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Growth, Yield and Water Use Efficiency of Maize-Sorghum Intercrop at Samaru, Northern Guinea Savannah, Nigeria

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ABSTRACT: Two field experiments were conducted during the rainy seasons in 2000 and 2001 at the Research Farm, Institute for Agricultural Research, Samaru, (11^0 11' N, 7 ^{0}37'E and 675m above sea level), Northern Nigeria to evaluate the effect of intercropping on the growth, yield and water use efficiency of a Maize-Sorghum intercrop. Intercropping is a cropping system widely practiced in the Nigerian savanna that utilizes moisture to produce several crops on one piece of land. The trial involved a maize and a sorghum variety planted as sole and intercrop in different planting arrangements (row and alternate) of both crops laid out in a randomized complete blocks design replicated three times. Results indicate that the row planting arrangement significantly out yielded the alternate arrangement but was similar to the sole crop planting arrangement. Land Equivalent Ratio (LER) values indicated more efficient utilization of space by intercrops than sole cropping. Intercropping also resulted in more efficient utilization of moisture by the intercrops compared to the sole crops.
Keywords: Maize-Sorghum intercrop, row planting, alternate planting, yield advantage, water use efficiency

INTRODUCTION

Intercropping is the growing of two or more crops simultaneously on the same field during a growing season (Ofori and Stern, 1987) and is a traditional practice in the tropics. Okigho and Greenland (1976) described intercropping as the most widespread cropping system in Africa. Also, they estimated that 99% of cowpea, 95% of groundnut, 90% of sorghum, 89% of millet and 75% of maize grown in Nigeria are intercropped. The farming systems in the Nigerian savanna can be classified as low input type of production. Intercropping is a common cropping system practiced by almost all small scale farmers. Many researchers have reported the advantages of intercropping over monocropping (Allen and Obura, 1983; Chang and Shibles, 1985; Olasantan, 1988, Stoop, 1987, Ogunwole, 2000, Quainoo *et al*., 2000, Makinde *et al.*, 2011). Other researchers have concentrated their work on how intercrops utilize resources more efficiently (Vandermeer, 1984) and on plant water status (Wahua and Miller, 1978; Shackel and Hall, 1984; Tavora and Lopes, 1990). Intercropping ensures better interception of sunlight energy, more effective utilization of water and nutrient and a higher exploration of the growing factors related to the environment (Willey and Osiru, 1972). Most crops grown in intercrops are crops of dissimilar growth patterns, such that the peak period of growth does not coincide. Maize and sorghum intercrop is a dominant practice among farmers in Northern Nigeria, with the 1:3 ratio of sorghum maize mixture being the dominant practice.

The objective of this study was to evaluate the effect of intercropping on resource utilization by maize and sorghum.

MATERIALS AND METHODS

The experiments were conducted during the rainy seasons of 2000 and 2001 at the Teaching and Research Farm of the Institute for Agricultural Research, (IAR) at Samaru, Northern Nigeria (11^0 11' N, 7 ^{0}37'E and 675m above sea level). The area lies within the Northern Guinea savannah zone of Nigeria. The length of the wet season is about 160-180 days (May to October) with mean annual rainfall of 1100mm. Mean daily air temperatures (minimum and maximum) range between 15^oC and 38^oC. The wind speed ranges from 77.2 km/day in

