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EFFECT OF WEED CONTROL TREATMENTS, SOWING DATE AND SOWING METHOD ON GROWTH AND YIELD OF FINGER MILLET (*Eleusine coracana* (L.) Gaertn) IN SUDAN SAVANNA OF NIGERIA

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ABSTRACT

Field experiment was conducted during 2016, 2017 and 2018 rainy seasons at the Research Farm of National Institute for Horticultural Research (NIHORT) Bagauda (Latitude 11° 33' N and Longitude 8° 23' E, 481m above sea level) Kano, in the Sudan savanna of Nigeria. The aim of the study was to evaluate the effect of weed control treatments, sowing dates and methods on the growth and yield of finger millet (*Eleusine coracana* (L.) Gaertn.). The experiment consisted of three (3) sowing date (late June, early July and late July), three (3) sowing methods (broadcasting, drilling and dibbling) and six weed control treatment (atrazine at 0.8 or 1.2kg a.i.ha^{-1}, 2,4-D at 0.5 or 0.75kg a.i. ha^{-1}, two hoe weeding at 3 and 6 weeks after sowing (WAS) and weedy check). These were laid out in a split-split-plot design and replicated three (3) times. Sowing dates were assigned to main plot, sowing methods to subplot while weed control to sub-sub plots. The results revealed that sowing on late June and early July produced significantly taller plant and higher grain yield. Broadcasting produced higher number of tillers (m^{-2}) and grain yield in 2016 (887.3kg ha^{-1}), 2017 (1230.0kg ha^{-1}) and 2018 (1255.0kgha^{-1}). Furthermore, two hoe weeding produced significantly higher grain yield (kgha^{-1}) in all the seasons which were statistically similar with plots treated with atrazine at 1.2kg a.i. ha^{-1} and those treated with 2,4-D at 0.5 and 0.75kg a.i. ha^{-1}. Based on these findings, it can be concluded that finger millet should be sown between late June to early July by broadcasting method and application of either atrazine at 1.2 kg a.i. ha^{-1} pre-emergence or 2,4-D at 0.5kg a.i. ha^{-1} post-emergence for higher grain yield (kgha^{-1}).

Key words: finger millet; weed control; sowing date; sowing method

INTRODUCTION

Finger millet (*Eleusine coracana* (L.) Gaertn) is a major food crop of the semi-arid tropics of Asia and Africa and has been an indispensable component of dryland farming systems (Kerr, 2014). It belongs to the family Poaceae, it is a native to Africa and was domesticated in the highlands of Ethiopia and Uganda 5000 years ago (NRC, 1996; Dida *et al.*, 2008). The crop is ranked fourth globally in importance among coarse grains, after giant millet (sorghum), pearl millets and foxtail millets (Gupta *et al.*, 2012; Upadhyay *et al.*, 2007), and it is cultivated in more than 25 countries, mainly in Africa and Asia (Chandrashekar, 2010).

Finger millet is adapted to a wide range of environmental and climatic conditions. It is preferably grown on well drained sandy loam with pH range of 5.0 to 8.2, and can tolerate less fertile soils with poorer growing conditions such as intense heat and low rainfall (Baker, 2003). It is primarily a subsistence staple cereal food for millions of people in dry lands of East and Central Africa and Southern India (Holt, 2000; Mgonja, 2005). This plant, though not produced in large quantity in Nigeria compared to other cereals, is an important crop because of its high nutritive value. It is rich in minerals, such as calcium, iron, and phosphorus (Glew *et al.*, 2008), and essential amino acids which include methionine and tryptophan (Fernandez *et al.*, 2003). Regular consumption of finger millet is known to reduce the risk of diabetes mellitus and gastrointestinal tract disorders which helps in controlling blood sugar level in condition of diabetes (Tovey, 1994), this is due to presence of phenolic compounds in finger millet's flour which lower digestibility and absorption of starch (Muninarayana *et al.*, 2010).

