Journal of Agricultural and Crop Research
Vol. 4(5), pp. 72-82, July 2016
ISSN: 2384-731X
Research Paper

Performance of pearl millet (*Pennisetum glaucum* (L.) BR.) varieties intercrop with legumes in Sudan Savanna of Nigeria

J. A. Bassi* • I.Y. Dugje

Department of Crop Production Faculty of Agriculture University of Maiduguri, Nigeria.

*Corresponding author. E-mail: jibrinbassi@gmail.com.

Accepted 3rd May, 2016

Abstract. Four pearl millet varieties (SOSAT-C-88, ZATIP, LACRI-9702-IC and EX-BORNO) were intercropped with four selected legumes: groundnut (Samnut – 14), soybean (TGX – 1830-2E), cowpea (IT89KD- 288) and bambara nut (Damboa white) at 1:1 alternate row arrangement in a field experiment conducted at Teaching and Research Farm of the Department of Crop Production, Faculty of Agriculture, University of Maiduguri in the Sudan Savanna ecological zone of Nigeria during the 2010 and 2011 wet seasons. Intercropping had no significant effect on the grain yield, yield attribute and partial land equivalent ratio (LER) of pearl millet varieties. However, pearl millet reproductive parameters were significantly better in SOSAT-C-88, ZATIP and EX-BORNO than LACRI-9702-IC. Grain yield/ha were significantly least for LACRI-9707-IC while legumes grown in association with LACRI-9702-IC produced better yield. Mean grain yield of the legumes were reduced by 47% as a result of intercropping with pearl millet. Intercropped pearl millet grain yield varied from 472 to 861 kg/ha, with SOSAT-C-88 recording the highest grain yield and partial land equivalent ratio (LER). Grain yield and partial LER of pearl millet varieties were significantly higher with SOSAT-C-88 + cowpea combination compared with the other legumes intercrop in both seasons. The highest total LER (1.35) and gross monetary return were obtained using the intermediate pearl millet variety, SOSAT-C-88 pearl millet + legumes. In both the seasons, total LER and gross monetary was higher at the legumes when cowpea was grown in association with SOSAT-C-88 variety.

Keywords: Performance, Legumes, Pearl Millet, Varieties Intercrop, *Pennisetum*.

INTRODUCTION

Intercropping is a system of growing two or more crops simultaneously on the same piece of land in a manner that will permit interaction of the component crops in a spatial and temporal context (Burner, 2003). It encompasses various spatial crop arrangements distinguished as row mixed, relay and strip intercropping (Olufajo, 2006). The rationale for intercropping practice in Nigeria and other places where the system has been recognized have been summarized by Baker (1978) to include an insurance against crop failure and Mumilo (2004) to include efficient utilization of environmental factors such as light, water, nutrients and protection of soil from erosion. Norman (1975) observed that 60 to 70% of pearl millet were grown as intercrops and that millet and legumes were rarely grown sole. It has been estimated that in order to meet daily calories requirement, a person will need 245 kg of cereal plus 30 kg of legume grain per year (Ikeorgu, 2003). Pearl millet is a stable food crop for more than 500 million people in Sub Saharan Africa and principal food crop in the arid and semi-arid regions of Nigeria (FAO, 2005). Fussell and Serafani (1985) recommend that, when choosing any crop combination, specific variety characteristics need to be considered in conjunction with management practices.

The aim of the present study is to asses various pearl millet varieties for high productivity under intercrop with legumes in the Sudan Savanna of northern eastern Nigeria.

MATERIAL AND METHODS

Field experiments were conducted in 2010 and 2011 rainy seasons at the Teaching and Research Farm of the Department of Crop Production, University of Maiduguri (11°53′ N and 13°50′ E). The experimental design was Randomised Complete Block Design (RCBD) in factorials arrangement with four legumes: cowpea (IT89KD-288), Groundnut (Samnut-14), Bambaranut (Local Damboa white) and soybean (TGX 1830-2E) which constituted the main plots while four pearl millet varieties: SOSAT-C-88, ZATIP, LACRI-9702-IC and EX-BORNO assigned to the subplot. Each of the pearl millet varieties was sown at 90 × 50 cm while each legume was intercropped into the pearl millet simultaneously at a distance of 45 cm from each pearl millet row and 25 cm within row in 1:1 alternate row arrangement. Sole pearl millet was added as one of the four main plots and separate plots of each sole legumes to evaluate biological and monetary efficiencies of the system in accordance with reports by Willey (1979) and Dugje and Odo (2006a). The pearl millet component was side-dressed with 30 kg N, 30 kg P_20_5 and 30 kg K_2O/ha at two weeks after sowing (WAS) using NPK (15:15:15). The second dose of 30kg N/ha was applied at 6WAS using urea (46% N). Also the legume component was side-dressed with 50 kg P_2O_5/ha (FPDD, 2002), using single super phosphate at 2 WAS. Insect pest control in cowpea plots were sprayed twice (at flowering and pod-filling stages) against insect pests using cypermetrin + dimethoate (Sherparplus) with active ingredients of 30 g/L + 250 g/L of water soluble concentrates. Data collected on pearl millet includes plant height, number of leaves/ plant, leaf area (cm^2), number of tillers/ plant, number of days to 50% flowering, panicle weight (g), panicle length/plant, panicle diameter (cm), grain yield/ plant (g), number of grains/ panicle, 1000-grain weight, harvest index (%), grain yield kg/ hectare and straw yields, legumes grain yield/ha, 100 grain weight and fodder yield/ hectare.

