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Performance of pearl millet [*Pennisetum glaucum (*L.) R. Br.] varieties intercropped with cowpea varieties as affected by planting dates in Nigerian Sudan savanna

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Abstract
Field experiments were conducted in 2015 and 2016 rainy seasons at the Teaching and Research Farm of the Department of Crop Production, University of Maiduguri, Maiduguri ($11^0$47N; $12^0$16E) to study the performance of pearl millet varieties (*Pennisetum glaucum*) (*L.*) R. Br.) intercropped with cowpea (Cowpea *Vigna unguiculata (L.)* Walp) varieties under different planting dates. The treatments consisted of three pearl millet varieties: ZATIP, SOSAT-C-88 and LACRI-9702-IC, two cowpea varieties: Borno Brown and SAMPEA 11 and four planting dates: 0 weeks after planting millet (WAPM), 1 WAPM, 2 WAPM and 3 WAPM. The experimental design was Split-Split plot with the pearl millet varieties allocated to the main plots, cowpea varieties assigned to the sub-plots and planting date assigned to the sub- sub plots in 1:1 alternate row arrangement, and replicated three times. The results showed that in 2015, 2016 and the combined mean, number of tillers/plants, harvest index and grain yield/hectare were significantly greater for SOSAT-C-88 than ZATIP or LACRI-9702-IC. Plant height, panicle were significantly greater for ZATIP, while, yield/hectare were significantly greater for Borno Brown than SAMPEA 11 variety. Delaying planting date by three weeks after planting the millet component decreased grain yield and fodder yield in cowpea. The land equivalent ratio of pearl millet and cowpea variety showed that, higher partial land equivalent ratio were produced by SOSAT-C-88 + Borno Brown. The partial land equivalent ratio of pearl millet variety for straw yield and grain yield advantages were higher for LACRI-9702-IC + cowpea intercrop. From this study, the millet variety SOSAT-C-88 intercropped with cowpea variety Borno Brown is ideal for both staple grain and cash returns from the system in the Sudan Savanna of Nigeria.

Keywords: vigna, intercrop, sampea, savanna, wasm

Introduction
In West Africa, cereals such as millet and sorghum are traditionally intercropped with cowpea. Pearl millet + cowpea intercrop has most frequently been used in multiple cropping research due to their ability to efficiently use environmental resources (Subbarao *et el*., 2006) [25]. Intercropping pearl millet with cowpea is a predominant feature in cropping systems as a means of maximizing the use of limited lands and also for food security to the subsistence farmers (Bhupinder *et al.*, 2013) [3]. Previous studies have indicated that millet + cowpea combination is an important cropping system in the Sudan savanna of Nigeria (Ntare, 1990) [12]. Under the indigenous system, farmers use local varieties of pearl millet which are tall, late maturing and photoperiod sensitive, producing panicle at the end of the rainy season (Remison, 2005a). Studies have shown that improving the productivity of millet + cowpea intercrop lies in improving the performance of the cowpea component which among others is the choice of the appropriate genotype (Ntare and Williams, 1992, Reddy and Oumara, 1985) [13, 20].

When choosing crop combinations specific variety characteristics need to be considered in conjunction with important management practices (Anaso *et al.*, 1998, Dugje and Odo, 2003) [2, 5]. Varietal selection for improving intercrop performance is dependent on the objectives of the system especially in the semi-arid zone of Nigeria. Varietal selection of pearl millet and planting configuration of legumes combination are important management practices that may avail desirable grain yield (Smith and Francis, 1986; Dugje and Odo, 2006a) [6]. An important consideration in millet + legume intercropping is the choice of appropriate crop varieties. In millet + cowpea intercropping in the Sudan Savanna, early maturing improved millet varieties have been shown to yield higher grains than late maturing types (Agboola and Eniola, 2000) [1]. Olufajo and Singh (2009) [14], reported that available growth resources over time and space in early improved millet variety account for the success of both vegetative and reproductive characters of pearl millet. Mohammed *et al.*, 2008 [11] reported that, performance of pearl millet in mixture with cowpea is somewhat complex because the maximum yield to be obtained will depend on many factors including varieties, cropping systems and environmental conditions.