Finger millet production in Nigeria is constrained by several factors especially with regards to appropriate sowing date and methods as well as inappropriate weed control strategies. The low yields on farmers' field in Nigeria and elsewhere have been attributed to poor agronomic management practices such as poor weed management, inappropriate sowing date and sowing methods among others. The objective of the study was to identify the appropriate weed control treatment with the best sowing date and methods for higher grain yield of finger millet.

MATERIALS AND METHODS

The experiment was conducted during the 2016, 2017 and 2018 rainy seasons, at the research farm of National Institute for Horticultural Research (NIHORT) Bagauda (Latitude 11° 33' N and Longitude 8° 23' E, 481m asl) Kano, in the Sudan savanna ecological zone of Nigeria. The experiment consisted of three (3) sowing dates (late June, early July and late July), three (3) sowing methods (broadcasting, drilling and dibbling) and six weed control treatments (Atrazine at 0.8 or 1.2 kg a.i. ha^{-1}, 2,4-D at 0.5 or 0.75 kg a.i. ha^{-1}, two hoe weeding at 3 and 6 WAS, and weedy check). These were factorially combined and laid out in a split-split-plot design and replicated three (3) times. Sowing dates were assigned to the main plot, sowing methods to

the subplot while weed control treatments were assigned to the sub-subplot.

In each year of the trial, the field was harrowed twice to achieve a fine tilth and made into flat beds, it was then marked into the required number of plots each of gross area of 3m × 3m ($9m^2$) and net plot size of 2m x 3m ($6m^2$). The borders between main plots, subplots, sub-subplots and replicates were 1.5m, 1m, 0.5m and 2m, respectively. The seeds were sown manually on treatment basis using a seed rate of 5 kg ha^{-1}. The late June, early July and late July sowing was done on 25th June, 9th July and 23rd July, respectively. Broadcasting was done by spreading the seeds on the soil evenly, dibbling was done by planting the seeds at 20 x 10cm inter and intra row spacing, respectively, while drilling was done by sowing the seeds at a spacing of 20cm inter row. The crop was harvested manually at physiological maturity when the panicle turned brownish in colour, confirmed by free threshing of the grains when the heads fingers were squeezed by hand.

Data were collected on plant height, plant dry weight, number of tillers (m^{-2}) and grain yield ($kgha^{-1}$). The data were subjected to analysis of variance as described by Snedecor and Cochran (1967) using GenStat software (GenStat, 2013), and the treatment means that were found to be significant were compared using Student-Newman Keuls Test.

RESULTS AND DISCUSSION

Plant Height (cm)

Plant height was significantly influenced by weed control treatments in which all the treated plots were at par and recorded the tallest plant throughout the experimental years, while the weedy check plots produced the shortest plant across the seasons (Table 1). This could be due to the effective removal of weed which resulted in reducing the competition between plant and the weeds for environmental resources. Shaalan *et al.* (2014) reported similar results in which they narrated that, the plant height increased with weed free conditions and decreased with increasing weedy duration. Furthermore, Basavaraj and Reddy (2014) reported that hand weeding twice produced significantly taller plants and dry matter accumulation than the other treatments.

Sowing date significantly affects the plant height of finger millet at 2016 only in which sowing on late June (61.5cm) and early July (59.9) were similar and recorded the tallest plants while sowing on late July recorded the shortest (56.4cm). This could probably be due to the fact that early sowing of a crop may allow it to make full use of soil moisture during the cropping season and also to utilize solar radiation more efficiently and proper assimilate partitioning which translated to maximum aerial biomass. Similar findings was reported by Gueye *et al.* (2015) who observed that early sowing of crop resulted in better plant growth and grain yield compared to other sowing dates.

