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Comparative Performance of Masakwa Sorghum and other Sorghum Cultivars under Rainfall Conditions

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ABSTRACT

A field experiment was carried out in Maiduguri in the semi-arid region of North eastern Nigeria during the 2007 cropping season. The aim of the experiment was to compare the performance of some sorghum cultivars ('Masakwa', 'BOSADP', 'Kilburi', 'Chakalare white', 'Chakalare brown', 'Jigari' and 'Kafimoro') under rainfall conditions. Treatments were laid out in a randomized complete block design (RCBD) with three replications each. Significant difference existed among the cultivars with respect to most of their quantitative traits evaluated. 'Chakalare white' and 'Chakalare brown' resulted in the highest grain yield, although they matured late. 'Masakwa' yield the least and also matured late. However, cultivars 'BOSADP' and 'Jigari' matured early and resulted in relatively higher grain yields even though not as high as 'Chakalare brown and Chakalare white'. Our study indicates that 'Masakwa' sorghum, which is predominantly grown only during dry periods under residual moisture on vertisols can in fact be grown on sandy soils under rainfall conditions. This is a preliminary study and a continuous and broader evaluation will be undertaken before a particular breeding strategy is undertaken.

Keywords: dry periods, residual moisture, *Sorghum bicolor*, vertisols, yield

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is indigenous to Africa, particularly Sub-Saharan Africa where it is now widely grown (Menz *et al*. 2004). It is well known for its capacity to tolerate conditions of limited moisture and to be productive during periods of extended drought circumstances, a situation that would impede production of most other crops. This makes it an important crop in arid and semi-arid environments, where it may not be economical to grow other cereals. It is an important food crop in Africa, Central America, and south Asia and is the fifth most important cereal crop after wheat, rice, maize and barley (FAO 2006).

Of all the factors that affect agricultural production, the deleterious effects of climate, in particular rain fall, soil characteristics and temperature are the most difficult to ameliorate. In addition, the variability and unpredictability of climatic factors have become the main risk factor in production (Acevedo and Fereres 1993; Hunduma 2006). According to Ashley (1993), and Schmidt and Bothma (2006), reported that abiotic stress such as drought and excessively high temperatures among others have been found to significantly reduce crop yields and restrict the ecology and the soils where commercially important species could be cultivated. Of the climatic elements, water is the most important and its availability or unavailability during the plant growth cycle will generally affect crop yield (Chiroma *et al*. 2006). Even though sorghum is one of the most drought-tolerant crops and an excellent crop model for evaluating mechanisms of drought tolerance (Tuinstra *et al*. 1997), a possibility of genetic erosion exists and there is a need to consolidate the moisture stress tolerance capabilities, especially in 'Masakwa' sorghum that are grown under dry conditions.

'Masakwa' sorghum grows well only on residual moisture during the dry season periods on vertisols (Chantereau and Nicou 1991; Tabo *et al*. 2004), and since it has become part of the people in dry areas, there is a need to initiate a breeding strategy so that it could be grown under rain and on soils other than vertisols since at present there a great risk that the vertisol stretches of land may be turned into desert as a result of the alarming rate of desertification and desert encroachment (Patil 2007). In addition, the amounts of rainfall in dry and semi-arid areas have been on the decline dramatically over the years. Therefore, when this situation persists and becomes aggravated, 'Masakwa' sorghum cultivation may be exterminated and could result in food insecurity in this region of the world.

Of all the sorghum cultivars available for cultivation by farmers 'Masakwa' sorghum has occupied an important position for some time in this region. 'Masakwa' sorghum is usually grown on vertisol from the end of the rainy season in September to January. Blench (1991) reported that 'Masakwa' was first developed in Asia and spread into Nigeria from the Nile Valley with Borno and Adamawa States representing the western limits to its distribution. The major area of production in Borno State is between Lake Chad in the north and the northern portion of Mandara hills in the south. These areas include Dikwa, Bama, Ngala, Gwoza, Mungono and New Marte Local Government Areas where the crop is being cultivated by small farmers in small hecterages.

In recent years, the industrial demand for sorghum grain has increased and is being used to substitute wheat and barley in food processing and brewing industries. The present level of sorghum production worldwide is 1.311 t/ha and the annual global production now fluctuates around 60 million tones (FAO 2006) of which 80-85% is consumed as food. Production levels must be doubled in order to accommodate the increase in demand of the crop for food and for biofuels, especially considering the vast stretches of available arable land. 'Masakwa' sorghum should therefore not be restricted to cultivation only in the dry seasons; it should, if possible, also be able to be cultivated during the rainy season periods and in this way the production level could be complemented and doubled if not tripled considering its high demand and numerous uses.