Pearl Millet *[Pennisetum glaucum* (L.) R. Br.] is widely cultivated with 35.6 million hectares devoted to the crop worldwide (Spencer and Sivakumar, 2009). It is one of the most important cereal crop with 12 million hectares sown and 9.6 million tons produced annually in West Africa including Nigeria, Niger, Mali, Burkina-Faso, and Senegal. Mean grain yield of millet in the world and Africa are 844 and 902 kg/hectare, respectively (FAO, 2017) [8]. Cowpea [*Vigna unguiculata* (L.) Walp] is an important food legume and versatile crop cultivated in areas between latitude 35° N and 35° S of the equator, covering Asia and Oceanic, the Middle East, Southern Europe, Africa, Central and Southern America (Ferry, 2009) [9]. In the Sudan Savanna area of Nigeria, millet and cowpea are the second most

important cereal and legume crops (Ikwelle, 2005) [2] after sorghum and groundnut. Some 8 million hectares of cowpea are grown in West Africa, especially in Nigeria, Burkina Faso, Mali, and Senegal. Pearl millet + cowpea intercrop is one of the commonest combination of crops in Semi-arid Zone of Nigeria and it is typical of many combinations throughout the world where a rapid – growing, early maturing crop is grown with a slower growing, and late maturing crop.

Materials and Methods

The experiment was conducted during 2015 and 2016 rain-fed cropping seasons at the Teaching and Research Farm, Department of Crop Production Faculty of Agriculture, University of Maiduguri. The experimental site was located between latitude $11^0 47^1$N and 56 00^1N, and longitude $03^0 12^1$ and 16^0E and altitude of 345 m above sea level, in the northern fringes of the Sudan savanna belt of Nigeria. The treatments consisted of three improved pearl millet varieties: (ZATIP, SOSAT-C-88 and LACRI-9702-IC) intercropped with two cowpea varieties: (Borno Brown and SAMPEA 11) and four planting dates: (simultaneous, one week, two weeks and three weeks after planting the millet WASM) in 2015 and 2016. The pearl millet was grown at (3) three plants/stand, while the cowpea were grown at 2 plants/stand (Dugje *et al*., 2009) [7]. The experimental design was split-split plot with pearl millet varieties assigned to the main-plot, cowpea varieties assigned to the sub-plot and planting date assigned to the sub-sub plots, which were replicated three times. The sub-plot size was 3.0 x 5.0 m (15.0 m^2). An alley of 2.0 m was allowed between the replicates, while 1.0 m and 0.50 m alley was allowed between the main plots and sub-plot, respectively. The pearl millet varieties were sown at 90 cm x 50 cm on 5th July each year while each cowpea variety was intercropped into the pearl millet at a distance 45cm from the pearl millet row and 50cm within the row at each planting dates: simultaneous planting date (0), 1 week after planting date, 2 weeks after planting date, 3 weeks after planting date and 4 Weeks after planting millet (WAPM).The cowpea varieties were planted into the pearl millet variety**.** Data collected from the experiment were subjected to two-way Analysis of variance (ANOVA). Both the year wise and combined years' analysis was run using a Computer Software, Statistix Version 8.0 (Statistix, 2005) [24]. Differences between treatments means were compared using Duncan's multiple Range Text (DMRT) at 5% level of probability.

Results

The effect of pearl millet variety, cowpea variety, planting date and their interaction on pearl millet plant height at different ages in 2015 showed that, there was no significant effect of millet variety on the pearl millet plant height at 6 WAS (Table 1). Pearl millet plant height was relatively taller for ZATIP and SOSAT-C- 88 compared to LACRI-9702- IC at 6 WAS. At 9 WAS and harvest ZATIP variety maintained its superiority in plant heights which were significantly (P<0.05) taller than SOSAT-C-88 and LACRI-9702-IC. Among the pearl millet variety lower plant height was produced by LACRI- 9702- IC compared to SOSAT-C-88 and ZATIP (Table 1). Among the two cowpea variety intercrops, greater pearl millet plant height was observed when the later was grown in association with cowpea variety SAMPEA 11 than Borno Brown at 6 WAS in 2015 cropping season.

Table 1: Effects of millet variety, cowpea variety, planting date and their interaction on millet plant height at 6, 9 Weeks after sowing (WAS) and harvest at Maiduguri 2015, 2016 and combined mean