Data obtained in a year and their combined totals for intercrop were subjected to analysis of variance (ANOVA). Data from three replication and differences between treatment means were compared using least significant difference (LSD) at 5% probability level ($P < 0.05$).

Pearl millet growth and development parameters

There was no significant difference in plant height among the pearl millet varieties at 6 WAS in 2010 (Table 1). However, the pearl millet variety EX-BORNO and LACRI-9702-IC slightly produced taller plant at 6 WAS compared to ZATIP and SOSAT-C-88 in 2010. In 2011, the result showed that plant height significantly differed at 6 WAS, as ZATIP and EX-BORNO produced significantly ($P < 0.01$) taller plants compared to LACRI-9702-IC and SOSAT-C-88. Plant heights were significantly ($P < 0.01$) lower for LACRI-9702-IC and SOSAT-C-88 compared to ZATIP. For the combined mean, there was no significant difference at 6 WAS, however, ZATIP and EX-BORNO produced comparable plant heights but relatively taller than SOSAT-C-88 and LACRI-9702-IC. At 9 WAS, in 2010, plant height was significantly ($P < 0.001$) greater for EX-BORNO and ZATIP compared to SOSAT-C-88 and LACRI-9702-IC that produced significantly ($P < 0.001$) lower plant height (Table 1). In 2011, at 9 WAS, ZATIP and EX-BORNO maintained their superiority in the plant height which were significantly ($P < 0.05$) taller than SOSAT-C-88 and LACRI-9702-IC that produced significantly ($P < 0.01$) shorter plants than the other varieties. For the combined mean, ZATIP produced significantly ($P < 0.001$) taller plant followed by EX-BORNO than SOSAT-C-88 and LACRI-9702-IC. At harvest in 2010, plant height was significantly ($P < 0.001$) higher for ZATIP than the other varieties, while SOSAT-C-88 produced significantly ($P < 0.001$) shorter plants than the other treatments at harvest. In 2011, at harvest, there was no significant difference in plant height, however, values were slightly higher for ZATIP and EX-BORNO compared to SOSAT-C-88 and LACRI-9702-IC that produced shorter plants at harvest (Table 1). The result for the combined mean at harvest, revealed that, ZATIP and EX-BORNO maintained their superiority in plant height which were significantly ($P < 0.001$) taller than SOSAT-C-88 and LACRI-9702-IC. However, SOSAT-C-88 produced significantly ($P < 0.001$) shorter plants than LACRI-9702-IC at harvest. In 2010, number of leaves/plant were significantly ($P < 0.001$) greater for EX-BORNO and ZATIP compared to SOSAT-C-88 and LACRI-9702-IC- at 9 WAS. Also at harvest, EX-BORNO and ZATIP produced greater number of leaves compared to the two varieties. In 2011, there was no significant difference among the pearl millet varieties at 9 WAS and at harvest. At 9 WAS, number of leaves per plant was greater for EX-BORNO and ZATIP, while SOSAT-C-88 and LACRI-9702-IC had lower and comparable number of leaves per plant (Table 1). At 9 WAS EX-BORNO produced relatively greater number of leaves per plant compared to SOSAT-C-88 and LACRI-9702-IC. At EX-BORNO and ZATIP produced relatively higher number of leaves per plant than SOSAT-C-88 and LACRI-9702-IC varieties which had comparable values for number of leaves. For the combined mean at 9 WAS there was significantly ($P < 0.05$) greater number of leaves per plant for EX-BORNO and ZATIP than SOSAT-C-88 and LACRI-9702-IC. No significant difference was observed among the pearl millet varieties at harvest. However,

Table 1. Effect of pearl millet variety on plant height of pearl millet at 6, 9 WAS and harvest and number of leaves/plant at 9 WAS and harvest at Maiduguri 2010, 2011 and combined mean.

Millet variety	Plant height			No. of leaves/plant	
	6 WAS	9 WAS	Harvest	9 WAS	Harvest
2010					
SOSAT-C-88	97.45	154.71	268.31	19.0	7.8
ZATIP	97.26	161.62	324.69	19.8	8.5
LACRI-9702-IC	98.75	150.45	275.91	19.1	7.1
EX-BORNO	98.14	161.43	302.42	20.5	8.3
SE (±)	1.76	1.40	7.07	0.45	0.22
LSD (0.05)	NS	2.87	14.44	0.93	0.46
2011					
SOSAT-C-88	85.45	143.68	250.13	18.9	9.3
ZATIP	89.92	147.00	278.11	19.4	10.3
LACRI-9702-IC	82.42	143.21	247.68	18.9	9.1
EX-BORNO	88.47	146.11	267.17	21.0	9.6
SE (±)	1.86	1.34	2.49	0.43	0.51
LSD (0.05)	3.34	2.81	NS	NS	NS
Combined mean					
SOSAT-C-88	91.45	149.19	259.22	19.0	8.6
ZATIP	93.59	154.31	301.40	19.6	9.0
LACRI-9702-IC	90.59	146.83	261.80	19.0	7.7
EX-BORNO	93.10	153.77	284.79	20.8	8.9
SE (±)	2.17	2.14	6.29	0.30	0.35
LSD (0.05)	NS	4.26	12.51	0.76	NS

NS = Not Significant. Values of 2010 and 2011 are pooled means of three replicates of four pearl millet varieties and four selected legume intercrops, while values of combined mean are pooled means of three replicates of four pearl millet varieties and four selected legume intercrops for the two years.