Sowing method significantly affected the plant height of finger millet at 9 WAS in all the experimental years, where dibbling and drilling methods produced the tallest plants in all the seasons, while broadcasting method recorded the shortest plant throughout the seasons. This might be due to sufficient utilization of growth factors such as light, space, nutrition, and soil moisture from less plant population as a result of reduced intra specific competition. Similar finding was reported by Gani *et al.* (2015) who elucidated that dibbling method produced significantly taller plant than the other methods of sowing. Also, Thakur *et al.* (2016) reported that tallest plant was obtained in finger millet crop sown by drilling method of sowing.

Plant dry weight (g)

Table 2 shows that weedy check recorded significantly lighter plant dry weight in 2016 (10.48g), 2017 (12.24g) and 2018 (11.59g), whereas the remaining treatments were at par throughout the seasons and recorded heavier dry weight. Andrade *et al.* (2002) reported a decrease in plant dry weight and dry matter accumulation as a result of lower plant growth rates caused by weed competition.

Sowing date did not significantly affect the plant dry weight in all the years and combined. However, sowing method significantly influenced plant dry weight across the seasons in which dibbling method consistently recorded significantly heavier plant throughout the experimental years, whereas broadcasting method recorded the lightest across the seasons. This could be explained on the basis that, row spacing resulted in more interception of solar radiation which translates to dry matter accumulation. This was in conformity with the finding of Tollenaar and Auguilera (1992) who reported that narrow row spacing produced larger leaf area index (LAI) which resulted in more interception of solar radiation and dry matter accumulation.

Number of Tillers (m^{-2})

Table 3 show that, application of 2,4-D at both rate (0.5 and 0.75kg a.i. ha^{-1}) and weeding twice at 3 and 6 WAS were similar and produced significantly the highest number of tillers across the experimental years while the weedy check consistently produced the least number of tillers in the respective years. This was an indication that these treatments were able to control weed more effectively, thereby producing more tillers as a result of reduced crop-weed competition. This was in conformity with the findings of Prithvi *et al.* (2015) who observed that application of herbicide and hoe weeding at 3 WAS recorded maximum number of productive tillers. In another development, Yawale *et al.* (2015) confirmed

that applications of herbicide produced higher number of tillers per plant of rice.

Sowing method significantly affected the numbers of tillers in 2016 and 2017 rainy seasons in which broadcasting method produced the highest while dibbling method recorded the least in the respective years. Though, the difference between dibbling and drilling methods in 2016 and 2017 were not significant. This could also be explained on the basis of high plant density of the broadcasting method in which the tillers produced by individual plant cumulatively resulted in higher number than the other method of sowing employed. This finding was corroborated with that of Maobe *et al.* (2014) who observed that the number of tillers increased as plant density of finger millet was raised.

Grain Yield (kgha^{-1})

Table 4 shows that two hoe weeding at 3 and 6 WAS produced significantly higher grain yield in all the seasons which were statistically similar with plots treated with atrazine at 1.2kg a.i. ha^{-1} and those treated with 2,4-D at bath doses in 2016, and those treated with atrazine at both doses and 2,4-D at both doses in 2017. The weedy check consistently recorded the least number of tillers in 2018 rainy season. Kumara *et al*. (2007) observed that weeding twice at 3 and 6 WAS and application of butachlor at 0.75 kg ha^{-1} + 2,4 D Na salt 0.75 kg ha^{-1} recorded significantly higher grain yield of finger millet as compared to unweeded control treatment. Also, Naik *et al*. (2000) observed the increases in grain yield in treated plots of finger millet due to increased yield components of the crop and reduced weed pressure.

Crops sown on late June and early July in 2016 and 2017 seasons recorded significantly higher grain yield, while those sown on late July recorded the lowest. Revathi *et al.* (2017) indicated that finger millet sown early produced better yield attributes and grain yield than the other times of sowing. Also, Pandiselvi *et al.* (2010) revealed that among the dates of sowing finger millet, the crop sown early produced highest grain yield than the other sowing dates.

Broadcasting method consistently produced the highest grain yield across the seasons while dibbling and drilling methods were at par in 2016 and 2017 and recorded the lowest. However, dibbling method recorded significantly lowest grain yield in 2018 than the other method of sowing. This was in conformity with the findings of Adeyeye *et al.* (2014) which indicated that the use of broadcasting method of sowing was found to be superior to other methods used for sowing of finger millet.

