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YIELD AND YIELD ATTRIBUTES OF SWEET SORGHUM (*Sorghum bicolor* Sub-species *saccharatum* (L.)Moench. VARIETIES AS INFLUENCED BY WEED CONTROL TREATMENTS AND PLANT POPULATION IN THE SEMI ARID REGION OF NIGERIA

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ABSTRACT
Field trial was conducted during the 2012 and 2013 wet seasons at Institute for Agricultural Research,Ahmadu Bello University, Zaria Farms at Kadawa and Minjibir, (11^0 39′N, 08^0 20′E) and Kano (12^0 08′ N, 08^0 40′ E)500m above sea level in the Semi arid ecological zone of Nigeria, to study the influence of weed control treatment and plant population on yield and yield attributes of sweet sorghum (Sorghum bicolor (L.)Moench. sub-species. saccharatum) varieties. The treatments consisted of four levels of weed control treatment (one rate each of atrazine and primextra gold at 2.1 kg a.i/ha, hoe-weeded control at 3 and 6 weeks after sowing (WAS) and weedy check), three plant densities (53,333, 106,667, and 160,000 plants/ha), and two varieties(NTJ2 and Ex-Daura). The treatments were laid out in a split plot design with three replications. The combination of weed control treatment and the plant population were assigned to main plot while the two varieties to sub-plot. The study revealed that primextra gold at 2.1 kg a.i/haand two hoe-weeding at 3 and 6 WAS resulted in significantly longer panicle length, higher 1000-grain weight, stalk, grain, and brix yields in both seasons and locations.The performance of this herbicide was comparable to hoe-weeding in keeping the trial fields weed free and lower competition for nutrients at both location seasons. Weedy check reduced all yields and yield attributes. The 160,000 plants/ha significantly suppressed weed infestation and resulted in longer panicles, higher 1000-grain weight, stalk, grains and brix yields at the two the locations and seasons.NTJ2 performed better in term yield and yield attributes, with higher stalk yield at Kadawa and grain yield at Minjibir. Based on the result obtained from this , it can be concluded that the use of NTJ2 variety, with application of primextra gold at 2.1 kg a.i/ha, and 160,000 plant population and NTJ2 variety had resulted gave season long weed control, the highest stalk and grain yields at Kadawa and Minjibir.
Keywords: Grainand stalk yields, plant population, sweet sorghum and weed control.

INTRODUCTION

Sweet sorghumis an annual crop that forms tillers, with ability to form a ratoon that enables multiple harvests per season in the tropical and semi-tropical (Vermerris *et al.,* 2007).The perennial nature of the crop in tropical areas allows it to grow tall during growing season, which gives the plant the opportunity to have thicker stalk with more juice produce. Sweet sorghum is C_4 malate former crop (Sipos *et al.*, 2009) and has the ability to better withstand drought conditions and tolerate a wider range of soils. Sweet sorghum is a water-use efficient crop, which has the potential to be a good alternative feedstock for ethanol production as a renewable source of energy to meet the increasing demand, its grain as food and feed ingredients, sugary juice from its stalk for making syrup, jaggery or ethanol, the bagasse and green foliage as an excellent fodder for animals with high biological value, as organic fertilizer, or for paper manufacturing. (Rajvanshi and Nimbkar, 2001).

In recent years global warming, energy crisis and environmental pollution have become more serious affecting agricultural production especially in the arid and semi arid ecologies, leading to more and more countries are attaching importance to sustainable green energy, such as biomass energy. Sweet sorghum comes readily an ideal alternative to other sources of green energy like sugar cane, maize etc. But sweet sorghum production is constrained by weed infestation among other biotic and abiotic factors, by competing for nutrients, light, water and space; harboring insect pests that damage the crop (Ogundale, 2006), and leading to yield losses that may exceed 70% or more of the potential yield (Lagoke *et al.*, 1986). Economic damage to agriculture from weeds far surpasses the incidental damage inflicted by insect pest, rodents and diseases (Oudejans, 1991). The traditional weed control methodof hoe-weeding, commonly used by farmers is characterized by high cost and drudgery. A less labour intensive and more effective method, which can bring about high profitability to production enterprise of farmers are scarcely in use. Chemical weed control may provide an alternative to such manual weed control in sweet sorghum in particular and crop production in general in the Sudan savannah ecology.

