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Effect of Plant Spacing and Variety on Performance of Rain-Fed Pearl Millet (Pennisetum Glaucum l) Grown on Two Soil Types at Zalingei Area, Sudan

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ABSTRACT

Two field experiments were conducted at the University of Zalingei demonstration farm, Zalingei, Sudan, during 2005 rainy season, to investigate the effect of plant spacing and variety on performance of rain-fed pearl millet and to invent crop pests and diseases. Two locations of different soil types (sandy loam and clay loam) were chosen for the study, treatments consist of three plants spacing (50,70and 90 cm), with 70 cm inter-row spacing. And four millet varieties (Dembi from North Darfur, Bauoda and Drmsa (local names) and Improved Dembi were used Treatments were arranged in split plot design replicated four times with plant spacing in the main plots and varieties in the subplots. For the pests and diseases inventory the growing season was divided into three periods (early season, middle of the season and late season). Results revealed that plant spacing had no significant effect on most of growth parameters except leaf area at location 1, where 90 cm plant spacing recorded the highest leaf area (165.8 cm^2), where as 50 cm plant spacing gave the lowest leaf area (136.4 cm^2), also results revealed that plant spacing had no significant effect on yield parameters except the 1000 grain weight and yield. On the other hand results indicated that the variety had significant effect ($P \leq 0.05$) on plant height, leaf area and stem diameter at location 2 .Drmsa and Bauda are tall varieties, however, North Darfur Dembi and Improved Dembi are short varieties. Results showed that variety had significant ($P \leq 0.05$) effect on most of yield attributes and yield. ND gave the highest yield at location 1(356.4 k/ fed) whereas, Drmsa the highest at location 2 (353.2 kg/ fed). Results showed that pearl millet was infected by many pests and few diseases and the spread of pests and diseases was affected by the growth stage, also the results showed that varieties were different in disease resistance, Drmsa recorded the highest foliage disease at early sowing date (41%) whereas, North Darfur Dembi infection was 30.9% but at late sowing date North Darfur Dembi recorded the higher infection percentage 36.1% and Bauoda recorded the lowest infection percentage (16.8%).More research with different varieties, different plant spacing, under different rain fall conditions should be done to find out the most suitable plant spacing and to get maximum benefit from the main yield limiting factors in the area.

Keywords: *Plant spacing. Variety .rain fed. Pearl millet*

1. INTRODUCTION

Cereals are important food crops, among which millet is the sixth most important cereal in the world. Pearl millet is grown as stable cereal on an estimated area of 25-36.9 million hectares [11; 8].In Sudan pearl millet locally known as Dukhun, is one of the important cereal crops , next to sorghum in both area and total production . It contributes the stable food of the majority of inhabitants of Western part of Sudan (Darfur and Kordofan) where it occupies an area of 1.2- 2.938 million hectares [4; 10; 15; 8]. Most of the millet area in the Sudan (95%) is cultivated and harvested under traditional rain fed agriculture using local varieties. Some farmers in the mechanized clay plain of central Sudan started to grow pearl millet instead of sorghum [6]. The grain consumed as human food, the stalks can be used as forage and as building material or fuel .A number of local varieties could be identified and named by farmers in Sudan according to time of maturity, plant height and grain color, the most widely varieties include Kano, mayoa, Abusoof or abushara, Dembi, Drmsa, Bauoda, Sharoba , Aish Bernu , Hammer. In Darfur Dembi is relatively a dwarf short day to maturity, red seeded variety .A taller longer season white seeded type has different names in different places [21; 3; 2] generally, pearl millet did not receive the appropriate attention.

Therefore, the present study was conducted to investigate the effect of plant spacing and variety on growth and yield of pearl millet under rain fed condition and to invent crop pests and diseases.

2. MATERIALS AND METHODS

Two field experiments were conducted at the University of Zalingei demonstration farm. Zalingei, Sudan, during 2005 rainy season, to investigate the effect of plant spacing and variety on performance of pearl millet grown on two soil types under rain fed condition and to invent crop pests and diseases Two locations of different soil types location1of sandy loam soil and location 2 of clay loam soil [17] were chosen for the study, at distance of 1 km from each other. Treatments consisted of three plant spacing (90cm, 70cm and 50 cm) which were designated as s_1, $s_1$and s_3 respectively with 70 cm space between rows for all treatments. Four millet varieties (Dembi from North Darfur local farmers, Improved Dembi from ministry of agriculture West Darfur state, Bauoda and Drmsa(local names)from local farmers in Zalingei area were grown. They were designated as ND, ID, B and DR respectively. Treatments were arranged in split plot design replicated four times with plant spacing in the main plots and varieties in the subplots. The size of the main plots and subplots were 16×4 and 4×4 m respectively. Measurements of vegetative growth attributes were carried on plant samples from the three central rows of each plot. Three