Treatment	6 WAS			9 WAS			Harvest		
	2015	2016	Comb	2015	2016	Comb	2015	2016	Comb
Millet Variety (M)									
ZATIP	96.04a	94.75a	95.40a	177.16a	169.67a	173.42a	265.29a	257.50a	261.40a
SOSAT-C-88	81.83a	91.33b	8658a	156.75b	166.04b	161.04a	228.03b	252.83ab	240.41a
LACRI-9702-IC	79.01a	86.25c	82.63a	152.25c	160.70c	156.84a	202.14c	249.62c	226.01a
SE (±)	0.82	1.45	0.93	1.02	2.11	0.67	1.23	3.80	1.46
Cowpea Variety (C)									
Borno Brown	85.97b	93.41a	89.69a	159.52b	162.69a	161.71a	232.58b	263.25a	247.90a
SAMPEA 11	95.31a	99.47a	97.39a	161.52a	168.91a	165.22a	237.27a	293.38a	265.32a
SE (±)	0.67	1.18	0.76	0.72	1.71	0.55	1.00	3.10	1.19
Planting Date (P)									
0WAPM	79.55a	86.50a	83.02d	155.28a	159.22a	157.21c	224.72a	244.27a	234.95c
1WAPM	81.92a	90.11a	86.02c	157.13a	162.66a	159.90c	235.72a	248.11a	241.92b
2WAPM	85.72a	93.55a	89.64b	159.33a	168.72a	164.03b	245.38a	254.11a	249.75b
3WAPM	87.55a	95.61a	91.55a	162.72a	172.61a	167.66a	251.75a	265.77a	258.76a
SE (±)	0.95	1.67	1.08	1.25	2.43	0.78	1.42	4.38	1.68
Interaction									
M x C	*	*	NS	*	*	*	*	**	*
C x P	NS	NS	NS	NS	NS	NS	*	*	*
M x P	NS	NS	NS	*	NS	NS	**	*	*
M x C x P	NS	NS	NS	**	*	NS	*	*	**

NS= Not significant, *= Significant (P<0.05), **= Significant (P<0.01), Comb= Combined and WAPM= Weeks after planting millet.
Means followed by the same letter in a column are not significantly different according to Duncan's Multiple Range Test (P<0.05). Values for 2015 and 2016 are pooled means of three replications, while values for combined means are pooled means of three replications for the two years.

Similar trend was observed at 9 WAS when pearl millet plant height was significantly (P<0.05) taller when grown in association with the cowpea variety SAMPEA 11 than when intercropped with Borno Brown. There was no significant effect

of planting date on the pearl millet plant height, however, relatively taller plant height was produced at 3 weeks after planting millet (WAPM) compared to the other planting dates. The interaction of millet variety x cowpea variety (M x C) was significant at 6 and 9 WAS and at harvest. Also, the interaction of cowpea variety x planting date (C x P), millet variety x planting date (M x P) and the three-way interaction between millet variety x cowpea variety x planting date (M x C x P) were significant at harvest in the 2015. In 2016, significantly (P<0.05) greater plant heights for pearl millet were produced by ZATIP and SOSAT-C-88 compared to LACRI-9702-IC at 6, 9 WAS and at harvest (Table 1). There was no significant effect of cowpea variety on pearl millet plant height at 6, 9 WAS and at harvest in 2016. Relatively taller plant height was observed for the pearl millet when grown in association with SAMPEA 11 compared to Borno Brown (Table 1). Taller plant height was produced at 3 WAPM compared to 0 WAPM or 1 WAPM in 2016. The interaction of millet variety x cowpea variety was significant at 6, 9 WAS and at harvest. The interaction of cowpea variety x planting date, millet variety x planting date, and millet variety x cowpea variety x planting date were significant at harvest in 2016. For the combined mean, plant height of pearl millet was not significantly (P>0.05) affected by the millet variety and cowpea variety at each growth stage. However at 6, 9 WAS and harvest pearl millet variety ZATIP relatively produced taller plant heights compared to SOSAT-C-88 or LACRI-9702-IC. LACRI-9702-IC produced relatively shorter plant height at all the growth stages for the combined mean. Planting cowpea at 2 or 3 WAPM significantly produced (P<0.05) taller plants compared to 0 or 1 WAPM at 6, 9 WAS and at harvest for the combined mean. There was no significant millet variety x cowpea variety interaction at 6 WAS, but the interaction was significant at 9 WAS and at harvest for the combined mean. Millet variety x cowpea variety, cowpea variety x planting date and millet variety x planting date interactions were significant at harvest. Similarly, the three – way interaction of millet variety x cowpea variety x planting date was significant at harvest for the combined mean (Table 1).

The interaction between millet variety x cowpea variety on millet plant height at different ages were statistically significant in 2015, 2016 and the combined mean (Table 2). In 2015 at 6, 9WAS and harvest, the variety ZATIP x Borno Brown interaction significantly (P<0.05) produced the tallest plants. LACRI-9702-IC x SAMPEA 11 interaction significantly (P<0.05) produced shorter plants than the SOSAT-C-88. In 2016, the interaction between ZATIP x SAMPEA 11 produced significantly (P<0.01) superior plant height at 6 and 9WAS. Also ZATIP x Borno Brown had superior (P<0.01) plant heights at 6 and 9WAS compared to LACRI-9702-IC x SAMPEA 11or Borno Brown at all the ages of the pearl millet plant height. The plant height of SOSAT-C-88 x Borno Brown or SAMPEA 11 were taller than the LACRI-9702-IC (Table 2). For the combined mean at 9 WAS and at harvest, ZATIP x Borno Brown or SAMPEA 11 significantly (P<0.001) produced the tallest plants compared to the other treatments. Lower pearl millet plant height was produced by LACRI-9702-IC irrespective of the cowpea variety interaction. Number of tillers per plant in millet variety was not influenced by cowpea variety or planting date in both the years and the combined mean (Table 3). Similarly, there was significant difference among the pearl millet varieties in the expression of number of tillers per plant at 3,6 and 9 WAS in 2015. Number of tillers/plants was slightly higher for SOSAT-C-88 compared to ZATIP and LACRI-9702-IC that had lower number of tiller per plant at 3, 6 and 9 WAS. Values were greater for SOSAT-C-88, while ZATIP and LACRI had lower number of tillers per plant. Number of tillers per plant was slightly higher when pearl millet was grown in association with cowpea variety SAMPEA 11 than Borno Brown at 3, 6, and 9 WAS in 2015.