The interaction between sowing date and sowing method on grain yield indicated that sowing by broadcasting method on late June and early July produced significantly higher grain yield (Table 5). Whereas, delay in planting up to late July using all the three sowing methods had resulted in lower grain yield. This could possibly be due to the better crop growth as a result of planting on time that coincided with the highest number of harvested panicles.

Also, significant interaction between sowing date and weed control treatment was observed in 2016, 2017 and 2018 rainy seasons on grain yield (Table 6). The result revealed that in 2016, sowing on late June weeded twice at 3 and 6 WAS was statistically similar with sowing on early July weeded twice and sowing on late June treated with 2,4-D at 0.5kg a.i.ha^{-1}, and produced significantly higher grain yield. These was followed closely by sowing on late June treated with atrazine at 1.2kg and 2,4-D at 0.75kg a.i.ha^{-1}. Sowing on late July in unweeded environment produced the lowest grain yield. In 2017, sowing on late June and early July weeded twice at 3 and 6 WAS produced the highest grain yield, though it wasn't differed significantly with sowing on late June treated with atrazine at 1.2kg, 2,4-D at 0.5kg and 2,4-D at 0.75kg a.i.ha^{-1}. In 2018, sowing on late June and early July weeded twice at 3 and 6 WAS produced significantly higher grain yield compared to others. This was an indication that this treatment was able to control weed more effectively and also attributed to better crop growth due to turning of the soil and incorporation of the nutrient for plant absorption. This was in conformity with the findings of Pradhan *et al*. (2010) who found that weeding twice resulted in the highest grain yield, straw yield and harvest index of finger millet than the other method of weed control employed.

CONCLUSION

Based on the findings in this study, it can be concluded that the farmers in the study area should adopt sowing of finger millet between late June to early July by using broadcasting method and pre-emergence application of atrazine at 1.2 kg a.i. ha^{-1} or post-emergence application of 2,4-D at 0.5 kg a.i. ha^{-1}. Nevertheless, two hoe weeding at 3 and 6 WAS especially in areas where manual labour is very cheap and available can also be done to achieve effective weed suppression and higher grain yield of finger millet.

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Table 1: Effects of Weed Control Treatment, Sowing date and Sowing Method on Plant Height (cm) at 9 WAS of Finger Millet at Bagauda in 2016, 2017, 2018 Rainy Seasons.

Treatments	2016	2017	2018
Weed Control Treatment (W)			
Two hoe weeding at 3 and 6 WAS	64.4a	58.7a	61.2a
Atrazine at 0.8kg a.i. ha^{-1} PE	63.1a	59.4a	61.5a
Atrazine at 1.2kg a.i. ha^{-1} PE	62.2a	59.4a	61.0a
2,4-D at 0.5kg a.i. ha^{-1} POE	63.1a	59.5a	61.9a
2,4-D at 0.75kg a.i. ha^{-1} POE	63.0a	59.3a	61.8a
Weedy check	56.8b	53.1b	55.6b
SE±	1.26	1.27	1.25
Sowing Date (D)			
Late June	61.5a	57.8	60.3
Early July	59.9a	56.6	58.5
Late July	56.4b	57.7	60.2
SE±	1.30	1.22	1.23
Sowing Method (M)			
Dibbling	64.2a	60.2a	62.8a
Drilling	61.5a	58.0a	60.3a
Broadcasting	57.1b	53.9b	55.9b
SE±	0.97	1.00	0.95
Interaction			
D x M	0.783	0.908	0.841
D x W	0.565	0.299	0.497
M x W	0.865	0.786	0.766
D x M x W	0.179	0.325	0.194

Means followed by the same letter within a column are not significantly different at 5% level of probability using Student-Newman Keuls Test. PE= preemergence application, POE= post emergence application, WAS= weeks after sowing.