October to 128 km/day in March, with a north easterly to south westerly wind direction dominating from November through April. The soil belongs to the Alfisols group (USDA System, Møberg and Esu, 1991) which has developed on deeply weathered Pre-Cambrian Basement Complex rocks but overlain by aeolian drift of varying thickness. The experiment was laid out in a randomized complete block design with three replicates. It comprised six treatments: maize variety, sorghum variety, four planting arrangements (1:1 row sorghum maize, 2:2 row sorghum maize, 1:2 alternate sorghum maize and 1:3 alternate sorghum maize,), and sole crops. The land was ploughed and harrowed to a fine tilth and ridged at 75cm apart and the field marked out into 30 plots of $11.25m^2$ (3m x 3.75m) sizes each. Paths of 1m across the row and 75cm (one ridge) along the rows were allowed to separate adjacent plots on the field. Two seeds of the hybrid maize (variety Oba Super 1) and four of hybrid sorghum (variety ICSV 111) were planted at 25cm spacing and later thinned to one plant per stand for maize and two to three for sorghum. Recommended cultural management practices were followed (NAERLS, 2001). For sole maize, compound fertilizer (15:15:15) was used at the rate of 120 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 30 kg K_2O ha^{-1}. Fifty percent of the N and all of the P and K were applied two weeks after sowing (FPDD, 1989). The remaining N (60kg/ha) was applied at six weeks after sowing as urea in granular form. For sole sorghum, compound fertilizer (15:15:15) was used at the rate of 64 kg N ha^{-1}, 32 kg P_2O_5 ha^{-1} and 15 kg K_2O ha^{-1}. Fifty percent of the N and all of the P and K were applied two weeks after sowing. For the mixtures, the fertilizer rate of 92 kg N ha^{-1}, 46 kg P_2O_5 ha^{-1} and 22.5 kg K_2O ha^{-1} was applied (FPDD, 1989). The plots were hand weeded at two weeks after sowing and also weeded and earthened up at six weeks after sowing. Leaf area was measured by taking the length and breadth from the widest point, of a functional leaf using meter rule as described by Watson, (1950). A total of 5 tagged plants were sampled at each sampling. The leaf area index (LAI) was computed as described by Duncan and Hasket, (1968). Plant height was measured fortnightly using ruler. Cob length was determined by randomly selecting five cobs from each sub-plot. Cob diameter was determined by selecting five cobs which were measured using a vernier calipher. The numbers of rows per cob were determined by selecting five cobs and counting the rows. The number of grains on each row was counted to determine number of grains per cob. Grain yield was determined by threshing and cleaning the harvested cobs from each net plot. The grains were then weighed and expressed in kilogram per hectare by extrapolation.

A neutron probe, model 503 Hydroprobe (CPN Corp., Martinez, California, U.S.A) which is a nuclear moisture depth gauge, was used to measure soil moisture content at depths 0 to 90 cm at 15 cm interval. The neutron probe allows small changes in *in-situ* soil water storage to be estimated. These subsequent estimates, which are repetitive at the same place, are also not confounded with soil variability, as long as the sphere of importance (or influence) not changing much. Soil moisture content was measured after every rainfall. Volumetric water content at each depth was computed using calibration equation for the site by Jensen *et al.* (1991). The soil water balance equation used to calculate water use is as follows.

$$\Delta S = P + G + N - Et - D - Ro + Ir$$

Where ΔS is the change in soil water content, P is rainfall, G is groundwater flow, N is surface inflow, Et is evapotranspiration, D is drainage and Ro is runoff and Ir is irrigation.

Drainage and runoff were assumed to be negligible. Data recorded were analysed for statistical significance using the Genstat Discovery Edition 2 software (VSN International, UK). Weather data was collected from the meteorological unit of the Institute for Agricultural Research, Ahmadu Bello University, Samaru.

RESULTS AND DISCUSSION

Weather

The trend of weather during the period of the trial (Table 1) indicates adequate moisture for crop growth. Rainfall amounts in both seasons were close to and above the long term mean (1100mm) respectively for the location. Temperature, evaporation and relative humidity were also within the ranges necessary for adequate plant growth (Downes, 1972). This manifested in the good growth of both crops observed in both seasons during the study.

Plant growth components

Plant height

The trend of plant height for maize treatments is shown in Table 2. Values of plant height for maize indicate that there was no significant difference in plant height for all treatments in both seasons. However, in 2000, tallest plants for maize were recorded in week 12 in the 2:2 row arrangements, while the shortest plants were recorded in the 3:1 alternate arrangement. This was however not statistically significant (p>0.05). This could be due to less competition for nutrients and moisture by the plants in rows than those in alternate stands. In 2001, tallest plants for maize were again recorded in week 12 in the 2:2 row arrangements, while the shortest plants were recorded in the 3:1 alternate arrangements. The trend is somewhat similar for the sorghum treatments, no treatment differed significantly from another in terms of plant height in both seasons. However, in 2000 at 12 weeks after sowing, plants in the 2:2 row planting arrangement had taller plants than the other treatments; this was not significantly different from the other treatments. The sole planting arrangement had non significantly shorter plants. In 2001, tallest plants for sorghum were recorded in week 12 in the 2:2 row arrangements, while the shortest plants were recorded in the 3:1 alternate arrangement. The 2:2 row arrangements seem better at utilization of solar radiation for vegetative growth than the other treatments. The trend showed a consistently better plant height in 2001 than in 2000. These results are in tandem with that reported by Makinde *et al.* (2011).

