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EFFECT OF SOWING TECHNIQUES ON YIELD AND RAINFALL PRODUCTIVITY OF PEARL MILLET IN GARDUD SOIL OF NORTH KORDOFAN STATE

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Abstract: Pearl millet is grown in environments that are drought-prone areas. The climate change is expected to increase vulnerability in all agro-ecological zones through rising temperature and more erratic rainfall, which will have drastic consequences on food security. Pearl millet is the cereal crop that has a great potential for ensuring food security and income generation in marginal areas because of its suitability to the extreme limits of agriculture. This study was carried out at the Jebel Kordofan experimental site, Sheikan province in North Kordofan state during 2010–2012 seasons to evaluate the effect of different sowing techniques on yield and rainfall productivity of local and improved millet cultivars. Treatments were a combination of four sowing techniques and two cultivars of pearl millet. The sowing techniques were: dry sowing, wet sowing, deep dibbling (10-cm depth) and priming with micro-dozing fertilizer. The two cultivars were Ashana (improved) and Dembi (local). These treatments were arranged in a split-plot design, the main plot for cultivars and subplot for sowing methods in four replications. The parameters studied were days to 50% flowering, plant height (cm), grain yield (kg/ha) and rainfall productivity (kg/ha/mm). The cultivars showed highly significant differences in the number of days to 50% flowering, plant height (cm), grain yield (kg/ha) and rainfall productivity (kg/ha/mm). The dry sowing technique significantly ($P \leq 0.05$) produced the tallest plant (149cm), higher water use efficiency (5.10 kg/ha/mm) and the highest grain yield (1637 kg/ha). It can be concluded that the seedbed prepared with a chisel plough and sown on dry soil produced the highest grain yield.

Key words: sowing techniques, millet cultivars, rainfall use efficiency, yield.

Introduction

Pearl millet (*Pennisetum glaucum (L.) R.Br*) is one of the two major crops grown to feed people living in the semi-arid, low-input dry land agricultural

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regions of Africa and Southeast Asia. It is a potential alternative grain crop for areas of the Great Plains with sandy soil, low rainfall, and a short growing season since dwarf hybrids with a good yield potential have been developed (Maman et al., 1999; FAO and ICRISAT, 1996). In Sudan, pearl millet area is about 1–2 million ha, with average grain yield of 0.2–0.4 t/ha and a total annual production of 0.2–0.6 million tons. About 95% of this area is found in western Sudan state, mainly in the sandy areas (Goz) which occupy the northern parts of these states. The yield is generally very low with the average of 240hg/ha (Abuelgasim, 2001).

Due to increasing water scarcity, particularly for agriculture, and high competition for water for urban and industrial uses, agriculture is expected to be increasingly dependent on rainfall as the cheapest source of water and maximizing the efficiency of its use to produce crop will be vital. Rainwater productivity can be increased further by timely farm operations such as timely planting and weeding. The adoption of agronomic procedures such as minimum tillage, appropriate fertilizer use, timely weeding, disease and insect control, timely planting, in conjunction with new cultivars has the potential to increase the yield and rainfall use efficiency of dryland crops (Turner, 2004). Water use efficiency is influenced by weather conditions that affect plant growth and development and ultimately, yield (Gracia et al., 2009; Hassan, 2013).

Pearl millet is adapted to the poor soil and low rainfall conditions, in addition to its capability of rapid and vigorous growth under favourable conditions. The objective of this study is to identify the effect of different sowing techniques on rainfall use efficiency and yield of local and improved pearl millet cultivars.

Materials and Methods

Site. This work was conducted for three seasons (2010, 2011 and 2012 and) at El-Obeid Research Station, the demonstration farm, Jebel Kordofan. The total annual rainfall received was 235 mm, 211 mm and 288 mm, respectively for three seasons (Table 1). The soil is sandy clay loam soil locally known as gardud (62% sand, 20% clay and 18% silt). It is characterized by surface compaction and a bulk density that increases substantially at a 15-cm depth from the surface (Omer, 1990). The mean soil moisture content at the beginning of each of the three seasons was 7%, 5% and 9%; and 6%, 6% and 8% at the end of each season, respectively. The soil was ploughed (before sowing) by the chisel plough to improve its physical properties.

