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Determination of intra and inter row spacing on the yield of pearl millet (*Pennisetum glaucum* L.) in the dry land areas of Wag Himra, eastern Amhara, Ethiopia

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ABSTRACT

Recently in Ethiopia pearl millet has drawn a lot of attention as a replacement for maize and sorghum in the dry land areas because of its ability to reliably produce grains on a wide range of soils and harsh production environment. A field experiment was conducted during the 2014 cropping season on the Research sites of Abergele and Aybra, at Sekota dryland agricultural research Centre, eastern Amhara, Ethiopia, with the objective of to increase the productivity of pearl millet in the study areas of Wag-Himra Zone through optimizing its intra and inter-row spacing. The treatments considered in the study were consisting of four intra row spacing's (5, 10, 15 and 20 cm) and four inter-row spacing (30, 50, 60 and 75 cm) and making a total of sixteen treatments. The Randomized Complete Block Design factorial arrangement with three replications a plot size of 5m × 3m was used. Based on the Combined analysis main effects of inter and intra row spacing by location showed significance difference ($p < 0.05$) for the parameters of grain yield. The heights grain yield was recorded from 50cm and 5cm inter and intra row spacing respectively, whereas the lowest grain yield was recorded from 60cm and 75cm with 20cm inter and intra row spacing respectively. It is possible to recommend that, sowing of pearl millet with inter row spacing of 50cm and 5cm intra row spacing is effective in attaining higher grain yield in the study area.

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INTRODUCTION

Pearl millet (*Pennisetum glaucum*) is the most important crop in the drier parts of semi-arid tropics and accounts for almost half of the global production of the millet species from amongst different species of millets cultivated (Singh *et al.*, 2017; Vinoth and Ravindhran, 2017). As general estimate, global millet production is broken down into pearl millet (50%), finger millet (10%) and other millets 40%. Over thirty percent of the population (over 100 million people) of Eastern and Central Africa (ECA) live in these semi-arid areas and rely on agriculture and livestock as their main livelihood (Mortimore *et al.*, 2009; Disasa *et al.*, 2016).

The communities in these areas depend on millets and sorghum

as the main staple crop-providing source of food, and source of income (Champion and Fuller, 2018). As the conditions become drier, pearl millet is the only crop that is grown where normal rainfall does not permit the reliable production of sorghum (Jukanti *et al.*, 2016). Production exceeds that of sorghum due to its draught-tolerant character and the reverse is the case as rainfall increases (Negi *et al.*, 2017; Chisi and Peterson, 2019). Being able to thrive where habitats are harsh, it is perhaps the best of all life-supporting grain (FAO, 2000).

With respect to its nutritional value, research was conducting by Kodkany *et al.* (2013) which showed that pearl millet bread to contain more iron can provide young children with their full daily iron needs. His report further pointed out that it yields reliably well in regions too hot and too dry to consistently

support good yield of maize or sorghum (Ullah *et al.*, 2017). Pearl millet is a hardy warm-season, dry land cereal grain crop. It is largely grown in the drought-prone regions of Africa and Asia where it performs better than other cereals (Chisi and Peterson, 2019). In Ethiopia, one improved variety is released for production in the dry land areas of the country. Though the crop is grown in some dry areas of the country, agronomic factors that limit pearl millet productivity are not yet studied (Disasa *et al.*, 2016). All agronomic practices (seed rate, fertilizer rate, spacing and other agronomic practices) were done depending on the agronomic packages settled to sorghum production.

Wag-himra administrative zone is one of the known dry land areas in Ethiopia. Especially low land areas receives limited amount of rainfall (not more than 275 mm annually) and the growing period is very short usually. The rainfall amount and distribution are highly variable and erratic in nature. The soils are highly degraded and low in fertility. Pearl Millet is grown in harsh environments where other crops grow or yield poorly (Disasa *et al.*, 2016; Negi *et al.*, 2017).

