FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 9 No. 5, May, 2025, pp 1 - 13
DOI: https://doi.org/10.33003/fjs-2025-0905-3632

PERFORMANCE OF GROUNDNUT VARIETIES AND MAIZE INTRODUCTION DATES IN INTERCROPPING AT MAKURDI

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ABSTRACT

The two year field experiment was conducted in the same location at the teaching and research farm, Joseph SarwuanTarka University, Makurdi, Benue State located in the Southern Guinea Savannah of Nigeria.to evaluate the Performance ofthree varieties of groundnut in relation to dates of introduction of maize in groundnut-maize intercrop. The aim of the study was to determine the appropriate time of planting maize in groundnut-maize intercrop and to evaluate the economic benefits of intercropping maize at different dates. The experiment was conducted in a 3 x 4 factorial arrangement laid out as a randomised complete block design (RCBD) replicated three times.The mixed crop treatments consisted of three groundnut varieties (SAMNUT 24,SAMNUT25 and SAMNUT26) and three dates of introduction of maize in groundnut (Simultaneous,2WAP and 4WAP), Sole maize and sole groundnut were used as controls.The results obtained showed that the seed yield of groundnut in intercrop with maize introduced at 4 weeks later (4 WAP) was significantly ($P \leq 0.05$)increased by 35.0 percent compared to that obtained from maize sown simultaneously with groundnutby 20.0 precent at 2 weeks after planting (2WAP). The highest (3.311 t/ha)intercrop yield of maize was obtained atsimultaneously plantingwith groundnut (3.079 t/ha). Plantinggroundnut and maize also gave the highest total land equivalent ratio (LER) of 1.81 and 1.90 for 2018 and 2019, indicating the highest yield advantage. The highest monetary advantage was obtained in SAMNUT 25 at simultaneousplanting in the intercrop.

Keywords: Intercrop, Maize, Groundnut, Date of planting, Intercropping

INTRODUCTION

Groundnut (Arachis hypogaea L.), is a leguminous oilseed crop in the family Fabaceae. It is an important source of protein for man and non-drying oil and cake which are important ingredients in animal feed (Undie et al., 2013) that ranked thirteenth (13^{th}) in importance among world crops (Hatam and Abasi, 1994; ICRISAT, 2008). Groundnut seeds are also used in various foods and confectionery. Maize (Zea mays L.) is a cereal crop rated as the third most important crop for both human and animal consumption in the world (FAO, 2015) and has contributed greatly to the economic growth of many developing countries. It is an important source of carbohydrate in the human diet and as animal feed worldwide (Onasanya et al., 2009). Today, the crop is one of the most important sources of World food supply. According to the Food and Agriculture Organization Statistics, 822.7 million metric tons of maize was produced worldwide in the year 2008 of which Africa produced 53.2 million metric tons (FAO, 2008).

Cropping system is defined as the combination of crops grown in a given area within a year (Okpara et al., 2005; Seran and Brintha, 2010). In small farms, the farmers raise crops as a risk minimizing measures against total crop failures and to get different produce to take for his family's food, income (Ullah et al., 2007). Subsistence farmers in the tropics rely on mixed cropping as their crop production system (Seran and Brintha, 2010).

Mixed cropping provides security in food output which is considered more important than food maximization (Undie et al., 2013). It also suppresses weeds, increases cash return to the farmer and provide higher yield advantages over sole cropping (Seran and Brintha, 2010).

Studies have been conducted on sole maize and sole groundnut, aimed at improving the productivity of the crops (Bala et al., 2011; Ijoyah and Jimba, 2012). Though, farmers in Makurdi, Nigeria intercrop maize and groundnut, however, there is limited information for the location on the appropriate time of introduction of maize that will improve the productivity of the component crops in the intercrop. The study was therefore carried out to determine the appropriate time of planting maize in groundnut-maize intercrop. identify the best performing groundnut variety in intercrop arrangement with maize in terms of growth and yield performance and evaluate the economic benefits of intercropping maize at different dates in groundnut-maize system.