Table 2: Interaction of Millet Variety and Cowpea Variety on millet plant height at 6, 9 WAS and Harvest 2015, 2016 and combined mean at Maiduguri

Millet variety x Cowpea variety	2015 2016 Combined							
	6 WAS	9 WAS	Harvest	6 WAS	9 WAS	Harvest	9 WAS	Harvest
ZATIP x Borno Brown	97.75a	179.92a	267.75a	99.66a	175.33a	281.91a	177.63a	274.83a
ZATIP x SAMPEA 11	94.33b	174.41ab	262.83b	96.58a	174.50a	274.25a	174.46b	266.54a
SOSAT -C -88 x Borno Brown	82.16c	162.33b	225.58d	86.08b	173.83a	277.44a	168.08.c	243.00b
SOSAT -C- 88 x SAMPEA 11	81.92c	153.17c	230.58c	87.00b	158.58b	237.58b	155.87c	251.51b
LACRI -9702- IC x Borno Brown	78.00d	153.50 c	204.47e	81.66c	157.58b	231.96b	155.54d	218.22c
LACRI-9702 –IC x SAMPEA 11	79.67cd	151.67c	200.00f	84.83c	155.00b	218.33c	153.34e	209.17c
SE (±)	1.66	1.25	1.74	2.05	2.98	5.37	0.95	1.51

Means followed by the same letter in a column are not significantly different according to Duncan's Multiple Range Test (P<0.05). Values for 2015 and 2016 are pooled means of three replications, while values for combined means are pooled means of three replications for the two years.

The results showed that, planting date had no significant effect on millet number of tillers per plant at 3, 6 and 9 WAS in 2015. Also number of tillers were greater for millet at 3 WAPM or 2 WAPM compared to the two planting dates. Pearl millet produced lower number of the tillers when cowpea was introduced at the 0 WAPM at 3, 6 and 9 WAS in 2015 cropping season (Table 3). There was significant interaction for number of tillers per plant at 3, 6 and 9 WAS during the 2015 cropping season. In 2016, number of tillers was greater for SOSAT-C-88, while the ZATIP and LACRI-9702 IC produced lower number of tillers per plant at 3, 6 and 9 WAS when averaged over both the years. Number of tillers per plant was slightly higher when the pearl millet was grown in association cowpea variety SAMPEA 11 compared to Borno Brown at 3, 6, and 9 WAS in 2016. Tillers was higher when the cowpea variety planted at 3 WAPM compared to 0 or 1 WAPM at 3, 6 and 9 WAPM during 2016 cropping season. Interaction effect between millet variety x cowpea variety x planting date on millet number of tillers were statistically significant at 3, 6 and 9 WAS in 2016. For the combined mean, cowpea variety and planting date did not influence pearl millet number of tillers per plant at 3, 6 and 9 WAS for the combined mean. SOSAT-C- 88 produced

significantly higher number of tillers per plant compared to ZATIP or LACRI-8702-IC variety. Relatively lower tillers were produced at ZATIP and LACRI-9702-IC at 3, 6, and 9 WAS during the combined mean. Among the cowpea variety SAMPEA 11 produced greater number of tillers for the pearl millet variety compared to Borno Brown variety. that produced lower tillers for the pearl millet. When the cowpea was planted at 3 WAPM pearl millet resulted to higher number of tillers in the pearl millet variety compared to either 0 or 1 WASM at 3, 6 and 9 WAS for the combined mean. Similarly, there was significant interaction between the millet variety x cowpea variety, cowpea variety x planting date, millet variety x planting date and the three-way interaction between millet variety x cowpea variety x planting date at 3, 6 and 9 WAS on tillers for the combined mean (Table 3)

Table 3: Effects of Millet variety, cowpea variety, planting date and their interaction on millet varieties number of tillers /pants at 3, 6 and 9 WAS at Maiduguri in 2015, 2016 and combined mean