Production of pearl millet with yield improvement would have a direct impact on the drought prone areas of Ethiopia since pearl millet is drought tolerant and early maturing with high water use efficiency. In order to improve pearl millet yield in the study area there is need to include the Intra and inter row spacing is crucial (Champion and Fuller, 2018). Especially in wag himira Zone, production of pearl millet needs critical attention since drought is the major problem in this area because moisture is the limiting factor for crop production in general and pearl millet production in particular (Jukanti *et al.*, 2016). Sekota dryland agricultural research center has registered Kolla -1 pearl millet Variety through adaptation for production of low land areas of Wag himra zone, however, information on their intra and inter-rows spacing on yield and yield components are lacking (Ullah *et al.*, 2017; Venkateswaran *et al.*, 2019).

To address the further research works on production gaps in Wage-Himra administration zone using Kolla-1 pearl millet variety. Therefore, this research study was initiated with to increase the productivity of pearl millet in the study areas of Wag-Himra Zone through optimizing its intra and inter-row spacing.

MATERIALS AND METHODS

Study area

The experiment was conducted at Abergele and Aybra testing sites of Sekota dryland agricultural research center in Eastern Amhara region, Ethiopia during the main cropping season for one year (2014). Abergele testing site has been characterized by an altitude of 1495m.a.s.l, minimum and maximum temperatures of 28°C and 42°C and an average annual rainfall of 250 to 650 mm with latitude of 12°62'83" N and 39°03'56" E, whereas, Aybra testing site also characterized as an altitude of 1976m minimum and maximum temperatures of 26.6°C and 31.6°C and an average annual rainfall of 500 to 650 mm with latitude of 12°68'35" N and with longitude of 39.01'41" E.

Experimental and treatment design

The treatments considered in the study were consisting of four intra row spacing's (5, 10, 15 and 20 cm) and four inter-row spacing (30, 50, 60 and 75 cm) and making a total of sixteen treatments. The Randomized Complete Block Design factorial arrangement with three replications of plot size of 5m × 3m was used. Blanket recommendations of Urea and DAP fertilizer (50kg/ha and 100kg/ha) were 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. The experimental sites were prepared well. Each plot and block was separated by 0.50 m and 1.5 m, respectively.

Test crop variety and parameters

Pearl millet variety Kolla-1 was used as a testing crop for the experiment. Important agronomic practices like land preparation and weeding were uniformly applied to all experimental plots as often as required. Days to heading, days to maturity, panicle length, Plant height at maturity (cm), number of tillers and number of effective tillers per plant, lodging (%), grain yield (kg/ha), thousand seed weight (gm) and biomass yield (kg/ha) were collected as growth and yield parameters of tef.

Data collection and statistical analysis

Data of many important growth and yield parameters collected during the experimental periods were purified and arranged for further analysis. The analysis of variance (ANOVA) was carried out for growth and yield parameters of the following statistical procedures appropriate for the experimental design using statistical analysis system (SAS) program package version 9.0 (SAS, 2002). Whenever treatment effects were significance at 0.01 or 0.05 level of significance errors, the means were separated by using the Duncan (Duncan, 1995) multiple range test (DMRT) procedures at 0.05 probability level of significance.

RESULTS AND DISCUSSION

Effect of row spacing on yield

The analysis of variance revealed that Grain yield was significantly ($P < 0.05$) affected by in case of inter row spacing's, whereas there was no significance difference ($P > 0.05$) in case of intra row spacing. The interaction between inter row and intra row spacing was also not statistically significance ($P > 0.05$) at Abergele in the year 2014 cropping seasons (Table 1). The highest grain yield (1056 kg/ha) was recorded from 50cm inter row spacing The lowest grain yield (793 and 837kg/ha) was recorded from 60 cm and 75 cm inter row spacing respectively at Abergele location in year 2014 cropping seasons. The current result not in line with (Yoseph, 2014) who found that yield and yield component of pearl millet cannot affect by different inter row spacing. But slightly similar with (Gulia *et al.*, 2007) who reported that for consistent high grain yield of pearl millet row spacing of 36-53cm is better than other.

Interactive effects of row spacing on crop parameters

The result indicated that there was no significance difference ($P > 0.05$) on the parameters of days to maturity, number of tillers, number of effective tillers, plant height, panicle length, lodging percentage and biomass yield by the main effects of intra and inter row spacing as well as their interaction for the year 2014 cropping season. The current finding agreed with the result of (Anshul *et al.*, 2017). Who found that no significance difference was observed on the parameters of days to maturity, number of tillers, number of effective tillers, plant height,

panicle length, thousand seed weight and biomass yield by the main effects of intra.