In the Sudan savannah ecology, where cereal are predominantly grown, farmers rarely follow the recommended planting density in their farming activities, this leads to reduction in yield as planting below the recommended level increases the incidence of weed competition and planting above the recommended density increases inter specific competition for growth resources among the plant (Munamara *et al.*, 2006; Gazubenli, 2010). It is therefore, necessary to guide farmers to plant at an optimal density to reap the benefit of weed suppression, thereby reducing competition and increase sweet sorghum yields of both stalk and grain. Based on the foregone, this study was therefore conducted to study find the most effective chemical weed control method and the optimum plant population for higher productivity of sweet sorghum in the Sudan savannah ecology.

MATERIALS AND METHODS

The field trial was concurrently conducted during the 2012 and 2013 rainy seasons at the Institute for Agricultural Research, Ahmadu Bello University Zaria farms located at Kadawa (11^0 39'N, 08^0 20'E) and Kano (12^0 08' N, 08^0 40' E) and 500 m above sea level) in the Sudan savannah ecology. Rainy season usually begins in late June and end mid-September, with the mean ranging from 600-700mm.

The treatments consisted of four weed control (atrazine and primextra gold each at 2.1 kg a.i/ha, hoe-weeded control and weedy check); three plant densities (53,333, 106,667 and 160,000 plants/ha), two varieties (Ex-Daura and NTJ2). The experiment was laid in a split plot arrangement with three replications. Combination of weed control treatments and plant densities were assigned to the main plots, while the two sweet sorghum varieties were constituted in the sub plots. The main plot size was $18m^2$ and the net plot was 12 m^2.Thinning to give the required plant population treatment 53,333, 106,667 and 160,000 plants/m^2were carried out at 2 weeks after sowing.

Pre-emergence application of atrazine and primextra gold each at 21 kg a.i/ha were carried out same day at sowing using CP3 Knapsack sprayer.and60 kg N/ha, 30 kg P_2O_5/ha and 30 kg K_2O was applied in split doses. A basal fertilizer dose of 30 kg/ha each of N, P and K3was applied using NPK 15-15-15 source, while nitrogen 30kg N/ha in the form of urea (46% N) was applied at 6 WAS, while hoe weeding was carried out at 3 and 6 weeks after sowing (WAS).

Harvest was done at near physiological maturity when the grain reached soft dough stage. The stalks were harvested by hand, cut up as close as possible to the ground, while the panicles were removed by hand after cutting the stalk down,panicles were dried, threshed to determine both stalk and grain yields. A brix measurement was taken at each location in the field using a hand-held refractometer.

Data collected was subjected to statistical analysis of variance (ANOVA) using Statistical Analysis System package (SAS, 2013). The treatment means were separated using Duncan Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Table 1 shows that primextra gold at 2.1 kg a.i/ha and hoe-weeded control gave the longest panicle in 2012, while in 2013 atrazine at 2.1a.i/ha and hoe-weeded control gave longest panicles than other weed control methods at Kadawa. At Minjibir there were no significant differences among the weed treatments in both years. The 160,000 plants/ha gave the longest panicle at the two locations and seasons, while NTJ2 gave longest panicles.

Tallest plants recorded at Kadawa was by hoe-weeded control andatrazine at 2.1 kg a.i/ha in both years, while at Minjibir the hoe-weeded control consistently gave the tallest plants the weedy check gave the shortest plants in both seasons and locations. 160,000 plants/ha recorded the tallest plants in 2012 at Kadawa, while in 2013 and at Minjibir in both years the 53,333 plants/ha gave the tallest plants. Plant height was not significantly influenced by variety in 2012 at both Kadawa and Minjibir however, in 2013 of both locations; NTJ2 consistently recorded the tallest plants.

Table 1. Influence of weed control treatment, plant population and variety on panicle length andplant height in the wet season of 2012, 2013 and mean at Kadawa and Minjibir.