plants were selected randomly from each plot and tagged for plant height, number of leaves ⁄ plant, leaf area and stem diameter. Plant height was measured at maturity this was done from the soil surface to the bottom of the head. The number of leaves⁄plant and leaf area measured after 60 days from sowing when plants showed good vegetative growth. Leaf area was obtained on basis of Marshal Formula [16]. The stem diameter was measured by using Vernia Clipper. Number of days to 50% flowering, number of days to milky stage and number of days to maturity were determined from sowing until 50% of the plants flowered, the grain showed milky signs and majority of the grains on the heads matured (maturity was indicated by the formation of black layer at the base of the grain. Plants were left in the field for 25-30 days after maturity; this was meant to allow for complete maturity and minimum grain moisture content to prevent rotting later on. The crop was manually harvested by using traditional implement and stored in paper bags at room temperature for a month to complete drying. Thereafter, head length and yield were recorded. Heads harvested from each plot were threshed and the weight of grain was determined, this was used in calculation of grain yield per hectare. A random sample of 1000- grains was taken from each plot and then weighed to obtain 1000-grain weight. All collected data for the two locations were statistically analyzed. Analysis of variance and test of significance were done according to standard procedure of split plot design [9]. Means were differentiated according to Duncan's Multiple Range Test (DMRT). For the Pests and diseases inventory the growing season was divided into three periods (early season, middle of the season and late season) according to pests and diseases incidence .Readings were taken periodically every seven days walking in W shape method during the inventory .Data were recorded due to disease incidence and infection symptoms or pest appearance for pests.

Table 1: Soil chemical and physical properties (location 1)

Depth (cm)	P^H paste	ECe dSm^{-1}	N (%)	P (ppm)	O.C. (%)	Soluble cations (meq⁄l)				Soluble anions (meq⁄l)			Mechanical analysis (%)		
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO3^{=}$	$HCO3^{=}$	Cl^{-}	sand	silt	clay
0-30	5.6	0.20	0.029	0.74	0.29	1.74	1.50	0.10	0.10	Nil	1.50	0.50	65	20	15
30-60	6.7	o.26	0.036	0.77	0.16	1.75	1.50	1.10	0.10	Nil	1.50	0.50	43	20	37

Source: Mohamed Ali (2002)

Table 2: Soil chemical and physical properties (location 2)

Depth (cm)	P^H paste	ECe dSm^{-1}	N (%)	P (ppm)	O.C. (%)	Soluble cations (meq⁄l)				Soluble anions (meq⁄l)			Mechanical analysis (%)		
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO3^{=}$	$HCO3^{=}$	Cl^{-}	sand	silt	clay
0-30	6.4	0.24	0.035	0.83	0.32	1.75	1.57	1.00	0.20	Nil	1.50	0.50	42	17	41
30-60	7.0	o.33	0.029	0.90	0.25	1.81	1.64	1.30	0.18	Nil	1.75	0.50	30	22	48

Source: Mohamed Ali (2002)

3. RESULTS AND DISCUSSION

Results in Table (3) showed that plant spacing had no significant effect on growth parameters at both locations except leaf area at location 1 in which 90 cm plant spacing recorded the higher leaf area (165.8 cm^2). Whereas,50 cm plant spacing recorded the lower leaf area (136.9 cm^2). Results indicated that near planting (50 cm) produced tall plants even the difference was insignificant, this might be due to plants competition. [14] Reported that plant height significantly increased with wider row spacing. For the effect of variety on growth parameters under different planting spaces, results showed significant ($P \leq 0.05$) differences between varieties for plant height at the two locations (Table 4), similar results were reported by [18]. ND and ID are short cultivars. Whereas, DR and B were tall cultivars, this might be due to genetic characteristics. There was significant ($P \leq 0.05$) difference between varieties for leaf area, stem diameter at location 2, whereas, differences between varieties for stem diameter at location 1 were not significant, this might be due to local varieties adaptability (B and DR) to the environment in the area compared with ND or ID. [7] Found that plant height of pearl millet was significantly different among the genotypes. Results in Table (5) indicated that plant spacing had no significant effect on yield attributes at the two locations except 1000-grain weight and yield. It was found that S_2 (70 cm plant spacing) produced the best grain yield. Whereas, S_3 (50 cm plant spacing) produced the lower grain yield (311.1 and 305.8 kg⁄fed) respectively at location 1. At location 2 S_1 and S_2 produced the same yield (326.7 kg ⁄ fed).Whereas, S_3 produced the lowest grain yield (286.3 kg⁄fed) this might be due to increase in plants number.