ZATIP and EX-BORNO produced the highest number of leaves per plant compared to the two pearl millet varieties (Table 1).

The results showed that there was no significant difference among the pearl millet varieties at 3 WAS in 2010 (Table 2). At 6 WAS pearl millet varieties ZATIP and SOSAT-C-88 produced significantly ($P < 0.001$) greater leaf area compared to the other treatments. At 9 WAS, ZATIP and SOSAT-C-88 produced significantly ($P < 0.01$) greater leaf area compared to LACRI-9702-IC and EX-BORNO which produced significantly ($P < 0.01$) lower leaf area. At harvest, similar trend was observed for ZATIP and SOSAT-C-88 compared to LACRI-9702-IC and EX-BORNO treatments. In 2011, there was no significant difference among pearl millet varieties in leaf area at 3 WAS. However, leaf area was significantly ($P < 0.05$) greater for SOSAT-C-88 and ZATIP compared to EX- BORNO and LACRI-9702-IC at 6 WAS in 2011. At 9 WAS, significantly ($P < 0.01$) greater leaf area was observed for ZATIP and SOSAT-C-88, while EX-BORNO and LACRI-9702-IC produced significantly ($P < 0.001$) lower leaf area. There was no significant difference in leaf area at harvest among the treatments. The variety ZATIP and SOSAT-C-88 produced relatively higher leaf area compared to the LACRI-9702-IC and EX-BORNO at harvest (Table 2). For the combined mean at 3 WAS, EX-BORNO produced slightly greater leaf area compared to SOSAT-C-88, LACRI-9702-IC and ZATIP. At 6 and 9 WAS, ZATIP and SOSAT-C-88 produced significantly ($P < 0.001$) greater leaf area than LACRI-9702-IC and EX-BORNO. Similar trend was observed at harvest when SOSAT-C-88 and ZATIP produced significantly ($P < 0.01$) greater leaf area compared to LACRI-9702-IC and EX-BORNO.

There was no significant difference among pearl millet varieties in the expression of number of tillers/plant at 3 WAS in 2010 (Table 3). Number of tillers/plant was slightly higher for SOSAT-C-88 compared to ZATIP, LACRI-9702-IC and EX-BORNO that had comparable number of tillers/plant in 2010. At 6 WAS in 2010, there was significantly ($P < 0.05$) greater number of tillers/plant for SOSAT-C-88 than the other varieties. At 9 WAS, values were significantly ($P < 0.001$) greater for SOSAT-C-88 and EX-BORNO while ZATIP and LACRI-9702-IC had comparable values. In 2011, number of tillers were significantly ($P < 0.05$) greater for SOSAT-C-88 and EX-

Table 2. Effect of pearl millet variety on pearl millet leaf area (cm^2) at 3, 6, 9 WAS and at harvest at Maiduguri 2010, 2011 and combined mean.

Millet variety	Leaf area (cm^2)			
	3 WAS	6 WAS	9 WAS	Harvest
2010				
SOSAT-C-88	133.3	152.1	183.7	136.2
ZATIP	133.0	164.3	190.7	138.0
LCARI-9702-IC	132.3	148.4	169.2	131.9
EX-BORNO	133.4	147.6	175.0	131.3
SE (±)	1.33	1.86	2.62	1.60
LSD (0.05)	NS	3.80	5.36	3.27
2011				
SOSAT-C-88	133.8	150.5	179.4	133.4
ZATIP	134.3	151.3	181.9	135.7
LACRI-9702-IC	134.1	147.3	172.3	132.4
EX-BORNO	135.5	145.6	170.7	131.2
SE (±)	1.27	1.34	2.22	1.47
LSD (0.05)	NS	2.75	4.54	NS
Combined mean				
SOSAT-C-88	133.7	151.3	181.6	134.8
ZATIP	133.6	157.9	186.3	136.9
LACRI-9702-IC	133.2	147.8	170.8	132.2
EX-BORNO	134.3	146.6	172.8	131.3
SE (±)	0.87	1.67	1.73	1.31
LSD (0.05)	NS	3.33	3.44	2.60

NS = Not Significant. Values of 2010 and 2011 are pooled means of three replicates of four pearl millet varieties and four selected legume intercrops, while values of combined mean are pooled means of three replicates of four pearl millet varieties and four selected legume intercrops for the two years.

BORNO, while ZATIP and LACRI-9702-IC produced significantly ($P < 0.05$) lower number of tillers/plant at 3 WAS. There was no significant difference among the pearl millet varieties at 6 WAS. At 9 WAS, SOSAT-C-88 and EX-BORNO produced significantly ($P < 0.001$) higher number of tillers per plant compared to LACRI-9702-IC and ZATIP varieties. The result for the combined mean was not significant at 3 WAS. At 6 and 9 WAS SOSAT-C-88 and EX-BORNO produced significantly ($P < 0.01$) greater number of tillers/plant compared to the ZATIP and LACRI-9702-IC (Table 3). Number of days to 50% flowering was significantly ($P < 0.001$) delayed for ZATIP and EX-BORNO compared to SOSAT-C-88 and LACRI-9702-IC in 2010. In 2011, days to 50% flowering were also significantly ($P < 0.01$) earlier for SOSAT-C-88 and LACRI-9702-IC than EX-BORNO and ZATIP, but SOSAT-C-88 significantly flowered earlier than other varieties. For the combined mean, SOSAT-C-88 and LACRI-9702-IC significantly ($P < 0.001$) flowered earlier than ZATIP and EX-BORNO that had significantly ($P < 0.001$) higher number of days to 50% flowering (Table 3).