MATERIALS AND METHODS

Site Description and Varieties

The experiment was conducted during the wet season (June - August) in 2018 and 2019 cropping seasons respectively at the Teaching and Research Farm of Joseph Sarwuan Tarka University, Makurdi, Nigeria. The site is located on longitude 07° 47.699' – 07° 52.789' N and latitude 08° 36.947'– 08° 41.969' E on elevation of 102 m above sea level. The experiment was conducted in the same location in each year to evaluate the performance of three varieties of groundnut (Arachis hypogaea L.) relative to dates of introduction of maize (Zea mays L.) in groundnut-maize intercrop at Makurdi. The soil at the experimental site was classified as sand-loam (USDA). The experimental site received a total annual rainfall of 150.50 mm in 2018 and 188.11mm in 2019 with 86 and 98 number of rainy days in 2018 and 2019 respectively. There were 7 months of rains from April to November in 2018 and 2019 respectively.

Soil Sampling and Analysis

Ten core soil samples were collected from different parts of the experimental area from a depth of 0 –15 cm and bulked into a composite sample and used for the determination of the physical and chemical properties of the soil (Table 1) before planting for 2018 and 2019. The composite soil was analysed

in Soil Science Laboratory, Joseph Sarwuan Tarka University, Makurdi, using standard equipment, reagents and methods.

Sources of planting materials

Three groundnut varieties (SAMNUT 24, SAMNUT 25 AND SAMNUT 26) were obtained from International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Kano, and maize variety (OBA-98) from International Institute of Tropical Agriculture (IITA) Ibadan, to determine growth and yield response of three varieties of groundnut (Arachis hypogaea L.) in relation to date of introduction of Maize (Zea mays L.) in groundnut-maize intercropping at Makurdi, a location in the Southern Guinea Savannah Ecological Zone of Nigeria.

Experiment design and treatment

The two year (2018 and 2019) field experiments were conducted in a 3 x 4 factorial arrangement laid out as a Randomized Complete Block Design (RCBD) replicated three times. Each replication contained 12 plots thus giving a total number of 36 plots for the experiment. A plot was measured 3 m x 4 m, separated from each other within the plot by 0.5 m and within the replication by 1.0 m and 1.0 m alley for easy assessment of the experiment. A plot contained 4 ridges and the experimental layout covered an area of 712 m^2.The treatments consisted of three varieties of Groundnut (Arachis hypogaea L.) with one variety of maize (Zea mays L.) introduced at various intervals (Simultaneously, 2 WAP and 4 WAP). The three groundnut varieties were planted on 22nd and 21st June in 2018 and 2019 respectively, at intra and inter row spacing of 0.2 m by 0.75 m, sowing two seeds per hole, which was later thinned to one seed per stand after ten days, giving a density of 66,666 plants/ha.

Maize (Zea mays L.) variety was planted at intra and inter row spacing of 0.5 m and 0.75 m planting three seeds per hole which was later thinned to two seeds per stand after 10 days, giving a plant density of 53,333 plants per/ha.

Factors considered were:

Factor A: Groundnut varieties used were SAMNUT 24, SAMNUT 25 and SAMNUT 26.

Factor B: Time of introduction of maize (Simultaneous, 2 WAP and 4 WAP); Sole groundnut and Sole maize constituted the control treatments.

Agronomic Practices

Land preparation

Experimental site was ploughed, harrowed and ridged using tractor. The ridges were designed with an intra-row spacing of 0.75 m. Each plot contained 4 ridges of 4 m x 3 m. A total number of 36 plots were marked in the field of 3 replications. A gap of 1m in-between each replication was marked as a path-way, and a gap of 0.5 m left between one treatment and another.

Planting

i. Groundnut: Spacing for sole and intercrop groundnut was at intra and inter row spacing of 0.2 m and 0.75 m respectively. Two seeds were planted per hole and were later thinned to one seed per stand on top of the crest, giving a plant population of 66,666 plants/ha.
ii. Maize: Sole and intercrop maize was planted at intra and inter row spacing of 0.5 m and 0.75 m respectively. Three maize seeds were planted per hole by the side of the ridge for intercrop and on top of the crest for the sole, and were later thinned to two seeds per hill, giving a plant population of 53,333 plants/ha.
iii. Both groundnut varieties and maize variety were sown at the depth of 3-5 cm. Maize was later introduced in groundnut at simultaneous, 2 and 4 weeks after planting (WAP). Sole maize and sole groundnut constituted the control treatments.