Treatments were a combination of two pearl millet cultivars and four sowing techniques.

Cultivars. Two pearl millet cultivars were used in this study. First, Ashana known as Okashana-2, an open-pollinated variety introduced from the SADC region of Southern Africa and released in Sudan in 1996 as early maturing (75 days), high yielding and resistant to downy mildew disease caused by (*Sclerospora graminicola* (Sacc.) J. Schröt.) (Mahietal, 1995). Second, Dembi cultivar is the most popular and widely grown local variety in Kordofan. It has a light brown to yellowish-brown seed color and is comparatively late in maturity (around 120 days) with medium or tall plant height.

Table 1. Rainfall amounts and distribution for seasons of 2010, 2011 and 2012 at Jebel Kordofan.

Month	Season of 2010		Season of 2011		Season of 2012	
	Rainfall (mm)/month	Rainy days/month	Rainfall (mm)/month	Rainy days/month	Rainfall (mm)/month	Rainy days/month
June	18.0	1	-	-	-	-
July	80.5	6	55.5	4	43.0	3
August	96.5	7	88.0	7	160.0	5
September	36.0	2	50.5	3	58.0	4
October	4.0	1	17.0	2	27.0	2
Total	235.0	17	211.0	16	288.0	14

Source: El-Obied research station.

Sowing techniques. Dry seeding: seeds were sown on dry soil to catch early rainfall showers as a method of planting farmers usually practice during April–May.

- Wet seeding: seeds were sown in wet soil after effective rainfall.
- Dibbling: seeds were sown at 10-cm depth.
- Priming and micro-dozing fertilizer: seeds were soaked in water for 8hrs and sown together with 0.3g/hole of NPK (17-17-17) equivalent to 8 kg/ha of fertilizer (Osman et al., 2010).

Design and replications. A split-plot design was used – main plots were cultivars and subplots were the sowing methods with four replications. Plot size was 5m width x 5m length area and net area of 3m x 5m.

Cultural practices. Land was prepared with a tractor-mounted chisel. Seeds were treated with Apron star at a rate of 3gm/kg (for all seed treatments). Sowing date: sowing was done manually as described below in Table 2.

The spacing used for Ashana cultivar was (75cm x 50cm, 6 rows) and Dembi (100cm x 75cm, 5 rows) (Hassan et al., 2011). The seedlings were thinned to 2–3 plants/hole. Plots were hand-weeded twice during the growing season. Other management practices followed ARC recommendations.

Data collection. Data was collected from the central rows (6 rows for Ashana and 3 rows for Dembi) of each plot, by discarding the marginal rows. The numbers of days to 50% flowering were recorded (days from plant emergence to 50% flowering). Plant height (cm) was measured as the average of 10 plants. Grains/plot were measured and expressed as yield (kg/ha). Rainfall use efficiency was calculated by dividing the total yield by the amount of rainfall received during the season and expressed as kg/ha/mm.

Table 2. Dates of sowing for the four sowing techniques.

Sowing techniques	1st season	2nd season	3rd season
Dry sowing	28/6/2010	18/7/2011	15/7/2012
Wet sowing	7/7/2010	24/7/2011	19/7/2012
Deep ripping	7/7/2010	24/7/2011	19/7/2012
Priming and micro-dozing	7/7/2010	24/7/2011	19/7/2012
Harvesting date	12/10/2010	17/10/2011	11/10/2012

Statistical analysis. Data for each season in addition to combined data were subjected to statistical analysis by the MSTAT-C statistical package developed by Michigan State University as described by Gomez and Gomez (1984).

Results and Discussion

The combined analysis of data during 2010–2012 seasons showed highly significant differences for the number of days to 50% flowering, yield, yield attributes and rainfall use efficiency due to seasons. The seasons interacted significantly with methods of sowing on 50% flowering and rainfall use efficiency.