Table 1: Mean of climatic data during 2000 and 2001 rainy seasons at Teaching and Research Farm, Institute for Agricultural Research, Samaru

Month	**Rainfall (mm)**		**Temperature (^{O}C)**				**Evaporation**		**Mean Relative Humidity**	
			Maximum		**Minimum**					
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Jan			31.9	30.9	17.5	14.6	9.35	8.20	23.70	13.61
Feb			38.7	32.3	17.1	17.2	NA	10.52	13.31	17.23
Mar			36.9	37.2	21.4	21.8	NA	10.92	11.70	11.77
Apr		83.9	39.5	36.1	25.1	24.1	NA	10.66	22.20	36.53
May	149.5	160.3	37.0	34.5	25.0	24.2	NA	9.01	37.67	48.64
June	193.4	177.7	31.7	31.8	22.3	22.8	NA	5.77	61.20	63.93
July	221.1	267.8	30.1	30.4	22.2	22.0	NA	6.30	71.40	71.38
Aug	245.2	360.9	29.2	29.8	21.2	22.1	5.60	5.44	78.45	79.80
Sep	182.1	271.7	31.0	31.0	22.0	21.9	5.20	5.58	71.86	86.73
Oct	78.2		32.6	32.7	20.3	20.0	5.17	5.88	57.41	47.87
Nov			33.1	33.4	15.5	16.0	6.78	7.53	29.5	21.63
Dec			31.2	32.7	22.2	16.4	7.38	8.83	19.96	20.35

Source: Institute for Agricultural Research Meteorological Office, Samaru NA = not available

Leaf area index, LAI

The trends of plant leaf area index for maize treatments in both seasons are shown in Table 3. Results obtained indicate an increasing trend of LAI in year 2000 as a result of the spatial arrangement of the crops, reaching a peak at 8 weeks after sowing. At 8 weeks after sowing, the sole, 1:1 row, 2:2 row arrangements had similar leaf area index and are significantly ($P<0.05$) different from the 2:1 and 3:1 alternate row planting arrangement respectively. Sorghum treatments did not exhibit any significant difference in leaf area index at any period in 2000. However, sole planting arrangement exhibited non significantly higher leaf area index than the rest of the treatments. This is in contrast to reports by Ogunwole (2000).

In 2001 season, leaf area index between the sole and 2:1 alternate row arrangement were statistically similar while there was a significant difference (*P<0.05*) in leaf area index in maize between these two and other treatments at 4 weeks after sowing. Sorghum treatments did not exhibit any significant difference in leaf area indices. The results indicate that planting maize in rows gave a more efficient utilization of radiation than in alternate stands with sorghum. Similar results have been reported by Ogunwole (2000).

Table 2: Plant height (cm) as affected by maize/sorghum intercrop at Samaru during 2000 and 2001 rainy seasons at Teaching and Research Farm, Institute for Agricultural Research, Samaru

	Plant height											
	2000						2001					
	Maize			Sorghum			Maize			Sorghum		
Treatments	4	8	12	4	8	12	4	8	12	4	8	12
Sole	23	72	12	17	51	137	32	82	183	19	63	153
1:1; Row	18	84	163	12	49	141	26	79	181	15	69	157
2:2; Row	21	79	172	12	62	159	21	68	190	17	57	168
2:1; Alt	22	68	169	17	55	149	30	86	169	21	59	150
3:1; Alt	21	70	137	16	52	148	31	77	173	19	66	152
SE±												
Significance												
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means within a column followed by different letters are significantly different at 5% level of significance using Duncan's Multiple Range Test (DMRT) NS= No Not Significant

Table 3: Leaf area index (LAI) as affected by maize/sorghum intercrop at Samaru during 2000 and 2001 rainy seasons at Teaching and Research Farm, Institute for Agricultural Research, Samaru

	Leaf area index (LAI)											
	2000						2001					
	Maize			Sorghum			Maize			Sorghum		
Treatments	4	8	12	4	8	12	4	8	12	4	8	12
Sole	1.21	3.0a	2.2	0.96	2.08	1.5	1.4	3.5a	2.9	1.1	2.5	1.9
1:1; Row	0.92	2.6ab	2.0	0.83	1.98	1.2	1.2	2.9b	2.4	0.97	2.7	1.5
2:2; Row	0.83	2.3ab	2.3	0.74	1.72	1.15	1.35	2.4c	1.9	0.82	2.3	1.6
2:1; Alt	0.86	2.2b	1.8	0.91	1.88	1.2	1.3	3.1a	2.4	0.85	1.95	1.5
3:1; Alt	0.82	2.1b	1.9	0.85	1.86	1.09	1.15	2.35c	1.8	1.09	2.05	1.2
SE±		0.31						0.25				
Significance		**						**				
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means within a column followed by different letters are significantly different at 5% level of significance using Duncan's Multiple Range Test (DMRT) NS= Not Significant ** = p<0.01

Grain yield

The trend of grain yield and yield advantage in terms of land equivalen ratio, LER, is shown in Table 4. In 2000, sole maize had significantly higher grain yield than the 2:1 and 3:1 alternate rotw arrangements, but was statistically similar to the 1:1 and 2:2 row arrangements. For sorghum, sole planted sorghum had a statistically significantly different grain yield from the other treatments. All the other treatments had similar grain yield. This could be attributed to less inter specie competition in the row compared to the alternate arrangement, where maize tends to compete with sorghum for resources.