It is for these reasons and possibilities, that we formulated this study to compare the performance of 'Masakwa'

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sorghum with the other local sorghum cultivars that are predominantly grown in this region in the rainy season on soils other than vertisols.

MATERIALS AND METHODS

The experiment was conducted at the University of Maiduguri Teaching and Research Farm during the rainy season of 2007. Maiduguri is located in the Sudan Savanna of Nigeria (11° 53′N and 13° 16′E) and has an annual rainfall of 450-600 mm per annum. Rainfall lasts for 5 months from June to October and the soil characteristics are essentially sandy loam to complete sandy. The treatments consisted of seven sorghum cultivars that are prominently grown in this area: 'Masakwa', 'BOSADP', 'Kilburi', 'Chakalare white', 'Chakalare brown', 'Kafimoro' and 'Jigari'. The seed materials were obtained from Maiduguri and Gwoza markets in Borno State, Nigeria and no viability test was conducted on the seeds before use. 'Masakwa' is however, grown only during the off-season period on vertisol on residual moisture. The treatments were laid in a randomized complete block design (RCBD) and replicated three times.

The seed materials, after treatment with Apron Star WS at recommended rates, were sown directly in to the field after land preparation on ridges when rain had fallen. A pinch of seeds were planted per hole and was later thinned down to 2 plants per stand at 2 weeks after sowing. The size of each plot was a 5 m × 2.25 m of 4 rows with an inter-plot distance of 1 m. The planting was done at a spacing of 75 cm × 50 cm. All the recommended cultural practices relating to the cultivation of sorghum in this kind of environment were adhered to as necessary according to Patil (2007).

Parameters for data collection were: number of plants per plot, number of leaves per plant, plant height and days to 50% flowering. Other parameters also determined were days to 100% flowering, panicle length, panicle weight, days to maturity, 1000-grain weight, number of seeds per panicle, yield per plant and yield per hectare also according to Patil (2007).

All data collected were subjected to analysis of variance (ANOVA) using a computer statistical package Statistix version 8.0 and the treatment means were separated using LSD at the 5% probability level.

RESULTS AND DISCUSSION

The results of ANOVA and the mean squares of yield and yield components of sorghum are presented in **Tables 1** and **2**, respectively. The results shows that a highly significant difference was observed for number of leaves per plant, days to 50% flowering, days to 100% flowering, plant height, number of grains per panicle, 1000-grain weight, yield per plant and yield per hectare. In contrast, however, there was no significant difference observed in the number of plants per plot and in pest and disease incidences among the sorghum cultivars evaluated. There was no significant difference in the number of plants per plot among the cultivars, because the germination and subsequent emergence were excellent. This was probably because of the seed viability or partly as a result of protection of the seed and the seedlings from pests and diseases as they were treated with chemicals before planting.

The preponderant and significant difference observed among the cultivars in respect of most of their quantitative traits confirms that they differ widely in their hereditary make up and also in their ability or inability to adapt to certain environmental conditions.

The plant height of a crop and indeed all quantitative traits are a function of both the genotypic and environmental factors (Muniaz *et al.* 2001). Plant height was significantly variable among the cultivars evaluated. The tallest cultivar height was 'Chakalare brown' (300 cm), followed by 'Chakalare white' and 'Kafimoro' both measuring 283 cm. These cultivars could be a very good source of straw for the purpose of building local houses. Ouendeba *et al.* (1996) reported similar instances where pearl millet straw is used for building thatched houses in Niger in West Africa. The shortest cultivar was 'BOSADP' at 133 cm, followed by 'Jigari' at 177 cm. Incidentally and expectedly, the shortest cultivars i.e. 'BOSADP' and 'Jigari' also produced the lowest number of leaves per plant of 9.53 and 9.20 respec-

Table 1 Analysis of variance showing sources of variation, degrees of freedom and mean squares of yield and yield components of masakwa and other sorghum cultivars.