Treatment	Rate (kg a.i/ha)	Panicle Length (cm)				Plant Height (cm)			
		Kadawa		Minjibir		Kadawa		Minjibir	
		2012	2013	2012	2013	2012	2013	2012	2013
Weed control treatment (W)									
atrazine	2.1	33.55b	38.99a	45.53ab	60.20a	226.6a	200.8a	167.4b	201.1b
primextra gold	2.1	35.41a	36.24b	43.58ab	54.95ab	195.4b	149.4b	161.5b	195.2b
Hoe weeded control		36.25a	39.75a	47.25a	61.74a	236.3a	211.9a	214.4a	236.4a
Weedy check		25.76c	30.42c	40.01b	45.95b	121.4c	151.9b	116.4c	118.6c
SE ±		0.796	0.687	1.61	2.02	4.71	6.32	5.02	5.75
plant population (P)									
53,333		30.44b	36.81b	42.53b	52.69b	186.3b	200.6a	171.1a	208.9a
106,667		28.64b	35.89b	41.28b	51.92b	184.6b	166.0b	154.5b	179.4b
160,000		39.14a	40.09a	48.76a	58.40a	266.1a	168.8b	140.3c	182.1b
SE ±		0.873	0.635	1.28	1.74	5.49	4.41	4.82	4.12
Variety (V)									
NTJ2		33.96a	38.21	46.36a	50.56	217.5	188.5a	164.2	197.7a
E-Daura		31.53b	36.99	42.02b	48.12	207.2	168.5b	165.3	182.5b
SE ±		0.563	0.486	1.14	1.43	3.33	4.47	3.39	3.12
Interaction									
W * P		NS	NS	NS	NS	NS	NS	NS[3]	NS
W * V		NS	NS	NS	NS	NS	NS	NS	NS
P * V		NS	NS	NS	NS	NS	NS	NS	NS
W * P * V		NS	NS	NS	NS	NS	NS	NS	NS

1. Means followed by the same letter (s) in the same column within the same treatment group are statistically similar at 5% level of probability using DMRT.3. Not significant at 5% level of significance

Atrazine and primextra gold each at 2.1 kg a.i./ha and hoe-weeded control gave statistically similar and significantly higher stalk yield than weedy check in the two years at Kadawa and in 2012 Minjibir while in 2013, primextra and hoe-weeded. weedy check consistently gave the lowest stalk yield in both seasons and locations. Similarly the highest plant population of 160,000 plants/ha recorded the highest stalk yield in both years and locations (Table 2).

Interaction between weed control treatment and plant population at Minjibir in the 2012 season showed the combination of atrazine at 2.1 kg a.i/ha and 106,667 plants/ha gave the highest stalk yield, and was similar to primextra gold at 2.1 kg a.i/ha and hoe-weeded control under the 160,000 plant population.

Table 2. Influence of weed control treatment, plant population and variety on stalk yield and brix % in thewet season of 2012, 2013 and mean at Kadawa and Minjibir

Treatment	Rate (kg a.i/ha)	Stalk Yield (t/ha)				Brix Yield (%)			
		Kadawa		Minjibir		Kadawa		Minjibir	
		2012	2013	2012	2013	2012	2013	2012	2013
Weed control treatment (W)									
Atrazine	2.1	40.09a	45.67a	26.60a	25.43b	17.19ab	19.72ab	14.33a	14.72b
Primextra gold	2.1	42.02a	46.88a	22.36a	27.53a	18.28a	15.49bc	13.78a	14.36b
Hoe weeded control		39.11a	44.53a	26.87a	28.56a	18.56a	21.54a	13.65a	16.15a
Weedy check		24.19b	26.43b	12.17b	18.69c	10.27b	14.45b	11.92b	11.97c
SE ±		1.77	1.06	1.53	1.42	0.479	0.412	0.309	0.210
plant population (P)									
53,333		41.45b	40.77b	23.94b	20.15b	14.42b	14.66c	14.16	13.98b
106,667		43.23b	39.05b	24.07b	20.77b	14.27b	17.55b	13.98	13.40b
160,000		49.34a	47.31a	33.12a	23.77a	20.14a	21.27a	13.99	15.52a
SE ±		2.96	2.19	2.21	2.08	0.428	0.398	0.240	0.212
Variety (V)									
NTJ2		42.69	39.69	25.68	21.76	17.18	15.48b	14.19a	14.66a
E-Daura		42.16	38.63	25.08	21.34	16.47	20.64a	13.66b	13.93b
SE ±		1.21	1.61	1.04	2.14	0.338	0.404	0.218	0.149
Interaction									
W * P		NS	*	NS	NS	NS	NS[2]	NS	NS
W * V		NS	NS	NS	NS	NS	NS	NS	NS
P * V		NS	NS	NS	NS	NS	NS	NS	NS
W * P * V		NS	NS	NS	NS	NS	NS	NS	NS

1. Means followed by the same letter(s) in the same column within the same treatment group are statistically similar at 5%level of probability using DMRT. 2. Not significant at 5% level of significance. 3.* significant at 5% level of 5% level of significance.

The influenced of weed control treatment was significant on brix yield at Kadawa in both years where there were no significant differences on brix percentage except with weedy check which gave the lowest percentage, similar trend was obtained at Minjibir in 2012, while in 2013 the hoe-weeded control gave highest brix percentage. The 160,000 plants population recorded the highest brix yield in all years, locations except at Minjibir in the 2012, where the effect was not significant. At Kadawa and Minjibir NTJ2 gave higher brix yield than Ex-Daura.