The result indicated that there was no significance difference ($P > 0.05$) all the parameters like days to maturity, number of tillers, number of effective tillers panicle length, plant height lodging percentage, biomass yield, thousand seed weight and grain yield by the main effects of seeding rate and inter row spacing as well as The interaction between inter row and intra row spacing was also not statistically significance ($P > 0.05$) at Aybra in the year 2014 cropping seasons.

Table 1. Mean grain yield and other agronomic parameters of pearl millet on the effects of inter row spacing and intra row spacing at Abergele in 2014 cropping seasons.

Inter row spacing	DAH	DAM	NT	NET	LP	PH	LDG	BM (kg)	TSW (gr)	G.Y (k.g)
30	60.54	81.66	1.93	1.18	18.32	156.36	51.36	2884.8	6.50	974 ^{ab}
50	57.69	82.23	1.78	1.13	18.26	150.24	46.55	3020.5	6.50	1056 ^a
60	57.69	81.66	1.91	1.17	18.11	152.95	43.33	2658.3	6.54	793 ^b
75	57.69	83.22	1.85	1.20	18.55	153.42	41.66	3207	6.41	837 ^b
Means	58	82	1.86	1.16	18	152	45	2920	6.40	90
CV	5.8	2.98	13.95	13.95	20.57	9.58	22.7	25.93	3.70	29.2
Duncan at 5%	ns	ns	ns	ns	ns	ns	ns	ns	ns	*
Intra row spacing										
5	57.58	81.25	1.86	1.86	18.35	149	48.33	2827	6.54	1037
10	58.66	83.58	1.79	1.12	18.36	154.61	48.33	2988	6.50	940
15	58.50	81.25	1.84	1.21	18.25	154.13	44.16	3011	6.43	904
20	58.11	81.33	1.94	1.17	18.20	155.15	41.66	2870	6.50	769
Duncan at 5%	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Where, DH= Days to heading, DM=Days to maturity, PH=Plant height, NT=Number of tillers per plant, NET, Number of effective tiller HL=Head length BM= Bio-mass, and GY=Grain yield. And NS, Non significance, * Statistically significant and ** Statistically highly significance.

Table 2. Mean grain yield and other agronomic parameters of pearl millet on the effects of inter row spacing and intra row spacing at Aybra in 2014 cropping seasons.

Inter row spacing	DAH	DAM	NT	NET	LP	PH	LDG	BM (k.g)	TSW (gr)	G.Y (k.g)
30	46.54	81.25	2.31	1.93	16.90	146.54	4.74	1721	8.40	739.38
50	46.38	83.58	2.19	1.74	17.80	149.40	4.82	1642	8.50	734.22
60	46.66	81.75	2.16	1.71	18.16	152.90	4.64	1816	7.78	664.89
75	46.88	81.33	2.26	1.76	17.22	144.72	4.81	1648	7.33	710.64
Means	46.00	91.00	2.2	1.78	17.61	148	4.76	1689	8.00	701.98
CV	2.94	4.98	6.19	15.45	19.4	7.21	16.8	20	16.80	17.83
Duncan at 5%	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Intra row spacing										
5	45.75	89.16	2.21	1.16	17.31	149.5	2827	4.82	8.37	1775.59
10	47.00	92.50	2.16	1.12	17.88	150.11	2988.9	4.92	7.62	1624.3
15	47.16	91.25	2.35	1.21	17.71	148.48	2971.1	4.48	7.93	1628.6
20	46.44	91.22	2.60	1.17	17.26	146.15	2870.4	4.80	8.16	1854.4
Duncan at 5%	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Where, DH= Days to heading, DM=Days to maturity, PH=Plant height, NT=Number of tillers per plant, NET, Number of effective tiller HL=Head length BM= Bio-mass, and GY=Grain yield. And NS, Non significance, * Statistically significant and ** Statistically highly significance.

