAS Institute In: USA

[11] Shinggu *C.P., S.A. Dadari, J.A 1 1 1 .Y. Shebayan, 1D.I. Adekpe,1M.A. Mahadi, 1A. Mukhtar and S.W. Asala. 2009.* Influence of Spacing and Seed Rate on Weed Suppression in Finger Millet (*Eleucine carocana gaertn*) Middle-East Journal of Scientific Research 4 (4): 267-270

[12] Bezaweletaw K, Sripichit P, W.Wongyai V, Hongtrakul (2006). Genetic variation, heritability and Path-analysis in Ethiopian finger millet (*Eleusine coracana* (L.)Gaertn) landraces. Kasetsart J. Nat. Sci., 40: 322-334.

[13] Nandini B, Ravishankar CR, Mahesha B, Shailaja H, Kalyana MKN (2010). Study of correlation and path analysis in F2 population of finger millet. Int. J. Plant Sc., 5(2): 602-605.

[14] Lule D., Kassahun T., Masresha F. and Santie De V. 2012. Inheritance and Association of Quantitative Traits in Finger Millet (*Eleusine coracana* Subsp. *Coracana*) Landraces Collected from Eastern and South Eastern Africa. International Journal of Genetics 2(2): 12-21.

[15] Sharathbabu KS, Shantakumar G, Salimath PM (2008). Geneticvariability and character association in white ragi (*Eleusine coracana* Gaertn). Karnataka J. Agric. Sci., 21(4): 572-575.

[16] Wolie A. and D. T. 2011. Correlation and path coefficient analyses of some yield related traits in finger millet (*Eleusine coracana* (L.)Gaertn.) germplasms in northwest Ethiopia. African Journal of Agricultural Research Vol. 6(22), pp. 5099-5105

[17] Singh KB, Bejiga G, Malhotra RS (1990). Association of some characters with seed yield in chickpea collections. Euphytica 49: 83- 88.

[18] Tazeen M, Nadia K, Farzana NN (2009). Heritability, phenotypic correlation and path coefficient Studies for some agronomic characters in synthetic elite lines of wheat. J. Food. Agric. Environ., 7(3&4): 278-282.

Copyright © 2014 IJRAS, All right reserved