Panicle characteristics of pearl millet varieties

The result showed that, SOSAT-C-88 and ZATIP produced significantly ($P < 0.001$) greater panicle weight than LACRI-9702-IC (Table 4). The three varietiess: SOSAT-C-88, ZATIP and EX-BORNO produced comparable values of panicle weight. In 2011 and combined mean, there was no significant difference among the pearl millet varieties on panicle weight. However, SOSAT-C-88 relatively produced heavier panicles compared to ZATIP, EX-BORNO and LACRI-9702-IC respectively. Panicle length was significantly ($P < 0.001$) longer for ZATIP than EX-BORNO, SOSAT-C-88, and LACRI-9702-IC in 2010, 2011 and the combined mean. The two varieties: SOSAT-C-88 and LACRI-9702-IC significantly ($P < 0.001$) produced shorter panicle length, but LACRI-9702-IC produced the shortest panicle among the varieties. The results showed that panicle diameter was significantly ($P < 0.001$) greater for SOSAT-C-88 compared to LACRI-9702-IC in both years and combined mean (Table 4). Pearl millet variety ZATIP and

Table 3. Effect of pearl millet variety on pearl millet number of tillers per plant at 3, 6 and 9 WAS and number of days to 50% flowering at Maiduguri 2010, 2011 and combined mean.

Millet variety	Number of tillers/plant			Number of days to 50% flowering
	3 WAS	6 WAS	9 WAS	
2010				
SOSAT-C-88	2.5	2.4	2.7	68.9
ZATIP	1.4	2.3	2.5	80.2
LACRI-9702-IC	1.3	2.2	2.4	68.0
EX-BORNO	1.5	2.3	2.6	76.4
SE (±)	0.68	0.34	0.04	0.74
LSD (0.05)	NS	0.07	0.08	1.51
2011				
SOSAT-C-88	1.3	2.3	3.0	68.0
ZATIP	1.2	2.2	2.7	77.0
LACRI-9702-IC	1.2	2.2	2.7	72.1
EX-BORNO	1.3	2.4	3.0	79.3
SE (±)	0.05	0.09	0.08	0.65
LSD (0.05)	0.16	NS	0.17	1.34
Combined mean				
SOSAT-C-88	1.9	2.3	2.8	68.8
ZATIP	1.3	2.2	2.6	78.6
LACRI-9702-IC	1.2	2.2	2.5	70.1
EX-BORNO	1.4	2.4	2.8	78.2
SE (±)	0.34	0.06	0.07	0.83
LSD (0.05)	NS	0.12	0.14	1.65

NS = Not Significant. Values of 2010 and 2011 are pooled means of three replicates of four pearl millet varieties and four selected legumes intercrop, while values of combined mean are pooled means of three replicates of four pearl millet varieties and four selected legume intercrops for the two years.

EX-BORNO significantly ($P < 0.001$) produced the smallest panicle diameter in both years and combined mean. The largest panicle diameter was observed for SOSAT-C-88 during both periods and combined mean.

Yield and yield components of pearl millet and legumes intercrop

There was no significant difference among the pearl millet varieties in 2010. However, relatively higher grain yield per plant was produced by SOSAT-C-88 and ZATIP compared to LACRI-9702-IC that produced relatively lower value in 2010 (Table 5). In 2011, ZATIP produced significantly ($P < 0.01$) greater grain yield/plant compared to LACRI-9702-IC and EX-BORNO. The significantly lowest plant yields was produced ($P < 0.01$) by LACRI-9702-IC and EX-BORNO for the combined mean. Grain yield/plant were generally higher for SOSAT-C-88 and ZATIP than LACRI-9702-IC or EX- BORNO. The results of the intercropped pearl millet varieties on number of grains per panicle showed that, ZATIP and SOSAT-C-88 produced significantly ($P < 0.01$) greater number of grains than LACRI-9702-IC in 2010 (Table 5). In 2011, there was significantly ($P < 0.01$) greater number of grains per panicle for ZATIP compared to LACRI-9702-IC. In 2010 and 2011, LACRI-9702-IC significantly ($P < 0.01$) produced lower number of grains. Similar trend was observed for the combined mean when ZATIP produced significantly ($P < 0.001$) greater number of grains per panicle compared to LACRI-9702-IC which maintained significantly ($P < 0.001$) lower number of grains than the other varieties. 1000 grain weight significantly ($P < 0.05$) differed among the pearl millet varieties in 2010, 2011 and combined mean. The variety SOSAT-C-88 significantly ($P < 0.05$) produced superior 1000 weight in 2010, 2011 and combined mean (Table 5). On the other hand, LACRI-9702-IC and EX-BORNO produced significantly ($P < 0.05$) the lowest weight for the combined.

The results of the intercropped pearl millet varieties showed that grain yield per hectare was significantly ($P < 0.05$) greater for SOSAT-C-88 than LACRI-9702-IC and ZATIP. The two other promising varieties in 2010 were EX-BORNO and ZATIP. In 2011, grain yield was also significantly ($P < 0.01$) greater for SOSAT-C-88 compared

Table 4. Effect of pearl millet variety on pearl millet panicle weight (g), panicle length/plant (cm) and panicle diameter at Maiduguri 2010, 2011 and combined mean.