Treatment	3 WAS			6 WAS			9 WAS		
	2015	2016	Combined	2015	2016	Combined	2015	2016	Combined
Millet Variety (M)									
ZATIP	1.44b	1.62c	1.63b	2.31c	3.01b	2.29c	3.29c	3.67b	3.44c
SOSAT-C-88	2.27a	2.17a	2.23a	3.29a	3.17a	3.23a	4.34a	4.69a	4.45a
LACRI-9702-IC	1.26c	1.35b	1.49c	2.35b	2.60c	2.43b	3.79b	3.66c	3.73b
SE (±)	0.07	0.09	0.05	0.06	0.08	0.06	0.06	0.08	0.04
Cowpea Variety (C)									
Borno Brown	1.61b	1.77b	1.69b	2.63b	3.22a	2.65b	3.52b	3.66b	3.59b
SAMPEA 11	1.79a	1.89a	1.84a	3.66a	3.10b	3.39a	3.99a	3.97a	3.98a
SE (±)	0.05	0.07	0.04	0.05	0.07	0.04	0.08	0.06	0.03
Planting date (P)									
0WAPM	1.63c	1.55c	1.59d	2.49d	2.53d	2.51d	3.63d	3.98b	3.80d
1WAPM	1.64b	1.78b	1.71c	2.67c	2.60c	2.64c	3.78c	3.93c	3.85c
2WAPM	1.67a	1.88b	1.78b	2.68b	2.69b	2.68b	3.81b	3.98b	3.90b
3WAPM	1.68a	1.94a	1.81a	2.74a	2.81a	2.78a	3.93a	4.08a	4.00a
SE (±)	0.33	0.33	0.20	0.23	0.29	0.21	0.23	0.28	0.16
Interaction									
M x C	NS	*	NS	*	NS	NS	NS	NS	*
C x P	**	NS	*	NS	NS	**	NS	*	NS
M x P	NS	*	**	NS	**	NS	*	NS	*
M x C x P	*	NS	NS	*	NS	NS	**	*	*

NS= Not significant, WAPM = Weeks after planting millet Means followed by the same letter in a column are not significantly different according to Duncan's Multiple Range Test (P<0.05). Values for 2016 are pooled means of three replications, while values for combined means are pooled means of three replications for the two years.

Pearl millet grain yield were generally greater in 2016 than 2015 (Table 4). The effect of pearl millet variety showed that, grain yield per hectare was significantly (P<0.05) greater for SOSAT-C-88 than for ZATIP or LACRI-9702-IC in 2015. The promising varieties in 2015 were SOSAT-C-88 and LACRI-9702-1C. There was, no significant effect of cowpea varieties on millet grain yield in 2015 cropping season. Millet intercropped with SAMPEA 11 produced relatively higher grain yield compared to Borno Brown. Planting date significantly (P<0.05) influenced grain yield of millet in 2015 cropping season. Planting 3 or 2 WAPM significantly (P<0.05) realized greater grain yield for pearl millet than simultaneous planting of the millet crop component In 2016 cropping season, pearl millet grain yield was significantly (P<0.05) higher for SOSAT-C-88 compared to LACRI -9702-1C or ZATIP. The most promising variety after SOSAT-C-88 was LACRI-9702-1C, which produced significantly greater in grain yield compared to ZATIP variety. There was relative increase in millet grain yield in 2016 when millet was intercropped with SAMPEA 11 compared to Borno Brown. Pearl millet grown with cowpea at 3 WAPM produced relatively higher millet grain yield compared to the three planting date. The 0 WAPM produced lowest millet grain yield compared to 1 WAPM and 2 WAPM. For the combined mean, grain yield per hectare was significantly (P<0.05) greater for SOSAT-C-88 compared to ZATIP. However values for LACRI-9702-IC was significantly lower than SOSAT-C-88 but greater than ZATIP (Table 4). Pearl millet grown in association with Borno Brown produced relatively lower millet grain yield compared to SAMPEA 11 in the combined mean. Intercropping cowpea 3 WAPM produced significantly (P<0.05) greater millet grain yield compared to 2 and 1 WAPM. Millet produced lower grain yield at simultaneous planting with (0 WAPM) compared to 3 WAPM. The interaction of millet variety x cowpea variety was statistically significant for the combined mean (Table 4).