In 2001, sole maize and the 1:1 row planting arrangement had a significantly higher yield than the other treatments. While the 3:1 alternate arrangement had significantly less yield than the 2:2 row and 2:1 alternate planting arrangement respectively. This may be due to less competition between the maize and sorghum as a result of the lower density of plants in the arrangement. Similar results have been reported by Ogunwole (2000) and Makinde *et al.,* (2011).

Table 4: Grain yield as affected by maize/sorghum intercrop at Samaru during 2000 and 2001 rainy seasons at Teaching and Research Farm, Institute for Agricultural Research, Samaru

	Grain yield (kg/ha)					
	2000			**2001**		
Treatment	Maize	Sorghum	LER	Maize	Sorghum	LER
Sole	3828a	2850.12a		4004.71a	3205.41a	
1:1; Row	3517.11a	2127.51b	1.35	3328.04a	2123.05b	1.31
2:2; Row	3513.86a	1705.09b	1.52	2605.09b	1905.09b	1.21
2;1; Alt	2304.12c	1567.90b	1.15	2519.63b	1705.12b	1.16
3:1; Alt	2715.41b	1223.08c	1.14	3273.51c	1577.19b	1.15
SE±	297	238		341	280	
Significance	**	**		**	**	
Interaction						
R X A	NS	NS		NS	NS	

Means within a column followed by different letters are significantly different at the 5% level of significance using Duncan's Multiple Range Test (DMRT). NS = Not Significant

Water use and water use efficiency

The effect of intercropping on water use and water use efficiency is shown in Table 5. The results indicate that in 2000, the 2:1 alternate arrangement recorded the highest water use efficiency amongst the maize treatments. For the sorghum treatments, sole sorghum recorded the highest water use efficiency values. In 2001, sole maize and the 1:1 row planting arrangement recorded the highest water use efficiency amongst the maize treatments. For the sorghum treatments, sole sorghum recorded the highest water use efficiency values. Apart from the maize treatment in year 2000, the alternate arrangements recorded the least water use efficiency values over the two seasons.

Yield advantage

Yield advantage in mixtures as expressed by Land Equivalent Ratio (LER) values, (Table 4) indicate more efficient use of space by all the mixture treatments compared to the sole crops. In 2000, the highest LER value (1.52) was recorded by 2:2 row maize sorghum arranagement, while the least (1.14) was recorded by the 3:1 alternate maize sorghum arrangement. In the second year, 2001, 1:1 row arrangement recorded the highest LER value (1.31) while the least was recorded by the 3:1 alternate arrangement respectively. This result in tandem with reports by Faris *et al.,* (1983), Olasantan (1988), Ogunwole (2000) and Makinde *et al.,* (2011).

CONCLUSION

The results of this study indicate that intercropping utilized the available resources more efficiently than the monocrop. The results also indicate the better adaptation of the row planting arrangement to the alternate planting arrangement. From the foregoing, it can be concluded that farmers in the ecology stand to benefit by adopting the 1:1 row planting arrangement, rather than the present practice of alternate arrangement. Further studies are necessary to establish the optimum fertilizer and moisture requirements of intercrops.

Table 5: Water use and water use efficiency as affected by sorghum maize intercrop at Samaru during 2000 and 2001 rainy seasons at Teaching and Research Farm, Institute for Agricultural Research.

	Water use and water use efficiency			
	2000		**2001**	
Treatment	**Water use (kg/mm)**	**Water use efficiency (kg/mm/ha)**	**Water use (kg/mm)**	**Water use efficiency (kg/mm/ha)**
Maize				
Sole	421	9.10	487	8.22
1:1; R	371	4.90	401	8.30
2:2; R	308	9.48	490	5.31
2:1; A	442	11.40	412	6.11
3:1; A	405	5.21	484	6.76
Sorghum				
Sole	578	4.93	552	5.81
1:1; R	597	3.56	515	4.12
2:2; R	515	3.31	520	3.66
2:1; A	534	2.94	492	3.46
3:1; A	568	2.15	581	2.71