Millet variety	Panicle weight (g)	Panicle length/plant	Panicle diameter (cm)
2010			
SOSAT-C-88	29.8	27.4	3.2
ZATIP	29.9	59.0	2.6
LACRI-9702-IC	24.3	24.5	2.8
Ex-BORNO	28.3	33.6	2.6
SE (±)	1.06	2.34	0.09
LSD (0.05)	2.17	4.79	1.19
2011			
SOSAT-C-88	38.1	28.4	3.0
ZATIP	34.0	62.3	2.5
LACRI-9702-IC	30.6	25.4	2.8
Ex-BORNO	32.4	30.4	2.6
SE (±)	1.37	1.13	0.08
LSD (0.05)	NS	2.32	0.17
Combined mean			
SOSAT-C-88	33.95	27.9	3.1
ZATIP	31.9	60.7	2.8
LACRI-9702-IC	27.5	24.9	2.8
Ex-BORNO	30.4	34.0	2.6
SE (±)	1.54	1.21	0.07
LSD (0.05)	NS	2.40	0.13

NS = Not Significant. Values of 2010 and 2011 are pooled means of three replicates of four pearl millet varieties and four selected legume intercrops, while values of combined mean are pooled means of three replicates of four pearl millet varieties and four selected legume intercrops for the two years.

to LACRI-9702-IC and ZATIP varieties. The most promising variety after SOSAT-C-88 was EX-BORNO, which did not significantly differ in grain yield. For the combined mean, grain yield per hectare was significantly ($P < 0.001$) higher for SOSAT-C-88 compared to LACRI-9702-IC. Grain yield per hectare was higher for SOSAT-C-88 by 9, 16 and 22% than EX-BORNO, ZATIP and LACRI-9702-IC respectively for the combined mean (Table 6). There was no significant difference among the varieties in straw yield/plant in both years and combined mean. However, ZATIP and LACRI-9702-IC produced relatively higher straw yield/plant compared to SOSAT-C-88 and EX-BORNO that had relatively lower straw yield in 2010. In 2011, ZATIP and EX-BORNO produced slightly greater straw yield/plant compared to SOSAT-C-88 and LACRI-9702-IC that had lower straw yield. For the combined mean, ZATIP and LACRI-9702-IC produced higher values compared to EX-BORNO and SOSAT-C-88. The results revealed that there were significant differences among the pearl millet varieties (Table 6). In 2010, the variety ZATIP significantly ($P < 0.001$) produced greater harvest index than EX-BORNO and LACRI-9702-IC. There was no significant difference between ZATIP and SOSAT-C-88. In 2011, harvest index was significantly ($P < 0.001$) greater for ZATIP and SOSAT-C-88 compared to EX-BORNO and LACRI-9702-IC. The variety LACRI-9702-IC significantly ($P < 0.001$) realized the lowest harvest index. For the combined mean, there was no significant difference among the pearl millet varieties in harvest index. However, ZATIP and SOSAT-C-88 produced relatively higher harvest index compared to the other two varieties. Similarly, LACRI-9702-IC and EX-BORNO produced the lowest harvest index in 2010, 2011 and for the combined mean.

Linear correlation coefficient (r) of millet agronomic parameters of four millet + legume intercrops and four pearl millet varieties, combined mean

The effect of intercropping Pearl millet + legume on interrelationship among agronomic parameters for the combined mean of 2010 and 2011 showed that, there was negative linear correlation between harvest index and number of days to 50% flowering (r = -051*) but positively correlated with grain yield /ha (r = 0.76**) and grain yield/ plant (r = 0.66**) ,while leaf area at harvest positively correlated with grain yield /hectare (r = 0.78**), grain yield/plant (r = 0.98**) and harvest index (r = 0.66*) for the combined mean (Table 7). Number of grains

Table 5. Effect of pearl millet variety on pearl millet grain yield/plant (g), number of grains/panicle and 100 seed yield (g) at Maiduguri 2010, 2011 and combined mean.

Millet variety	Grain yield/plant (g)	No. of grains/panicle	1000 seed weight (g)
2010			
SOSAT-C-88	42.9	2287.7	9.2
ZATIP	39.4	2389.5	8.9
LACRI-9702-IC	35.0	2038.9	8.9
EX-BORNO	37.8	2138.5	8.6
SE (±)	1.40	83.64	0.19
LSD (0.05)	NS	170.82	0.39
2011			
SOSAT-C-88	40.2	2232.1	9.5
ZATIP	41.8	2314.0	9.3
LACRI-9702-IC	34.2	2023.5	8.5
EX-BORNO	35.3	2248.0	9.0
SE (±)	1.27	87.16	0.28
LSD (0.05)	2.59	178.02	0.58
Combined mean			
SOSAT-C-88	41.6	2259.9	9.4
ZATIP	40.6	2351.8	9.1
LACRI-9702-IC	34.6	2031.2	8.7
EX-BORNO	36.6	2193.5	8.8
SE (±)	1.41	56.3	0.17
LSD (0.05)	2.80	111.92	0.35

NS = Not Significant. Values of 2010 and 2011 are pooled means of three replicates of four pearl millet varieties and four selected legume intercrops, while values of combined mean are pooled means of three replicates of four pearl millet varieties and for selected legume intercrops for the two years.