Source of variation	Df	Plants/plot	Plant height (cm)	Leaves/plant	Days to 50% flowering	Days to 100 % flowering	Days to maturity	Panicle length (cm)	Panicle weight (kg)	Grain per panicle	1000 grain weight (g)	Busseola count (%)	Anthracnose incidence (%)	Yield/plant (g)	Yield (Kg/ha)
Replication	2	2.91	0.240	0.74	6.14	4.00	4.76	0.79	0.04	5031.60	6.67	87.43	19.05	3.26	1917.05
Treatments	6	2.82	1.20**	72.01**	269.75**	491.41**	5.21**	99.85**	0.01**	23.87**	36.54**	522.22	749.21	14.93**	34.06**
Error	12	2.18	0.16	1.23	6.87	11.61	4.81	20.22	0.001	4366.10	3.84	360.32	280.16	3.06	6113.70
Total	20	7.91	1.60	73.98	282.76	507.02	14.78	120.86	0.05	9421.57	47.05	969.97	1048.42	21.25	8064.81

** Significant at 1 % level of probability

Table 2 Mean performance of yield and yield components in masakwa and other sorghum cultivars.

Treatments	Number plants/ plots	Plant height (cm)	Leaves/plant	Days to 50% flowering	Days to 100% flowering	Days to maturity	Panicle length (cm)	Panicle weight (kg)	Grains/ panicle	1000 grain weight (g)	Yield/plant (g)	Yield kg/ha	Busseola count (%)	Anthracnose incidence (%)
Masakwa	49.67	193	21.33	82.67	90.33	103.33	9.60	0.16	552.33	29.53	16.33	696.75	60.00	60.00
BOSADP	48.67	133	9.53	61.33	63.33	76.67	18.27	0.15	713.33	24.81	20.17	860.73	53.33	23.33
Kilburi	47.33	237	17.07	87.33	97.00	107.33	15.37	0.14	552.33	33.36	18.42	785.97	33.33	53.33
Chakalare white	49.67	283	18.47	74.33	78.33	101.33	24.40	0.17	707.33	32.50	22.66	966.97	36.67	63.33
Chakalare brown	48.67	300	19.20	75.67	84.00	107.00	19.17	0.13	563.33	32.87	22.06	957.89	40.00	63.33
Kafimiro	49.00	283	12.33	68.33	76.67	90.00	24.00	0.16	615.00	29.69	18.27	779.52	60.00	56.67
Jigari	47.33	177	19.20	64.33	68.33	81.33	20.50	0.32	792.33	25.48	20.20	861.72	66.67	33.33
Grand Mean	48.62	230	15.30	73.43	79.71	95.29	19.19	0.18	656.57	29.75	19.73	836.72	50.00	50.48
SEM	1.21	3.3	0.90	2.14	2.78	3.47	3.67	0.02	53.95	1.60	1.43	63.84	15.50	13.67
CV	3.04	17.72	7.24	3.57	4.27	4.45	22.44	15.05	10.06	6.59	8.86	9.34	37.96	33.16
$LSD_{0.05}$	-	7.2	1.97	4.66	6.06	7.55	8.00	0.05	117.56	3.49	3.11	139.11	-	-

tively. Even though, 'Masakwa' were among the shortest cultivars, the same cultivar produced the highest number of leaves per plant (21.33), which was attributable to its shorter internodes. This same cultivar however, did not produce the highest grain yield considering the abundant photosynthetic surface which was expected to translate to final grain yield. This result and relatively poor performance in grain yield despite abundant photosynthetic surface was therefore not unexpected because 'Masakwa' have not been naturally grown under rainy season condition.

'BOSADP' produced panicles earlier than the other cultivars because it took 61.33 days to reach 50% flowering and 63.33 days to reach 100% flowering. 'Jigari' follows on the other hand and took 64.33 days and 68.33 days to reach 50 and 100% flowering, respectively. Expectedly therefore, 'BOSADP' and 'Jigari' cultivars with fewer numbers of days to flowering were deemed to have matured earlier than those with higher number of days. Izge *et al*. (2007) reported similar results in a genetic study of pearl millets under a semi-arid environment. Early maturity in crop plants is of a great advantage in this particular region because of shorter duration of rain. In addition early maturing sorghum cultivars have been found to be very vital in filling in the hunger gaps when stored food have been exhausted and crops on the farms are not matured to be harvested. Highest number of days to flowering was observed on 'Kilburi' with 87.33 and 97.00 days to reach 50 and 100% flowering, respectively, followed by 'Masakwa' which took 82.67 days and 90.33, respectively. Plant growth duration (maturity) is an important factor in the development of yield in grain sorghum. The effects of genotype maturity on yield may vary among environments that differ in climatic factors such as temperature and photoperiods. 'Masakwa' took longer to flower probably because it is photoperiodic in nature (Mohammad Saeed and Francis 1986). The days to maturity could probably be seen to have had a positive correlation with days to flowering because cultivars with fewer days to flowering matured earlier than those with more days to flowering. 'BOSADP' matured earlier than the other cultivars, followed by 'Jigari', while 'Kilburi', 'Chakalare brown' and 'Masakwa' matured late. The shortest panicle length was observed on 'Masakwa' (9.60 cm) followed by 'Kilburi' (15.37 cm), while 'Chakalare white' had the longest panicle (24.40 cm) followed closely by 'Kafimoro' (24.00 cm).