Grain weight significantly (P<0.001) differed among the pearl millet varieties in 2015 (Table 4). The variety LACRI-9702-IC significantly (P<0.001) produced superior 1000 grain weight, on the other hand, ZATIP produced significantly lower grain weight compared to SOSAT -C-88 variety. Slightly higher 1000 grain weight was observed for millet intercropped with SAMPEA 11 compared to Borno Brown. planting date had no significant effect on millet 1000 grain weight in 2015. Relatively higher gra in weight was produced at 3 WAPM compared to 0, 1 or 2 WAPM (Table 4). Although there was no significant difference, lower grain weight for the pearl millet was produced by ZATIP in 2016. The

Table 4: Effects of millet variety, cowpea variety, planting date and their interactions on millet grain yield (kg/ha), 1000 grain weight, straw yield and harvest index at Maiduguri 2015, 2016 and combined mean

Treatment	Grain yield kg/ha			1000 grain weight (g)			Straw yield/plant (g)			Harvest index (%)		
	2015	2016	Comb	2015	2016	Comb	2015	2016	Comb	2015	2016	Comb
Millet Variety (M)												
ZATIP	1614.08c	3429.31c	2521.69c	7.47c	9.60a	8.54a	55.30b	60.64b	56.92b	47.69b	36.46c	43.28a
SOSAT-C-88	3444.29a	5299.70a	4371.99a	9.39b	10.67a	10.03a	62.33a	74.80a	68.52a	59.99a	65.88a	62.93a
LACRI-9702-IC	2464.75b	4688.22b	3576.48b	10.17a	10.83a	10.50a	47.06c	55.82c	51.44c	36.46c	47.69b	44.44a
SE (±)	66.89	147.54	83.67	0.09	0.19	0.07	0.63	1.43	0.61	0.70	0.68	0.45
Cowpea Variety (C)												
Borno Brown	2506.78a	4375.44a	3441.11a	9.09a	9.89a	9.49a	54.01a	62.56a	58.26a	42.11b	52.45a	47.28a
SAMPEA 11	2808.64a	4569.41a	3689.03a	9.93a	10.17a	10.05a	54.45a	68.88a	61.67a	46.83a	58.13a	52.48a
SE (±)	54.62	120.47	74.40	0.08	0.15	0.06	0.51	1.17	0.50	0.57	0.55	0.36
Planting Date (P)												
0WAPM	2401.67d	4387.81a	3394.74c	9.01a	9.84a	9.43a	51.93a	62.17a	57.05a	45.81a	50.86a	48.33a
1WAPM	2419.78c	4465.23a	3442.51b	9.04a	9.98a	9.51a	53.51a	62.45a	57.98a	46.35a	52.07a	49.21a
2WAPM	2499.79b	4474.91a	3487.31b	9.07a	10.06a	9.61a	54.02a	65.50a	59.76a	46.57a	52.76a	49.67a
3WAPM	2629.56a	4561.60a	3595.58a	9.09a	10.26a	9.68a	54.97a	65.77a	60.31a	46.78a	53.52a	50.15a
SE (±)	77.34	170.36	102.39	0.11	0.22a	0.13	0.73	1.65	0.71	0.81	0.78	0.51
Interaction												
M x C	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	*	NS
C x P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M x P	NS	NS	NS	NS	NS	*	NS	NS	**	NS	NS	NS
M x C x P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS= Not significant, *= Significant (P<0.05), **= Significant (P<0.01), Comb= Combined and WAPM= Weeks after planting millet.
Means followed by the same letter in a column are not significantly different according to Duncan's Multiple Range Test (P<0.05). Values for 2015 and 2016 are pooled means of three replications, while values for combined means are pooled means of three replications for the two years.