Table 3 shows that primextra gold at 2.1 kg a.i/ha and hoe-weeded were at par and recorded the highest 1000-grain weight at Kadawa in 2012 season,while in 2013 season only primextra gold gave the highest 1000-grain weight. At Minjibir atrazine and primextra gold each at 2.1 kg a.i/ha and hoe-weeded control recorded similar and higher 1000-grain weight than the weedy check. At Kadawa in 2012 season, the 53,333 plants/ha gave the highest 1000-grain weight while the 160,000 plants/ha the lowest, in 2013 however, 53,333 and 106,667 plants/ha were at par and gave the higher 1000 grain weight. At Minjibir, the 106,667 plants/ha gave the highest 1000-grain weight in 2012 while in 2013 it was only the 160,000 plants/ha that recorded the highest 1000-grain weight.

Hoe-weeded control and primextra gold at 2.1 kg a.i./ha were similar and gave higher grain yield than either atrazine at 2.1 kg a.i./ha or the weedy check at Kadawa and Minjibir in the two seasons, similarly 160,000 plants/ha gave the highest grain yield at both location and years. NTJ2 variety gave significantly higher grain yield than Ex-Daura in both locations and seasons except in 2012 at Kadawa where the was not significant difference between the two varieties.

Table 3. Influence of weed control treatment, plant population and variety on 1000-grain weight and grain yield in the wet season of 2012, 2013 and mean at Kadawa and Minjibir

Treatment	Rate (kg a.i/ha)	1000-Grain Weight (g)				Grain Yield (kg/ha)			
		Kadawa		Minjibir		Kadawa		Minjibir	
		2012	2013	2012	2013	2012	2013	2012	2013
Weed control treatment (W)									
atrazine	2.1	30.41b	32.55b[1]	32.96b	33.22a	1377.6b	1623.61	1815.9b	1816.4b
primextra gold	2.1	31.76b	36.25a	31.93b	32.85ab	1963.9a	1917.1a	2050.4a	2785.9a
Hoe weeded control		36.96a	30.41c	35.77a	34.62a	2022.0a	2030.5a	2188.3a	2983.1a
Weedy check		24.28c	30.76c	22.44c	28.55b	777.6c	916.6c	815.9b	866.4c
SE ±		0.615	0.634	0.518	0.687	52.8	60.1	64.3	68.2
plant population (D)									
53,333		36.17a	32.46a	31.82b	32.44b	1500.2b	1489.8b	2500.2b	2385.2b
106,667		34.51b	32.63a	32.07b	34.66a	1498.7b	1587.7b	2498.7b	2353.3b
160,000		30.13c	29.74b	37.43a	30.00c	2046.7a	2088.6a	2746.7a	2895.7a
SE ±		0.519	0.681	0.428	0.756	49.2	56.8	39.3	33.5
Variety (V)									
NTJ2		33.98a	34.83	32.60b	36.50	1739.8a	1893.2	1983.8a	2571.2a
E-Daura		31.23b	35.06	34.95a	35.57	1623.9b	1934.3	1769.1b	2024.9b
SE ±		0.419	0.375	0.367	0.521	37.0	38.4	45.5	43.6
Interaction									
W * D		NS	NS	NS	NS	NS	NS[2]	NS	NS
W * V		NS	NS	NS	NS	NS	NS	NS	NS
D * V		NS	NS	NS	NS	NS	NS	NS	NS
W * D * V		NS	NS	NS	NS	NS	NS	NS	NS

1. Means followed by the same letter(s) in the same column within the same treatment group are statistically similar at 5% level of probability using DMRT. 2. Not significant at 5% level of significance

RESULTS AND DISCUSSION

Sweet sorghum main economic yields (stalk, grain and brix) were significantly different at the two locations and seasons. Generally the plots that received hoe-weeding at 3 and 6 WAS and primextra gold at 2.1 kg a.i/hahad the lower weed infestation, thus lower weed competition for nutrients leading to higher yields. This is similar to report of Shebayan (1998); Adekpe *et al.* (2004). Yields and yield traits of the crop was enhanced by these treatments as depicted in favourable and longer panicles, higher 1000-grain weight, stalk, grain and brix percentage. Crop performance at Kadawa was significantly higher in the two seasons which could be attributed to good weather condition where the rainfall was higher and better distributed which allowed better crop development at both vegetative and reproductive phases. The better performance may also be attributed to better soil condition, where the crop was able to obtain enough nutrients for development of photosynthetic structures that resulted in assimilate synthesis for good growth and yield than at Minjibir. Weed control treatment could be said to have significantly enhanced crop productivity.