Table 2: Effects of Weed Control Treatment, Sowing Date and Sowing Method on Plant Dry Weight (g) at 9 WAS of Finger Millet at Bagauda in 2016, 2017, 2018 Rainy Seasons.

Treatments	2016	2017	2018
Weed Control Treatment (W)			
Two hoe weeding at 3 and 6 WAS	19.26a	20.66a	20.01a
Atrazine at 0.8kg a.i. ha^{-1} PE	18.96a	20.75a	19.42a
Atrazine at 1.2kg a.i. ha^{-1} PE	18.25a	20.09a	19.20a
2,4-D at 0.5kg a.i. ha^{-1} POE	18.64a	20.04a	19.39a
2,4-D at 0.75kg a.i. ha^{-1} POE	18.65a	20.05a	19.40a
Weedy check	10.84b	12.24b	11.59b
SE±	0.514	0.559	0.533
Sowing Date (D)			
Late June	17.04	18.44	17.79
Early July	17.18	19.00	17.89
Late July	18.08	19.48	18.83
SE±	0.804	0.849	0.811
Sowing Method (M)			
Dibbling	19.24a	20.53a	19.94a
Drilling	16.96b	18.64b	17.71b
Broadcasting	16.11c	17.74b	16.86c
SE±	0.223	0.299	0.231
Interaction			
D x M	0.778	0.517	0.771
D x W	0.032	0.172	0.017
M x W	0.120	0.360	0.203
D x M x W	0.141	0.056	0.145

Means followed by the same letter within a column are not significantly different at 5% level of probability using Student-Newman Keuls Test. PE= preemergence application, POE= post emergence application, WAS= weeks after sowing.

Table 3: Effects of Weed Control Treatment, Sowing Date and Sowing Method on Number of Tillers (m^{-2}) of Finger Millet at Bagauda in 2016, 2017, 2018 Rainy Seasons and Combined.

Treatments	2016	2017	2018
Weed Control Treatment (W)			
Two hoe weeding at 3 and 6 WAS	372.3a	378.5a	384.3a
Atrazine at 0.8kg a.i. ha^{-1} PE	274.4b	306.5b	300.2b
Atrazine at 1.2kg a.i. ha^{-1} PE	280.4b	324.4b	317.7b
2,4-D at 0.5kg a.i. ha^{-1} POE	391.4a	410.4a	397.6a
2,4-D at 0.75kg a.i. ha^{-1} POE	397.5a	407.7a	416.0a
Weedy check	182.1c	217.0c	211.7c
SE±	16.51	16.88	18.44
Sowing Date (D)			
Late June	331.3	343.2	350.6
Early July	300.8	348.8	342.9
Late July	317.1	329.3	320.4
SE±	10.04	20.37	11.74
Sowing Method (M)			
Dibbling	283.0b	300.8b	300.0
Drilling	307.2b	331.6b	348.0
Broadcasting	358.9a	389.9a	365.8
SE±	10.73	11.91	17.84
Interaction			
D x M	0.576	0.550	0.012
D x W	0.043	0.027	0.063
M x W	0.449	0.776	0.827
D x M x W	0.957	0.963	0.956

Means followed by the same letter within a column are not significantly different at 5% level of probability using Student-Newman Keuls Test. PE= preemergence application, POE= post emergence application, WAS= weeks after sowing.

Table 4: Effect of Weed Control Treatment, Sowing Date and Sowing Method and on Grain Yield (kgha^{-1}) of Finger Millet at Bagauda in 2016, 2017, 2018 Rainy Seasons and Combined.