Variety LACRI-9702-IC produced relatively heavier 1000 grain weight than the other varieties. Pearl millet grown in mixture with cowpea variety SAMPEA 11 produced heavier grains than Borno Brown. Also planting date produced higher millet grain weight at 2 and 3 WAPM compared to 1 or 0 WAPM. For the combined mean, pearl millet variety ZATIP relatively produced lower grain weight compared to SOSAT-C-88 or LACRI-9702-IC. Relatively lower 1000 grain weight for the pearl millet was observed in association with Borno Brown compared to SAMPEA 11 in the combined mean. Similarly planting cowpea 3 WAPM produced higher grain weight than the other planting dates. Lower grain weight was observed at simultaneous planting of cowpea with millet (0 WAPM). The interaction of millet variety x planting date on millet 1000 grain weight was statistically significant (P<0.05) in the combined mean (Table 4). There was significant difference among the pearl millet varieties on straw yield/plant in 2015 cropping season. SOSAT-C-88 produced significantly (P<0.05) higher straw yield/plant compared to ZATIP. The highest straw yield was observed for SOSAT-C-88. No significant effect of cowpea variety on the straw yield of pearl millet was observed. Millet intercropped with SAMPEA 11 relatively produced higher straw yield per plant compared to Borno Brown. Similarly, there was no significant effect of the planting date on the millet straw yield. Among the planting dates millet straw yield was relatively higher at the 3 or 2 WAPM compared to 0 or 1 WAPM. Millet grown simultaneously with cowpea (0 WAPM) and 1WAPM produced relatively lower straw yield in 2015 cropping season. In 2016, similar trends to 2015 was observed when SOSAT-C-88 produced significantly (P<0.01) greater straw yield/plant compared to the other varieties. ZATIP produced significantly (P<0.01) greater straw yield than LACRI-9702-IC. Also pearl millet intercropped with Borno Brown produced relatively lower straw yield compared to SAMPEA 11 variety, Lower straw yield was produced at the 0 WAPM compared to 1, 2 and 3 WAPM planting dates. Similarly, 3 WAPM produced higher straw yield compared to 0 WAPM 2016 cropping season. The results for the combined mean of the two cropping seasons showed that, pearl millet variety SOSAT-C-88 produced significantly (P<0.05) greater straw yield compared to ZATIP variety. The variety LACRI-9702-IC produced significantly (P<0.05) the lowest straw yield than ZATIP or SOSAT-C-88. Pearl millet grown in association with SAMPEA 11 produced higher straw yield compared to Borno Brown in the combined mean. There was no significant effect of planting date on pearl millet straw yield per plant, however, relatively greater straw yield was observed at 3 WAPM compared to 2 WAPM. Among the planting dates, 0 WAPM produced relatively lower straw yield compared to other planting date. There was significant difference among the pearl millet varieties on pearl millet harvest index (Table 4). SOSAT-C-88 significantly (P<0.01) produced greater harvest index than, ZATIP or LACRI-9702-IC. However, there was no significant effect of cowpea varieties on pearl millet harvest index in 2015 cropping season. Higher harvest index was observed for pearl millet grown in association with SAMPEA 11 than Borno Brown. Relatively higher harvest index for pearl millet was produced at the 3 or 2 WAPM compared to 0 or 1 WAPM. The lower millet harvest index was produced at 0 WAPM in 2015 cropping season. There was significant difference among the pearl millet varieties with ZATIP producing lower harvest index than SOSAT-C- 88 or LACRI-9702-IC in 2016 cropping season. However, harvest index was significantly (P<0.01) greater for SOSAT-C-88 compared to LACRI-9702-IC (Table 4). There was no significant effect of cowpea variety on millet harvest index in 2016, however, relatively higher harvest index was produced in association with SAMPEA 11 compared to Borno Brown. Also,

higher harvest index was observed at 3 WAPM compared to 2 WAPM sowing date. The 0 WAPM produced lower harvest index when compared to 1 WAPM. There was no significant difference in harvest index, among the pearl millet varieties in the combined mean. SOSAT-C-88 produced relatively higher harvest index compared to LACRI-9702-IC or ZATIP. Relatively higher millet harvest index was observed when millet was intercropped with cowpea variety SAMPEA 11 than Borno Brown. The effect of planting date showed that, 3 WASM produced higher harvest index compared to 0, 1 or 2 WASM.

The relative competitive ability was higher for SOSAT-C-88 than either of the two cowpea varieties in 2015 (Table 5). The situation was similar in 2016, when SOSAT-C-88 had higher competitive abilities compared to cowpea varieties. For the combined mean, the relative competitive ability was also higher for SOSAT-C-88 compared to ZATIP intercrop with the cowpea components. In similar trend with cowpea varieties on relative competitive ability, Borno Brown had higher competitive ability compared to ZATIP in 2015 and for the combined mean. The land equivalent ratio of pearl millet variety + cowpea variety was higher for SOSAT-C-88 in combination with Borno Brown intercrop compared to other treatments in 2015, 2016 and the combined mean (Table 5). Similarly, in both years LACRI-9702-IC + cowpea intercrop had greater land equivalent ratio compared to ZATIP + cowpea intercrop that had lower land equivalent ratio in 2015, 2016 and the combined mean.

The monetary advantage from the pearl millet variety + cowpea variety intercrop was greater for SOSAT-C-88 in combination with cowpea variety SAMPEA 11 in 2015 and the combined mean while SOSAT-C-88 and Borno Brown had greater advantage in 2016 (Table 5) The values of monetary advantage ranged from N304,344.76 to N 986,223.44 for SOSAT-C-88 and N227,506.31 to N905,411.91 for LACRI-9702-IC compared to ZATIP that had lower values that ranged between N 266,301.22 to N793,421.80 in both the years and the acombined mean.