The Combined analysis of inter row spacing by location showed significance difference ($P<0.05$) for the parameters of grain yield and days to heading for the year 2014. The heights grain yield was recorded from 50 cm inter row spacing (895 kg/ha) whereas the lowest grain yield was recorded from 60 cm (772kg/ha) and 75 cm (777kg/ha). There was no significance difference between the treatments of 30 cm and 50 cm inter row spacing on the grain yield. The heights days to heading was recorded from 30 cm inter row spacing, whereas the lowest days to heading was recorded from 60 cm and 50 cm inter row spacing's respectively and there was no significance differences between the treatments of 50 cm, 60 cm and 75 cm inter row spacing's for the parameter of days to heading. Based on the combined analysis by location the main effect of inter row spacing had no significance effect on the parameters of days to maturity, number of tillers, number of effective tillers, panicle length, thousand seed weight and biomass yield for the year

2014 cropping season. The Combined analysis of intra row spacing by location showed significance difference ($P<0.05$) for the parameter of grain yield for the year 2014. The heights grain yield was recorded from 5cm intra row spacing (906 kg/ha) whereas the lowest grain yield was recorded from 20 cm 687kg/ha). There was no significance difference between the treatments of 5 cm and 10 cm intra row spacing. Intra row spacing had no significance effect on days to heading, days to maturity, number of tillers, number of effective tillers, panicle length, thousand seed weight and biomass yield for the year 2014 cropping season. The current result goes in line with (Anshul *et al.*, 2017; Ullah *et al.*, 2017) who found that different intra row spacing did not show significance difference on the parameters of number of tillers, number of effective tillers, plant height, thousand seed weight and panicle length on pearl millet whereas different intra row spacing had significant effect on the grain yield of pearl millet (Champion and Fuller, 2018; Chisi and Peterson, 2019).

Table 3. Mean grain yield and other agronomic parameters of pearl millet as affected by intra and inter row spacing combined by location for the year 2014 at Aybra and Abergele locations.

Inter row spacing	DAH	DAM	NT	NET	LP	PH	LDG	BM (k.g)	TSW (gr)	G.Y (k.g)
30	53.5 ^a	85.95	2.12	1.52	17.61	151.45	28	1812	7.45	856a
50	52 ^b	87.23	1.98	1.44	18.03	149.82	25.68	1877	7.50	895a
60	51.75 ^b	86	2.04	1.44	18.14	152.92	23.98	1661.6	7.16	772b
75	52.29 ^{ab}	87	2.01	1.48	18.05	147.65	22	1889	6.87	777b
Means	52.37	86.63	2.04	1.47	17.96	150.42	24.82	1811	7.24	800
CV	4.45	4.16	13.29	19	6	8.59	9.73	27	15	25
Duncan at 5%	*	ns	ns	ns	ns	ns	ns	ns	ns	*
Intra row spacing										
5	52.66	85	2.04	1.48	17.83	149.22	26.57	1801	7.45	906 ^a
10	52.83	88	1.97	1.37	18.12	152.36	26.62	1845	7.33	821 ^{ab}
15	52.63	86.86	2.07	1.51	18.09	149.7	23.12	1831	7.18	771 ^{bc}
20	52.27	86.27	2.05	1.52	17.73	150.65	23.23	1745	7.33	687 ^c
Duncan at 5%	NS	ns	ns	ns	ns	ns	ns	ns	ns	*

Where, DH= Days to heading, DM=Days to maturity, PH=Plant height, NT=Number of tillers per plant, NET, Number of effective tiller HL=Head length BMY= Bio-mass, and GY=Grain yield. And NS, Non significance, * Statistically significant and ** Statistically highly significance.

Conclusions

In general, main effect of different inter row spacing had significance effect on the grain yield of pearl millet at Abergele location, whereas the main effect and the interaction between intra and inter row spacing had no significance effect all other parameters at Abergele location for the year 2014 cropping season. The main effects of inter and intra row spacing and their interaction had no significance effect all the parameters at Aybra location in the year 2014 cropping season, but the combined analysis by location showed significance difference on the main effects of inter row spacing and intra row spacing for the parameters of grain yield, similarly the main effects of inter row spacing had significance effect on the parameters of days to heading, whereas the interaction between inter row spacing and intra row spacing had no significance effect for all the parameters. Thus, it is possible to recommend that, sowing of

pearl millet with inter row spacing of 50cm and 5cm intra row spacing is effective in attaining higher grain yield in the study area.

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