When [19] studied the influence of inter- row spacing (75,100 and 150 cm and the intra-row spacing (50, 75 and 100 cm) on grain yield and its component pf two pearl millet cultivars he found that all traits were significantly affected by inter- row spacing in both seasons and intra-row spacing in the first season, also results recorded by [13; 12] may strengths the above findings. Whereas, [22] found that plant height, 1000 grain weight, panicle length, panicle weight, number of panicles, grain yield and Stover weight were not significantly affected by the intra-row spacing. Results in Table (6) reveled significant ($P \leq 0.05$) difference between varieties to reach 50% flowering at the two locations, it was found that ND reached 50% flowering earlier (60.6 and 62.3 days) compared with other varieties. For milky stage plants at location 1 showed significant ($P \leq 0.05$) difference, that ND reached earlier (72.2 day) and B and DR were more later (76.6 day) which was reflected on reaching maturity stage . It was indicated clearly that variety had significant ($P \leq 0.05$) effect on number of days to maturity, that ND reached maturity stage earlier (80.2 and 89.6 days) and B was the latest variety for reaching maturity stage (85.7 and 93.5 days) at the two locations respectively .results indicated that variety had significant ($P \leq 0.05$) effect on yield (Table 4) that ND produced higher yield at location 1 (356.4 kg／fed) and DR at location 2 (353.7 kg／fed). This might be due to the adaptability of the two varieties to the soil conditions at both locations similar results were recorded by [20] that yield of pearl millet varies with different hybrids. Also [18] reported that significant differences were observed in grain yield, Stover yield, days to 50% flowering and plant height among the varieties. The interaction of planting space× variety showed no significant effect on pearl millet performance, this might be due to rain fall distribution. In contrast results obtained by [19] indicated that the interaction among the cultivars, inter and intra-row spacing for the two cultivars studied was significant for grain yield, he concluded that the best spacing for pearl millet in Lagawa area was 75 × 50 cm for Ugandi and 100 × 50 cm for Dembi. These results suggest further research with different cultivars and under different rainfall conditions in order to find most suitable inter-row and intra-row spacing in the area. Results of pests and diseases inventory showed that pear millet was infected by many pests, such as the larvae of butter fly (Spodoptera sp.) , stem borer (Chilo partellus) , aphids (Schisaphis graminum) , white ants (Microtermes theracalis)pearl millet head worm(Heliocalis albipunctella) , desert locust (Schistocerca gregaria) and birds (Quelea quelea athiopica) . Beside the above mentioned pests , pearl millet was also found to be infected by some diseases such as , the damping-off of young seedlings which is caused by the fungus (Pythium sp. & Rhizoctonia sp.), Downey mildew which is caused by (Sclerospora graminicola) and the smut diseases which is caused by (Sphacelotheca sp.), these diseases were reported in pearl millet worldwide [5] . The results also revealed that the spread of pests and diseases in pearl millet was affected by growth stage of the crop, results in Table (7) showed that the butter fly larvae and the damping- off diseases were appeared early in the season, however pearl millet head worm and smut diseases were appeared in middle and late season, these results were similar to those reported by [1]. Different varieties of pearl millet reflect different levels of resistance. With regard to soil type, results showed that disease incidence on pearl millet were found to be high in case of location 2 than in location 1. Beside the above mentioned pests and diseases, results also showed that there was high infestation of Buda (Striga hermontheca) among the pearl millet crop under test and this might be due to the law soil fertility .

Table 3: effect of plant spacing on growth parameters at the two locations

Location of Experiment	Plant spacing	Plant height at maturity (cm)	No. of leaves／plant at 60 days after sowing	Leaf area(cm^2)	Stem diameter at maturity (cm)
Location 1	50 cm (s_1)	153.6	31.6	136.4	0.92
	70 cm (s_2)	149.6	34.1	148.2	1.01
	90 cm (s_3)	142.9	35.7	165.8	1.06
	C.V (%)	13.8	5.6	1.5	1.1
	L.S.D	17.7	14.8	16.5*	0.73
Location 2	50 cm (s_1)	134.2	24.2	164.5	0.93
	70 cm (s_2)	133.4	29.7	169.2	0.97
	90 cm (s_3)	132.9	24.0	166.0	0.97
	C.V (%)	22.0	29.0	15.2	9.6
	L.S.D	25.9	6.6	5.6	0.08

* Significant at 5% level
Location 1 of sandy loam soil Planting space 50 cm (s_1) Planting space 70 cm (s_2)
Location 2 of clay loam soil Planting space 90 cm (s_3)