The significant difference due to varieties appeared on mean number of days to 50% flowering (Table 3) where the early maturing cultivar (Ashana) flowered earlier than the late maturing local cultivar (Dembi) under rain-fed conditions. A similar result was reported on different locations of these varieties (Abdalla et al., 2012).

Table 3. The effect of cultivars on the number of days to 50% flowering, plant height (cm), grain yield (kg/ha) and rainfall use efficiency (kg/ha/mm) combined for three seasons at Jebel Kordofan site.

Cultivars	Number of days to 50% flowering	Plant height (cm)	Grain yield (kg/ha)	Rainfall use efficiency (kg/ha/mm)
Ashana	51	138	1547	5.62
Dembi	61	148	1056	3.87
SE ±	0.45***	2.8*	79.3**	0.23**
C.V. (%)	7.2	8.6	42.2	41.2

Methods of sowing showed no significant difference in the number of days to 50% flowering, but interacted significantly with seasons and varieties and revealed that the dry sowing method attained the 50% flowering earlier (43 days) of the cultivar Ashana, in the season with high rainfall (2012) than the latest dibbling methods (70 days) of Dembi, for the same season (Table 5).

Table 4. The effect of methods of sowing on plant height (cm), grain yield (kg/ha) and rainfall use efficiency (kg/ha/mm) combined for three seasons at Jebel Kordofan site.

Sowing techniques	Plant height (cm)	Grain yield (kg/ha)	Rainfall use efficiency (kg/ha/mm)
Dry sowing	149	1637	5.91
Wet sowing	141	1311	4.75
Deep dibbling	141	1211	4.44
Priming and fertilizer	143	1048	3.88
SE ±	2.2*	115**	0.41**
C.V. (%)	8.6	42.2	41.2

The plant height was significantly affected by cultivars and sowing methods. The local cultivar (Dembi) gave the taller plants (148cm) than Ashana (138cm) in this study as the difference in the cultivar genetic composition (Table 3). This finding is similar to Abdalla et al. (2012) and Mohamed et al. (2013) in finding difference heights across the major pearl millet growing region. The planting methods significantly ($P \geq 0.05$) affected plant height (cm). The dry sowing method gave the tallest plants in comparison to the other methods (Table 4), and this could be attributed to the efficient use of rainfall for growth. This is in conformation with the findings of Eastham and Gregory (2000) findings that, in dry seeding, seeds emerge at the onset of rains and thereby gain several days for more growth than sowing after rain. Also, Mohamed et al. (2013) concluded that early sowing produced taller plants of pearl millet.

The varietal difference was highly significant ($P \leq 0.01$) on grain yield. The improved cultivar (Ashana) produced higher grain yield (1547kg/ha) than the local one (Dembi) (1056kg/ha) (Table 3) and also among the study seasons (Table 7). This varietal difference was confirmed by many researchers (Hassan et al., 2011; Abdalla et al., 2012; Mohamed et al., 2013).

The sowing methods play an important role in obtaining higher yield. Grain yield was highly significantly affected by sowing methods in the combined analysis. Higher grain yield was obtained by dry sowing and lower yield from priming and fertilizer (Table 4). The increments in grain yield from the dry sowing method were 24%, 35% and 56% over the wet, dibbling and priming methods, respectively (Figure 1). This might have been associated with the utilization of rainwater in early sowing. This matches the results of Upadhyay et al. (2001) who reported that higher grain yield was obtained from early sowing and considerable reduction in yield with delayed sowing. On the other hand, Shinggu and Gani

(2012) reported that the planting method and the sowing date did not have an effect on grain yield and 100-seed weight.

Table 5. The interaction between cultivars, methods of sowing and seasons on the number of days to 50% flowering (2010–2012 seasons) at Jebel Kordofan site.