/panicle was negatively associated with number of days to 50% flowering (r = 0.64**), grain yield /hectare (r = 0.85**), grain yield /plant (r = 0.67**). Number of leaves at harvest was negatively correlated with leaf area at harvest (r = 0.81**), while number of panicles /plant was positively associated with grain yield/ha (r = 0.92**), grain yield/plant (r = 0.85**) and number of grains /panicle (r = 0.86**). Number of tillers /plant was positively associated with grain yield/ plant (r = 0.73**), leaf area at harvest (r = 0.81**) and number of grains / panicle (r = 0.76**). Panicle diameter significantly correlated with harvest index (r = 0.81**) and number of leaves at harvest (r = 0.90**). Similarly, plant height at harvest was positively associated with number of grains /panicle (r = 0.63**) but negatively associated with number of days to 50% flowering (r = - 0.66**) while panicle length significantly correlated with number of grains / panicle (r = 0.63**) and negatively associated with number of days to 50% flowering (r = - 0.79**) (Table 7). Panicle weight was positively associated with number of leaves/plant at harvest (r = 0.61*), plant height at harvest (r = 0.82**) and number of tillers at 9WAS (r = -0.55*). There was no linear correlation among the other agronomic parameters determined.

Yield and yield components of legumes intercrop

There was significant effect of pearl millet variety on legume seed yield per hectare in 2010 and 2011. In 2010, grain yield was significantly (P < 0.05) greater for the legumes grown in association with SOSAT-C-88 and LACRI-9702-IC compared to the other two pearl millet varieties. Significantly (P < 0.05) lower grain yield was produced by the legumes when intercropped with ZATIP or EX-BORNO varieties (Table 8). In 2011, the legumes intercropped with LACRI-9702-IC or SOSAT-C-88 produced significantly (P < 0.001) greater grain yield than the two varieties. For the combined mean, there was no significant difference in grain yield, however, legumes grown in mixture with SOSAT-C-88 or LACRI-9702-IC slightly produced superior yield compared to legumes intercropped with ZATIP or EX-BORNO (Table 8). The effect of pearl millet variety on legume 100 grain weight, showed that weight was slightly heavier for legume intercropped with LACRI-9702-IC or SOSAT-C-88 in 2010 (Table 8). In 2011 and combined mean, there was no significant difference in legume 100 weight. Values were similar and comparable, except under LACRI-9702-IC where legumes maintained superior 100 grain weight

Table 6. Effect of pearl millet variety on pearl millet grain yield (kg/ha), straw yield/plant (g) and harvest index (%) at Maiduguri 2010, 2011 and combined mean.

Millet variety	Grain yield (kg/ha)	Straw yield/plant (g)	Harvest index (%)
2010			
SOSAT-C-88	2845.3	48.2	37.3
ZATIP	2457.2	49.5	38.0
LACRI-9702-IC	2351.9	50.4	35.5
EX-BORNO	2555.3	46.5	33.2
SE (±)	186.24	1.90	1.42
LSD (0.05)	380.36	NS	3.01
2011			
SOSAT-C-88	2879.1	50.9	52.5
ZATIP	2474.0	54.2	53.3
LACRI-9702-IC	2333.2	53.1	43.6
EX-BORNO	2707.5	53.9	49.2
SE (±)	190.70	1.87	1.49
LSD (0.05)	359.46	NS	3.05
Combined mean			
SOSAT-C-88	2862.2	49.5	44.7
ZATIP	2465.6	51.8	45.7
LACRI-9702-IC	2342.5	51.7	39.5
EX-BORNO	2631.4	50.2	41.2
SE (±)	124.7	1.55	2.44
LSD (0.05)	544.62	NS	NS

NS = Not Significant. Values of 2010 and 2011 are pooled means of three replicates of four pearl millet varieties and four selected legume intercrops, while values of combined mean are pooled means of three replicates of four pearl millet varieties and four selected legume intercrops for the two years.

(Table 8). There was no significant difference in legume fodder yield in 2010 and combined mean. In the 2010, the legume grown in associations with SOSAT-C-88 and LACRI-9702-IC produced relatively higher fodder yield compared to the two varieties. In 2011, legume grown in associations with SOSAT-C-88 or LACRI-9702-IC produced ($P < 0.05$) higher fodder yield compared to other combination. The result for the combined mean revealed that legume fodder yield was superior under SOSAT-C-88 and LACRI-9702-IC.

Effect of pearl millet variety on relative competitive ability, land equivalent ratio and monetary advantage

The relative competitive ability was greater for SOSAT-C-88 + legume and EX-BORNO + legume intercrop in 2010. The situation was similar in 2011, when SOSAT-C-88 + legume and ZATIP + legume had higher competitive abilities. The combined mean was slightly superior for SOSAT-C-88 + legume intercrops. The competitive ability was higher by about 18 to 22% for SOSAT-C-88 + legume intercrop compared to the LACRI-9702-IC + legume that had the least competitive ability among the millet varieties. The land equivalent ratio for pearl millet variety + legume intercrop was greater for SOSAT-C-88 in 2010, 2011 and for the combined mean. Also, in 2010 and 2011 LACRI-9702-IC + legume had greater land equivalent ratio, compared to EX-BORNO + legume or ZATIP + legume intercrop. The variety ZATIP had the least land equivalent ratio in 2010 and 2011 and EX-BORNO for the combined mean (Table 9). The monetary advantage from the pearl millet variety intercrop was greater for SOSAT-C-88 in 2010 and ZATIP in 2011 and the combined mean. The values of monetary advantage range from ₦120,907.79 to ₦165,997.56 for SOSAT-C-88 and ₦137,993.22 to ₦158.682.78 for ZATIP compared to LACRI-9702-IC and EX-BORNO that had the lowest values that range between ₦78,585.56 and ₦91,303.59 for LACRI-9702-IC and ₦95,178.83 to ₦120,227.25 for

Table 7. Linear correlation coefficient (r) of millet agronomic parameters of four millet + legume intercrops and four pearl millet varieties, combined mean.

	Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	D50F															
2	GY/ha	0.02														
3	GYP	0.11	0.04													
4	HI	-0.50*	0.76**	0.66**												
5	LAH	0.21	0.78**	0.98**	0.58*											
6	NGPP	-0.64**	0.85**	0.67**	0.21	0.14										
7	NLSH	0.01	0.01	0.17	0.31	0.81**	0.03									
8	NPPH	0.05	0.92**	0.85*	0.03	0.02	0.86**	0.02								
9	NTLS9	0.33	0.23	0.73**	0.04	0.81**	0.70**	0.01	0.14							
10	PDH	0.25	0.14	0.11	0.81**	0.44	0.19	0.90**	0.03	0.11						
11	PHH	-0.66**	0.01	0.01	0.25	0.35	0.63**	0.21	0.13	0.21	0.30					
12	PLH	-0.79**	0.15	0.02	0.01	0.16	0.77**	0.02	0.62**	0.44	0.05	0.22				
13	PWH	0.32	0.11	0.13	0.14	-0.11	0.01	0.61*	0.26	0.55*	0.01	0.82**	0.15			
14	SYPP	0.05	0.01	0.02	0.01	0.23	0.02	0.02	0.02	0.15	0.16	0.15	0.05	0.03		
15	TSW	0.21	0.16	0.27	0.02	0.35	0.12	0.01	0.17	0.11	0.42	0.38	0.23	0.17	0.02	

*Significant (P < 0.05) **significant (p < 0.01), values without asterisk (s) have no significant linear correlation, DF = 14. 1. D50F = Days to 50% flowering 2.GY/ha=Grain yield kg/hectare 3.GYP = Grain yield /plant 4.HI = Harvest index 5.LAH = Leaf area 6.NGPP = Number of grains/panicle 7.NLSH = Number of leaves at harvest 8.NPPH = Number of panicle/plant 9.NTLS = Number of tillers /plant 10.PDH = Panicle diameter at harvest 11.PHH = Plant height at harvest 12.PLH = Panicle length at harvest 13. PWH = Panicle weight harvest 14.SYPP = Straw yield/ plant 15.TSW = One thousand seed weight.

EX-BORNO in both years and the combined mean.

DISCUSSION

Intercropping legumes with pearl millet had no much significant effect on panicle characters and other yield parameters. Growth resources: water, nutrients and light interception most likely affected the performance of the crop components. Reddy and Willey (1981) agreed that variation in rate of vegetative development, final canopy, and rooting characteristics for extraction of nutrients and water were some of the major factors identified for the success of intercrops. Dugje (2004) reported that presence of groundnut in the pearl millet intercropping reduced the number of fertile tillers, grain yield and harvest index. The response of pearl millet and legumes revealed that, both panicle characters and other yield parameters were greater for SOSAT-C-88 variety. The presence of the legumes in the intercropping systems with pearl millet reduced the performance of both pearl millet and the legumes components. Fussell and Serafani (1985) and Dugje and Odo (2006a) noted that, yield of intercropped pearl millet was less than that of sole millet due to greater plant density. Both ZATIP and EX-BORNO produced greater reproductive characters than LACRI-9702-IC. While SOSAT-C-88 produced greater reproductive characters than three varieties. The legumes perform well when it was grown in association with the LACRI-9702-IC and SOSAT-C-88 varieties with cowpea and groundnut which produced the highest yields. The shorter structure and less elaborate canopy of these varieties allowed more light penetration and subsequent interception by the legumes component understory (Ntare, 1989). ZATIP and EX-BORNO could not avail these complementarily relationships as they probably competed better for

Table 8. Effect of millet variety on legume grain yield (kg/ha), 100 grain weight and fodder yield (kg/ha) in 2010, 2011 and combined mean at Maiduguri.

Millet variety	Grain yield (kg/ha)	100 grain weight (g)	Fodder yield (kg/ha)
2010			
Legume + SOSAT-C-88	674.33	47.50	622.92
Legume + ZATIP	598.43	45.08	561.83
Legume + LACRI-9702-IC	681.17	49.25	632.42
Legume + EX-BORNO	626.00	46.08	604.08
SE (±)	33.92	2.76	73.75
LSD (0.05)	72.65	5.70	NS
2011			
Legume + SOSAT-C-88	581.83	49.91	520.08
Legume + ZATIP	500.42	43.9	370.58
Legume + LACRI-9702-IC	594.08	51.4	467.50
Legume + EX-BORNO	510.25	47.4	465.50
SE(±)	31.33	3.01	36.55
LSD (0.05)	64.68	NS	75.45
Combined mean			
Legume + SOSAT-C-88	620.46	48.71	571.50
Legume + ZATIP	556.25	44.81	466.21
Legume + LACRI-9702-IC	632.29	49.83	545.46
Legume + EX-BORNO	575.58	46.75	534.74
SE (±)	32.59	2.16	52.67
LSD (0.05)	NS	NS	NS

NS = Not significant. Values for 2010 and are pooled means of three replicates of four legumes and four pearl millet varieties while values for combined means are pooled means of three replicates of four legumes intercrop with four pearl millet varieties intercropped for the two years.

Table 9. Effects of pearl millet variety on relative competitive ability, land equivalent ratio and monetary advantage (₦) of pearl millet + legume intercrop at Maiduguri.