REFERENCES

Allen, J.R. and Obura, R.K. (1983). Yield of corn, cowpea and soyabean under different intercropping systems. *Agronomy Journal*, Madison **75:** 1005-1009

Chang, J.F. and Shibles, R.M. (1985). An analysis of competition between intercropped cowpea and maize. *Field Crops Research*, Amsterdam. **12:** 145-152

Downes, R.W. (1972). Effect of temperature on the phenology and grain yield of sorghum. *Australian Journal Agricultural Research* **23:** 585-594

Duncan, N. G. and Hasketh, J.D. (1968). Net photosynthesis rates, Relative growth rates and leaf number, 22 races of maize at eight temperatures. *Crop Science* **8:** 670-674.

Faris, M.A., de Araujo M.R.A., de Lira A., and Arcovere, A.S.S. (1983). Yield stability in intercropping studies of sorghum or maize with cowpea or common bean under different fertility levels in Northeastern Brazil. *Canadian Journal of Plant Scince* **63:** 789-799

Fertilizer Procurement and Distribution Division (FPDD). (1989). Fertilizer use and management practices for crops in Nigeria., Federal Ministry of Agriculture and Rural Development, Lagos, Nigeria pp 29.

Jensen, J.R., Oyelere P. and Obitie A. (1991). Field calibaration of CPN Neutron Probe on the Middle Slope of Savanna Soil at Samaru. ABU/DLDS/EEC University Linkage Project Technical Report No. 3

Makinde, A.A., Bello, N.J., Olasantan, F.O., Adebisi, M.A. and Adeniyi H.A. (2011). Seasonality and crop combination Effects on growth and yield of two sorghum (*Sorghum bicolor)* cultivars in sorghum/maize/okra intercrop in a Forest-Savanna Transition Zone of Nigeria. *Agricultural Journal* **6(3):** 92-99

Møberg, J.P. and Esu, I.E. (1991). Characteristics of some savannah soils of Nigeria. *Georderma* 48: 113-129

National Agrcultural Extension and Research Liaison Services (2001). *Maize Production. Bulletin on maize production practices*. National Agricultural Extension & Research Liaison Services, ABU, Zaria. 23pp

Ofori, F. and Stern, W.R. (1987). Cereal-legume intercropping systems. *Advances in Agronomy*, San Diego **41:** 41-89.

Ogunwole, J.O. (2000). The microclimate of a cereal based intercrop at Samaru, northern Nigeria. Ph.D Thesis, Dept. of Soil Science, Ahmadu Bello University, Zaria

Okigho, B.N. and Greenland, D.J. (1976). Intercropping systems in tropical Africa. In Papandick, R.I.; Sanchez, P.A.; Tripplet, G.B. (Eds). *Multiple cropping*. Madison: American Society of Agronomy, pp. 63-101.

Olasantan, F.O. (1988). The effect of soil temperature and moisture content on crop growth and yield of intercropping maize and melon. *Experimental Agriculture* **24:** 67-74

Quainoo, A.K., Lawson, I.Y.D. and Yawson, A. (2000). Intercrop performance of maize, sorghum and soyabean in response to planting pattern. *Journal of the Ghana Science Association*. **2(2):** 31-35**.**

Shackel, K.A. and A.E. Hall (1984). Effect of intercropping on water relations of sorghum and cowpea. *Field Crops Research*, Amsterdam. **8:** 381-387

Stoop, W.A. (1987). Adaptation of sorghum/maize and sorghum/pearl millet intercrop systems to the toposequence land types in the North Sudanian zone of West African Savanna. *Field Crops Research*. **16 (3):** 255-272**.**

Tavora, F.J.A.F. and Lopes, L.H. de O. (1990). Deficiencia hidirica no consorcio milho x cowpea. *Pesquisa Agropecuaria Brasileira*, Brasilia. **25(7):** 1011-1022

Vandermeer, J.H. (1984). The interpretation and design of intercrop systems involving environmental modification by one of the components: a theoretical framework *Biological Agriculture and Horticulture*, Bicester. **2:** 135-156.

Watson, D.J. (1950). The dependence of Net Assimilation Rate on Leaf area index (LAI). *Annals of Botany*, **22:** 37 – 54.

Wahua, T.A. and Miller, D.A. (1978). Leaf water potential and light transmission in intercropped sorghum and soyabean. *Experimental Agriculture* **14:** 373-378.

Wiley, R.W. and Osiru, D.S.O. (1972). Studies of mixtures of Maize and Beans (*Phaseolus vulgaris)* with particular reference to plant population. *Journal of Agricultural Science* **79:** 517-529.