Sowing methods	Ashana			Dembi			Mean	SE ±
	2010	2011	2012	2010	2011	2012		
Dry sowing	64	54	43	64	65	53	57	0.84ns
Wet sowing	55	52	44	55	63	65	56	
Dibbling sowing	55	52	44	55	61	70	56	
Priming and fertilizer	55	53	44	55	60	69	56	
Season mean	57	53	44	57	62	64		
Mean (cultivars)		51			61			
SE ±	0.45***							
SE ± (interaction)	2.1*							
C.V. (%)	7.16							

Rainfall use efficiency was highly significantly affected by cultivars. In this study, the improved early maturing cultivar possessed the higher rainfall use efficiency (5.10kg/ha/mm) than the late maturing one (Table 3). Generally, early maturing varieties have a strong advantage in yield over the late one when moisture is limited (Laing and Fischer, 1977).

Table 6. The interaction effect of seasons and methods of sowing on rainfall use efficiency (kg/ha/mm).

Methods of sowing	1st season (2010)	2nd season (2011)	3rd season (2012)	Mean	SE ±
Dry sowing	3.13	0.84	13.7	5.91	0.41**
Wet sowing	2.31	0.85	11.1	4.75	
Deep dibbling	3.12	0.80	9.34	4.44	
Priming and fertilizer	3.33	0.80	7.50	3.88	
Mean	2.97	0.84	10.4		
SE ± (season)	0.34***				
SE ± (interaction)	0.71**				
C.V. (%)	41.2				

The sowing methods significantly affected the rainfall use efficiency. Dry sowing methods utilized the rain more than the others (Table 4). The significant interaction of seasons and methods of sowing revealed that dry sowing performed better in the season with high rainfall (2012) as this technique captured more rain. In much dry land environment, early sowing is usually one of the most reliable strategies to maximize the water use efficiency (Stappar and Harris, 1989).

However, the dibbling method showed constancy in performance across the different seasons of this study (Table 6). Tunner (2004) stated that increasing the depth of rooting is the major way to increase the water use of the crop by itself.

Table 7. The individual and combined grain yield (kg/ha) of pearl millet cultivars at Jebel Kordofan site during 2010–2012 seasons.

Methods of sowing	Ashana			Dembi			Combined sowing methods	SE ±
	2010	2011	2012	2010	2011	2012		
Dry sowing	805.5	196.3	4690.0	731.0	163.3	3238.0	1637.0	115**
Wet sowing	602.0	187.0	4105.0	524.0	173.8	2274.0	1311.0	
Deep dibbling	683.0	219.8	3559.0	841.0	149.8	1814.0	1211.0	
Priming and fertilizer	1017.0	195.7	2303.0	614.0	136.4	2021.0	1048.0	
Yield per seasons	777.3	199.7	3664.0	677.8	155.8	2337.0		
SE ±	62.1^{ns}	9.2*	263*					
C.V.%	44.0	15.8	30.7					
Combined mean		1547			1056			
SE ±	79.3**							
C.V.%	42.2							