'Jigari' ranked among the cultivars with the highest panicle weight which could be due to the fact that birds infested the other cultivars but did not infest 'Jigari'. Even though the tannin factor of these cultivars were not determined, Farias *et al.* (2007) reported that 'Jigari' has a high tannin content and it has been found to discourage birds. Tannin an acidic complex can affect both the taste and nutritional value of sorghum. Historically, sorghum with high tannin content was not desirable because it's not palatable to birds. High tannin sorghum is still grown where birds are a problem around the world. Secondly, 'Chakalare white' (0.17 kg) ranked high on the basis of panicle weight. Lowest panicle weight was observed in 'Chakalare brown' (0.13 kg) and 'Kilburi' (0.14 kg). 'Jigari' which had among the highest panicle weight incidentally also produced the highest number of grains/panicle (792) followed by 'BOSADP' (713). 'Masakwa' and 'Kilburi' produced the least number of grains per panicle (552) followed by 'Chakalare white' with 563 grains per panicle.

The result of the 1000 grain weight indicated significant difference among the treatments and 'Kilburi' ranked highest (33.36 g), and this could be seen as a form of compensation since it ranked lowest in number of grains per panicle. Ross and Kofold (1978) also reported similar result in sorghum. It was followed by 'Chakalare brown' (32.87 g), which also had lower number of grains per panicle and 'BOSADP' produced lightest grains (24.81 g) followed, by 'Jigari' (25.48 g).

The cultivar that gave the highest grain yield was 'Chakalare white' with 22.66 g/plant and 966.97 kg/ha. It was followed closely by 'Chakalre brown' which had 22.06 g /plant and 957.89 kg/ha. Surprisingly however, 'Jigari' that was among the best in panicle weight was not among the ones that produced the best grain yields. 'Masakwa' on the other hand produced the lowest yield of 16.33 g/plant and 696.75 kg/ha, followed by 'Kafimoro' which produced 18.27 g/plant and 779.52 kg/ha. The performance of 'Masakwa' sorghum under rainy season conditions on soils of the semi-arid regions have not been reported anywhere in literature. Low yield in 'Masakwa' could be attributable to few numbers of grains in its panicle probably because it has low tannin content in the seeds. Farias *et al*. (2007) reported that tannin content in seeds have been found to deter bird infestation in sorghum. Therefore, cultivars with low tannin content are naturally devastated by birds and this ultimately leads to lower grain yields.

With some genetic modification of 'Masakwa' sorghum therefore, the low yield attributes could be reversed under rain and on soils other than vertisols.

The results indicated that there were significant differences among the cultivars for most of the quantitative traits investigated. The study revealed that 'Chakalare white' and 'Chakalare brown' produced the highest grain yield even though, they matured late.

Jigari and 'BOSADP' on the other hand matured earlier, which is appropriate for this environment as they could escape drought, but their yields were not as high as the 'Chakalare brown' and 'Chakalare white'. 'Masakwa' the crop of interest produced a relatively fair grain yield, matured late and had the highest number of leaves per plant. This is about the first time this kind of study have been conducted, where 'Masakwa' sorghum were grown under rain rather than post rainy period.

Therefore, cultivar selection should strictly be based on the individual interest. For high grain yield, 'Chakalare brown' and 'Chakalare white' are recommended even though they matured late. The cultivar 'BOSADP' and 'Jigari' on the other hand, are best for environments infested by birds. The performance of 'Masakwa' in terms of grain yield was encouraging under rainy season condition and this could be a head-way in the area of 'Masakwa' research for production under a rain fed condition other than post rainy period.

This study even though not exhaustive will surely remain a bench mark for more studies yet to be initiated. The materials from this work could be used as a candidate gene to form a breeding population for the improvement of 'Masakwa' sorghum for adaptability to rain fed conditions with an improved grain yield.

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