Weedy check produced lower yield and yield parameters, which is expected because of the competition for nutrients between the weeds and the crop and similar to findings of Adekpe *et al.,* 2004), Adekpe and Adigun (2004), and Shebayan (1998). Comparing the two major economic yields at the two locations, it was clearly showed that stalk yield at Kadawa was significantly higher than at Minjibir looking at the two varieties also, NTJ2 at Kadawa gave higher stalk than grain, while the same variety gave better grain at Minjibir. Both soil characteristics and weather conditions at the two locations might have contributed to these results.

Application of primextra gold at 2.1 kg a.i/ha though showed some degree of phytotoxicity on the crop, but later resulted in recovery to give good yields comparable to hoe-weeded control, indicating rate applied was not toxic to retard growth nor yield. Highest physiological yield indices were obtained from 160,000 plant population at both locations and seasons. This was expected as high plant population enhanced increased photosynthesis with the development of more leaves per unit area, thereby enhancing the effective use of growth and yield resources, which superseded any inter or intra row competition between crop stands.

More so, the increased smothering effect of the highest plant population on weeds further enhanced both growth and yield. This is in agreement with Conley *et al.* (2005),Thakur *et al.*(2009), who reported that low high leaf area gave higher surface for the interception of radiation and other resources of growth coming higher density which compensate for inter and intra crop competition making the latter not strong enough to curtail productivity. More so, sweet sorghum crop has capacity to develop new reproductive structure (tillers) in response to an increase in available resources per plant. The 160,000 plants/ha recorded significantly lower weed cover score and weed dry weight. This result could be attributed to relatively higher weed smothering ability of the narrower spacing of the higher density, the favourable weather condition, as plants yield more under favourable conditions of weather. The result was similar to Gazubenli (2010) who reported that there was more efficient and effective utilization of available resources infavourable environmental conditions under high planting density. Higher densityalso effectively harvested the larger radiant energy producing vigorous plants that yielded higher stalk and grain yield as reported by Wortman *et al.*(2010), and Munamara *et al.*(2006). The maximum stem fresh weight and a total sugar (brix) yield was related to highest plants population of 160,000 plants/ha as observed at Kadawa compared to Minjibir, similar to Ali *et al.(*2003) report.

Yield and yield characteristics, such panicle length, 1000-grain weight, stalk and brix yields were influenced by variety. The maximum panicle length at Kadawa and Minjibir were at variance. NTJ2 gave highest at Kadawa while Ex-Daura was highest at Minjibir, similar trend was obtained for 1000-grain weight, stalk yield and brix yields. This may be an indication of genetic superiority of the NTJ2 the two environments, the more favourable conditions, interms of weather and soil, of Kadawa might have facilitated the NTJ2 superior performance over the local land race Ex-Daura.

The interaction among the parameters revealed that there were significant interaction between weed control treatment and plant population with respect to stalk yield. This may because of availability of more nutrients, resulting from reduced competition from weeds which were mobilized to stalk thereby giving rise to higher stalk yield. The relatively lower yield obtained under the 160,000 plant population might be due to effect the intra and inter row competition and herbicide toxicity affected the crop stands. The lowest stalk yield were obtained with the weedy check could be attributed to competition between crop and weed for growth resources. Similar findings were earlier reported by (Adekpe, 2006 and Ishaya, 2004).

CONCLUSION

The result of the study showed the significant response to application of herbicides.and variation in plant population by many of the yield parameters. Application of primextra gold at 2.1 kg a.i/ha and increase in plant population resulted in increased stalk, grain and brix yields amongst other yield parameters. Based on the result obtained, it can be concluded that the use of variety NTJ2 with application of primextra gold at 2.1 kg a.i/ha and 160,000 plants/ha at Kadawa had resulted in good stalk yield, while at Minjibir, good grain yield. Further studies may be necessary to determined further optimal population, appropriate fertilizer rate that may increase yields in the Sudan savannah ecology. It is therefore recommended that farmers at both Kadawa and can grow NTJ2 sweet sorghum variety at a plat population stand of 160,000plant/ha, using primextra gold at 2.1 kg a.i/ha for weed control for good stalk yield, while at Minjibir farmers can use the same, but for good grain yield.

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