Table 4: effect of variety on growth parameters at the two locations

Location of Experiment	variety	Plant height at maturity (cm)	No. of leaves/plant at 60 days after sowing	Leaf area(cm^2)	Stem diameter at maturity (cm)
Location 1	Improved Dembi (ID)	137.9	33.4	131.1	0.99
	North Darfur Dembi (ND)	136.8	31.8	154.5	0.95
	Drmsa (DR)	159.9	30.1	156.1	1.01
	Bauoda (B)	144.5	38.0	169.0	1.08
	C.V (%)	1.8	3.1	10.2	15.5
	L.S.D	22.0*	27.0	11.2*	0.2
Location 2	Improved Dembi (ID)	125.5	24.1	147.8	0.90
	North Darfur Dembi (ND)	129.9	26.6	178.4	0.96
	Drmsa (DR)	150.1	26.2	177.2	0.96
	Bauoda (B)	142.5	26.4	162.8	0.99
	C.V (%)	7.9	13.5	12.6	10.4
	L.S.D	7.6*	2.5	18.2*	0.07*

* Significant at 5% level

Table 5: effect of plant spacing on yield attributes at the two locations

Location of experiment	Plant pacing	No. of days to 50% flowering	No. of days to milky stage	No. of days to maturity	Head length (cm)	1000-grain weight	Yield (kg/fed)
Location 1	50 cm (s_1)	63.8	73.2	80.5	17.3	8.7	307.7
	70 cm (s_2)	65.0	75.3	80.2	18.6	9.4	311.1
	90 cm (s_3)	65.5	71.2	81.7	18.0	8.1	305.8
	C.V (%)	7.0	5.9	4.5	8.5	1.2	6.6
	L.S.D	4.9	9.0	4.6	1.9	1.3*	2.9*
Location 2	50 cm (s_1)	67.0	72.8	90.3	21.1	8.3	326.7
	70 cm (s_2)	68.1	74.8	92.4	21.7	8.4	326.6
	90 cm (s_3)	68.3	76.8	3.3	20.6	7.7	268.3
	C.V (%)	7.7	9.7	2.6	14.0	8.0	19.0
	L.S.D	4.5	6.3		2.6	0.6*	27.0*

* Significant at 5% level

Table 6: effect of variety on yield components at the two locations

Location of experiment	variety	No. of days to 50% flowering	No. of days to milky stage	No. of days to maturity	Head length (cm)	1000-grain weight	Yield (kg/fed)
Location 1	Improved Dembi (ID)	64.5	74.9	84.9	18.4	8.5	264.3
	North Darfur Dembi (ND)	60.6	71.4	80.2	18.9	9.8	356.4
	Drmsa (DR)	62.6	74.9	80.9	18.5	8.3	308.4
	Bauoda (B)	63.1	74.0	85.7	17.7	9.2	3o2.1
	C.V (%)	3.0	8.2	7.6	3.0	1.2	4.2
	L.S.D	1.6*	10.6	4.5*	3.9	1.3	18.3*
Location 2	Improved Dembi (ID)	64.6	75.0	91.4	20.6	8.0	287.8
	North Darfur Dembi (ND)	62.3	72.2	89.6	21.9	8.1	308.4
	Drmsa (DR)	67.2	75.3	92.9	22.0	8.1	353.7
	Bauoda (B)	67.2	76.6	93.5	20.1	8.2	299.4
	C.V (%)	2.6	4.8	1.7	20.7	10.3	4.8
	L.S.D	1.3*	2.6*	1.2*	3.2	0.6	25.0*

* Significant at 5% level

Table 7: pests and diseases affected pearl millet.

Period of sampling	Pests	Diseases
Early season	Larvae of butter fly, the aphids, pearl millet stem borer, white ants and grass hoppers.	Damping-ff of young seedlings, seed and root rot.
Middle of the season	Pearl millet head worm.	Downey mildew and smut diseases.
Late season	Pearl millet head worm, desert locust and birds.	Downey mildew and smut diseases.

4. CONCLUSIONS

- Results showed that plant spacing had no significant effect on growth parameters studied except plant height. Where, varietes showed significant differences between them for this character.
- Plant pacing had no significant effect on most of yield attributes at the two locations. Whereas, varieties under planting space reveled significant effect on some yield attributes.
- There are many pests and diseases affecting millet during growth stages with difference between varieties in the degree of infection.

5. RECOMMENDATIONS

According to the above mentioned points some recommendations could be stated which can effectively affected millet production in Darfur Sudan.

- Growing North Darfur Dembi in the areas of low rainfall and light soil whereas, other varieties can be grown on the moderately rain fall and heavy textured soil
- Applying intra-row spacing of 70 ×70 cm in areas of light or heavy textured soil in the area.
- Intensify of agricultural extension for pest control and pesticides management in rain fed areas.
- Further research with many indigenous and improved varieties should be done in Darfur states in collaboration with agricultural research stations and ministries of agriculture in the states.

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