Table 5: Effects of intercropping on relative competitive ability, land equivalent ratio (LER) and monetary advantage (N) of pearl millet variety + cowpea variety in 2015, 2016 cropping seasons and the combined mean at Maiduguri

Intercrop System	RCA Millet	RCA Cowpea	Total LER	Monetary Advantage (N)
2015				
ZATIP + Borno Brown	0.54	0.90	1.44	279,245.22
SOSAT-C-88 +SAMPEA 11	0.93	0.82	1.75	779,467.26
LACRI-9702-IC + Borno Brown	0.75	0.90	1.65	636,966.50
ZATIP + IT 89 KD – 288	0.54	0.82	1.36	266,301.22
SOSAT-C-88 + Borno Brown	0.93	0.90	1.83	906,571.63
LACRI-9702-IC +SAMPEA 11	0.75	0.82	1.57	327,506.31
2016				
ZATIP + Borno Brown	0.80	0.71	1.51	239,721.81
SOSAT-C-88 +SAMPEA 11	0.90	0.57	1.47	604,344.76
LACRI-9702-IC + Borno Brown	0.88	0.71	1.59	702,411.91
ZATIP + SAMPEA 11	0.80	0.57	1.37	393,421.80
SOSAT-C-88 + Borno Brown	0.90	0.71	1.61	956.223.44
LACRI-9702-IC +SAMPEA 11	0.88	0.57	1.45	462,566.10
Combined mean				
ZATIP + Borno Brown	0.67	0.81	1.48	259,473.46
SOSAT-C-88 +SAMPEA 11	0.92	0.70	1.62	691,906.01
LACRI-9702-IC + Borno Brown	0.82	0.81	1.63	669,689.20
ZATIP + SAMPEA 11	0.67	0.70	1.37	329,061.46
SOSAT-C-88 + Borno Brown	0.92	0.81	1.73	931,397.53
LACRI-9702-IC +SAMPEA 11	0.82	0.70	1.52	336,269.76

RCA = Relative Competitive Ability, LER = Land Equivalent Ratio

Discussion

Intercropping cowpea with pearl millet had no significant effect on plant height, number of leaves/plants, leaf area, number of tiller/plant and days to 50% flowering in both the years and combined analysis. However, sole pearl millet crop, generally expressed superior vegetative characters including, plant height, number of leaves, leaf area, number of tiller/plants, panicle characters and harvest index than millet grown in intercropping with cowpea. The presence of cowpea in the intercropping system reduced the performance of the development characters of pearl millet as the growth resources: nutrients and water most likely affected the performance of the crop components. Reddy and Willey (1981) [19] agreed that variation in rate of vegetative development, final canopy, plant height and rooting characteristics for extraction of nutrients and water were some of the major factors identified for the success of intercrops. Dugje, (2004) [6] reported that presence of groundnut in the pearl millet intercropping reduced the number of fertile tillers, grain yield and harvest index. Low yields was more pronounced in pearl millet variety ZATIP, these low yields and associated variations can be attributed to year. Although the 2015 cropping season had low precipitation, the few torrential rainy days were accumulated between July and August and by the end of September the soil started to dry out due to high temperatures compared to 2016 cropping seasons. Ports. (1990) reported co efficient of variation from fields plots for corn and soybean yields ranging from 2 to 19 % over 10 studies years. SOSAT-C-88 and LACRI-9702-IC had greater vegetative and reproductive characters and flowered earlier than ZATIP variety. The greater photosynthetic capacity of leaf area enhanced greater number of tillers/plant and grain yield. SOSAT-C-88 variety produced greater vegetative and reproductive characters than LACRI-9702-IC. This was shown

by greater number of fertile tillers, leaf area, panicle diameter, panicle weight grain yield / plant and number of grains /panicles. Pal and Murari, (1985) [16] reported that the presence of intrinsic genetic character and leaf area were the major determinants of growth and yield components of pearl millet under intercropping. ZATIP variety had the least elaborate vegetative character and produced lower number of tillers/plant and grain yield. The lower vegetative character of these varieties limited grain yield due to minimal dominance and complementary. Olufajo and Singh (2008) [11], agreed that positive available growth resources over time and space in pearl millet + cowpea intercropping system as the major success of both vegetative and reproductive character of pearl millet. Oluwasimire (2006) reported that improving productivity of pear millet + cowpea intercrop lies in the performance of appropriate variety. Bassi, and Dugje (2016) [5] reported that increase in number of tillers/plants contributed to increase in leaf area, panicle characteristics and grain yield /hectare. The panicle characteristics, grain yield /hectare, number of grains/panicle and harvest index was not favorable for ZATIP intercropped with Cowpea. The lower vegetative and reproductive capacity was the major factor responsible for limited grain yield. Dugje (2004) [4] reported that pearl millet yield component is only reduced if the legume is more intimately mixed with pearl millet intercrop as it may increase root ramification per unit area of the soil occupied by the two crops which enhanced greater extraction of water and competition for nutrients. Singh *et al*. (2004) [21] reported that, grain yield/ hectare is determined during grain filling period and higher values indicate successful capture of growth resources during the period.

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