Treatments	2016	2017	2018
Weed Control Treatment (W)			
Two hoe weeding at 3 and 6 WAS	807.1a	1187.0a	1251.0a
Atrazine at 0.8kg a.i. ha^{-1} PE	645.6c	1119.0ab	1058.0b
Atrazine at 1.2kg a.i. ha^{-1} PE	777.7ab	1149.0ab	1123.0b
2,4-D at 0.5kg a.i. ha^{-1} POE	763.5ab	1145.0ab	1095.0b
2,4-D at 0.75kg a.i. ha^{-1} POE	743.3ab	1123.0ab	1100.0b
Weedy check	688.1bc	1059.0b	956.0c
SE±	25.00	24.37	25.90
Sowing Date (D)			
Late June	1062.0a	1217.0a	1125.0
Early July	989.0a	1134.0a	1047.0
Late July	161.3b	1040.0b	1120.0
SE±	25.40	21.69	18.90
Sowing Method (M)			
Dibbling	634.8b	1069.0b	960.0c
Drilling	690.6b	1092.0b	1077.0b
Broadcasting	887.3a	1230.0a	1255.0a
SE±	32.30	31.90	34.20
Interaction			
D x M	0.006	0.942	0.949
D x W	<.001	0.005	0.001
M x W	0.295	0.307	0.520
D x M x W	0.447	0.294	0.289

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using Student-Newman Keuls Test. PE= preemergence application, POE= post emergence application, WAS= weeks after sowing.

Table 5: Interaction of Sowing Date and Sowing Method on Grain Yield (kg ha^{-1}) of Finger Millet at Bagauda, 2016 Rainy Season

	Sowing Method		
	Dibbling	Drilling	Broadcasting
Sowing Date			
Late June	854.6c	1046.8b	1285.8a
Early July	820.0c	919.8bc	1227.2a
Late July	229.8d	105.1d	149.0d
SE±	52.20		

Means followed by the same letter are not significantly different at 5% level of probability using Student-Newman Keuls Test.

Table 6: Interaction of Sowing Date and Weed Control Treatment on Grain Yield (kg ha^{-1}) of Finger Millet at Bagauda in 2016, 2017 and 2018 rainy Seasons

	Sowing Date		
	Late June	Early July	Late July
Weed Control Treatment			
	2016 rainy season		
Two hoe weeding at 3 and 6 WAS	1137.0a	1119.0a	165.0g
Atrazine at 0.8kg a.i.ha^{-1} PE	1037.0bc	964.0d	279.0f
Atrazine at 1.2kg a.i.ha^{-1} PE	1083.0ab	1028.0bc	222.0g
2,4-D at 0.5kg a.i.ha^{-1} POE	1134.0a	985.0cd	172.0g
2,4-D at 0.75kg a.i.ha^{-1} POE	1086.0ab	950.0d	195.0g
Weedy check	897.0e	889.0e	64.0h
SE±	47.00		
	2017 rainy season		
Two hoe weeding at 3 and 6 WAS	1292.5a	1289.0a	1081.0cde
Atrazine at 0.8kg a.i.ha^{-1} PE	1192.6b	1101.3cd	1062.3def
Atrazine at 1.2kg a.i.ha^{-1} PE	1238.2ab	1139.4c	1070.4cde
2,4-D at 0.5kg a.i.ha^{-1} POE	1274.1a	1140.0c	1006.8ef
2,4-D at 0.75kg a.i.ha^{-1} POE	1240.8ab	1104.7cd	1024.7ef
Weedy check	1051.9def	1043.9def	994.2f
SE±	44.22		
	2018 rainy season		
Two hoe weeding at 3 and 6 WAS	1290.0a	1272.0a	1190.0b
Atrazine at 0.8kg a.i.ha^{-1} PE	1100.0cd	1009.0e	1137.0bc
Atrazine at 1.2kg a.i.ha^{-1} PE	1146.0bc	1079.0cde	1146.0bc
2,4-D at 0.5kg a.i.ha^{-1} POE	1197.0b	1048.0de	1041.0de
2,4-D at 0.75kg a.i.ha^{-1} POE	1149.0bc	1012.0e	1139.0bc
Weedy check	870.0f	862.0f	1065.0de
SE±	45.20		

Means followed by the same letter(s) are not significantly different at 5% level of probability using Student-Newman Keuls Test.