Millet variety + Legume	RCA millet	RCA legume	Total LER	Monetary advantage (₦)
2010				
SOSAT-C-88 + Legume	0.74	0.44	1.18	165,997.56
ZATIP + Legume	0.68	0.40	1.08	137,993.22
LACRI-972-IC + Legume	0.60	0.56	1.16	87,782.53
EX-BORNO + Legume	0.73	0.42	1.15	120,227.25
2011				
SOSAT-C-88 + Legume	0.70	0.65	1.35	120,907.79
ZATIP + Legume	0.69	0.43	1.12	158,682.78
LACRI-972-IC + legume	0.57	0.66	1.23	91,303.59
EX-BORNO + Legume	0.65	0.50	1.15	95,178.93
Combined mean				
SOSAT-C-88 + Legume	0.72	0.54	1.26	134,974.41
ZATIP + Legume	0.68	0.42	1.10	143,552.28
LACRI-972-IC + Legume	0.59	0.61	1.20	78,585.56
EX-BORNO + Legume	0.67	0.46	1.13	114,287.53

RCA = Relative Competitive Ability
LER = Land Equivalent Rati

light interception, thus inhibiting the growth and development in both space and time. The efficiency of pearl millet varietal intercropping in this study revealed near mutual co-operation between LACRI-9702-IC, SOSAT-C-88 and legumes in straw yield and between SOSAT-C-88 and cowpea in grain yield and cash return. If the objective is to obtain near 'full' yield of legume and near 'full' yield from pearl millet, then growing SOSAT-C-88 with cowpea as intercrops will be ideal in the Sudan Savanna of Northern Eastern Nigeria.

CONCLUSION

The varietal differences among pearl millet component showed that grain yield/hectare increased with increase in plant height, number of tillers/plant, leaf area and number of grains/panicle for SOSAT-C-88 and ZATIP varieties. Among the selected legumes, cowpea and groundnut intercrop produced greater number of leaf branches, pod yield/hectare and fodder yield/hectare when grown in association with pearl variety SOSAT-C-88 and LACRI-9702-IC. The low plant height, sparse canopy and early flowering of these varieties provided both spatial and temporal complementarities in resource use by the legume component. The low performance of bambaranut and Soybean provide the reciprocal response in the performance of the pearl millet component. The mutual relationships observed among agronomic parameters of pearl millet revealed that, grain yield/hectare increase with increase in leaf area, number of leaves/plant, number of tillers/plant, number of days to 50% flowering, panicle length, panicle diameter, panicle weight, grain weight, grain yield/plant and harvest index. The increase among the yield components was an evidence of reduced plant competition within the pearl millet and between the legume components.

The partial land equivalent ratios of pearl millet variety for grain yield were higher for SOSAT-C-88 + legume intercrop. Cash return was higher at SOSAT-C-88 + cowpea intercrop as indicated by the greater monetary advantage.

In this study, intercropping has shown superior biological and economic advantages for the realization of intercropping objectives in the Sudan Savanna. In terms of pearl millet varieties SOSAT-C-88 proved to be the best for intercropping with legumes as it significantly produced superior biological and economic advantages.

In terms of legumes, cowpea had the highest grain yield which was higher than other legumes intercropped with pearl millet. This suggests that SOSAT-C-88 + cowpea intercrop is ideal for both staple grain and cash return from pearl millet + legume intercropping system in the Sudan Savanna.

REFERENCES

Baker EFI (1978). Mixed cropping in Northern Nigeria. I.V. Extended trials with cereals and groundnut, Experimental Agriculture, 16: 361-369.

Burner DM (2003). Influence of alley crop environment on orchard grass and tall herbage. Agron. J. 95:1163-1171.

Dugje IY (2004). The performance of pearl millet varieties in mixture with groundnut in the Nigerian Sudan savanna. Samaru J. Agric. Res. 20:3-17.

Dugje IY, Odo PE (2006a). Variety and inter-row spacing influence on Direct Estimation of leaf area index of pearl millet. J. Sustain. Trop. Agric. Res. 18:27-32.

Food and Agriculture Organisation, FAO (2005). The world sorghum and millet economies. Facts, trends and outlook FAO Document Repository W 1808/E.

FPDD (2002). Fertilizer use and management practice for crop production in Nigeria. Fertilizer Procurement and Distribution Division, Federal Ministry of Agriculture and Rural Development, Abuja Nigeria. p. 47.

Ikeorgu JE (2003). Contribution of leguminous crops to nutrient availability and productivity of cowpea based systems. Niger. Agric. J. 14:216-301.

Mumilo K (2004). Sustainable dry land cropping in relation to soil productivity. FAO Soils Bullet. 72:16-18.

Norman DW (1975). Rationalizing mixed cropping under indigenous conditions in Northern parts of Nigeria. Samaru Res. Bullet. No. 205:16.

Ntare BR (1989). Evaluation of Cowpea Cultivars for intercropping with Pearl Millet in the Sahelian zone of West Africa. Fied Crops Res. 20:31-40.

Olufajo OO (2006). Sorghum and soybean intercropping as affected by cultivars and plant arrangement in a sub-humid tropical environment. Samaru J. Agric. Res. 12:3-4.

Reddy MS, Willey RW (1981). Growth and resource use studies in an intercrop of pearl millet and groundnut. Field Crops Res. 4:13-24.

Willey RW (1979). Intercropping- Its importance and research needs. Competition and yield advantages. Field Crop Abstracts, 32(2):1-10.

Fussell EA, Serafani WC (1985). Raising and sustaining productivity of small holder farming systems in the tropics. Field Crops Abstracts, 32:73-85.