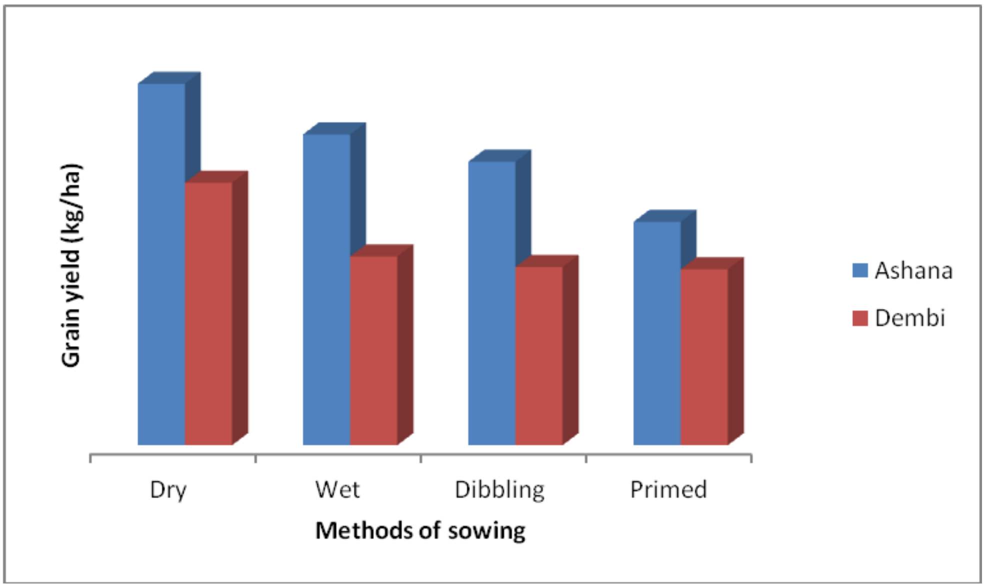

Figure 1. Millet cultivar yields under different sowing methods (during 2010–2012 seasons) at Jebel Kordofan area.

Conclusion

The improved variety (Ashana) gave high water use efficiency, earliness and grain yield under rainfed conditions as compared with the local one (Dembi), hence, the improved cultivar is considered the most important agronomic option to improve rainfall use efficiency and yield of pearl millet in rain-fed areas. Dry sowing has a high probability of poor seedling emergence due to seed desiccation and damage by insect and rats when practiced by farmers (during late April and May). An improvement in this technique developed in this study is dry sowing between the last week of June and the second week of July with a seed dresser. This modified dry sowing significantly gave higher grain yield than the others.

As a conclusion, the agronomic options to increase the yield and rainfall use efficiency of pearl millet under rain fed areas are as follows: soil preparation by a chisel plough in gardud areas; selection of the early maturing cultivar; dry sowing (from the 4th week of June to 2nd week of July) and dibbling at 10 cm. It is recommended to use the modified dry sowing in the gardud area of pearl millet for high yield and better rainfall use efficiency.

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UTICAJ TEHNIKA SETVE I PRODUKTIVNOST PADAVINA NA PRINOS PROSA CRNI MUHAR NA ZEMLJIŠTU GARDUD U SEVERNOM KORDOFANU

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R e z i m e

Crni muhar se gaji u sredinama koje su pogođena sušom. Očekuje se da će klimatske promene povećati osetljivost u svim agro-ekološkim zonama, kroz rastuće temperature i obilne padavine, što će imati drastične posledice na prehrambenu sigurnost. Crni muhar je žito koje ima veliki potencijal za obezbeđenje prehrambene sigurnosti i stvaranje prihoda na marginalnim područjima, zbog svoje pogodnosti gajenja i u ekstremnim uslovima poljoprivrede. Ovo studija je izvršena na eksperimentalnom lokalitetu Jebel Kordofan, u pokrajini Sheikan u državi Severni Kordofan tokom sezona 2010–2012. godine, kako bi se procenio uticaj različitih tehnika setve i padavina na produktivnost prinosa lokalnih i poboljšanih sorti prosa. Tretmani predstavljaju kombinaciju četiri tehnike setve i dve sorte crnog muhara. Tehnike setve su uključivale: suvu setvu, vlažnu setvu, duboku sadnju (na dubini od 10 cm) i potapanje sa mikrodoziranim đubrivom. Dve sorte su bile uključene: Ashana (poboljšana) i Dembi (lokalna). Ovi tretmani su bili raspoređeni po dizajnu podeljenih parcela, glavna parcela za sorte i potparcela za metode setve u četiri ponavljanja. Proučavani su parametri: dani do 50% cvetanja, visina biljke (cm), prinos zrna (kg/ha) i produktivnost padavina (kg/ha/mm). Sorte su pokazale visoko značajne razlike u odnosu na broj dana do 50% cvetanja, visinu biljke (cm), prinos zrna (kg/ha) i produktivnost padavina (kg/ha/mm). Tehnika suve setve značajno ($P \leq 0.05$) je dala je najviše biljke (149cm), veću efikasnost korišćenja vode (5, 10 kg/ha/mm) i najviši prinos zrna (1637 kg/ha). Može se zaključiti da je setvena parcela pripremljena čizel plugom i setva u suvom zemljištu dala najviši prinos zrna.

Ključne reči: tehnike setve, sorte prosa, efikasnost upotrebe padavina, prinos.

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