Fertilizer application

The recommended rate of compound fertilizer NPK 20:10:10 was applied at the rate of 90 kg N/ha, 45 kg P_2O_5/ha and 45 kg K_2O/ha on sole maize (Kamara et al., 2020). SSP (18 %) was applied on sole groundnut during planting at the rate of 90 kg P_20_5kg/ha (Aduayi et al., 2002). For groundnut-maize intercrop, 90 kg N/ha, 45 kg P_2O_5/ha and 45 kg K_2O/ha were applied (Enwezor et al., 1989). The row method of fertilizer application was applied on the groundnut-maize intercrop. To each plot of sole maize and groundnut-maize intercrop, NPK20:10:10 fertilizer was applied twice; at 3 and 6 WAP.

Weeding

Weeding was done manually using West African hand held hoe at 3, 6 and 9 week after planting (WAP).

Harvesting

Groundnut varieties were harvested at 80 - 90 % physiological maturity when the pods lining become thin and the leaves turn yellow and start dropping. The pod with conflicted stands of orange or slightly developed brown colour was categorized as mature (Carter, 2017). SAMNUT 24 was harvested 80 days after planting (80 DAP). SAMNUT 25 AND SAMNUT 26 were harvested 90 days after planting (90 DAP) (ICRISAT, 2019). Maize was harvested when dry at 115 days after planting (DAP).

Data Collection

Data taken for groundnut include plant height, number of leaves, number of branches, days to 50 % flowering, number of pods per plant, number of seeds per pod, pod yield per plot and 100 seed weight.

Data taken for maize include plant height (measured as the distance in cm from the soil surface to the tip of the topmost leaf), number of leaves per plant, leaf area (cm^2), days to 50 % flowering, number of cobs per plant, cob weight (g), cob length (cm), cob diameter (girth) (cm) (The diameter of the head, center and tail-end of the cob was measured and averaged), number of rows per cob, number of seeds per row, number of seeds per cob, grain weight (t/ha) and 100 seed weight. The cobs and grain weight were weighed using digital weighing scale to obtain their weights (g). The cobs were shelled manually and the total grains for each plot was weighed to obtain the yield (t/ha).

Assessment of Crop Performance in Intercropping Systems

Land equivalent ratio (LER)

The land equivalent ratio (LER) is a concept in agriculture that describes the relative land area required under sole cropping (monoculture) to produce the same yield as under intercropping (Mead and Willey, 2008).

LER was calculated using the formula:

$$LER = La + Lb = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where, La and Lb are LERs of crop a (groundnut) and crop b (maize), respectively;

Yab = yields of crop a (groundnut) in intercropping,

Yba = yields of crop b (maize) in intercropping,

Yaa = yield of crop a (groundnut) in sole crop yields and Y

Ybb = yield of crop b (maize) in sole crop yields.

$$LER = \frac{yield\ of\ groundnut\ (sole)\ kg}{yield\ of\ groundnut{+}maize\ (kg)} + \frac{yield\ of\ maize\ sole\ (kg)}{yield\ of\ groundnut{+}maize\ (kg)}$$

Relative crowding coefficient (RCC)

Relative crowding coefficient is calculated as the following:

$$Kab = \frac{Yab-Zba}{(Yaa-Yab)Zab} \quad (1)$$

$$Kba = \frac{Yba - Zab}{(Ybb-Yba)Zba} \quad (2)$$

Where: Kab= the relative crowding coefficient for species a (groundnut) in intercropping with specie b (maize);
Kba= the relative crowding coefficient for specie b (maize) in intercrop with species a (groundnut);
Yaa = yield of species a (groundnut) in monocrop;
Yab= yield of species a (groundnut) in intercrop with specie b (maize);
Ybb= yield of specie b (maize) in monocrop;
Yba= yield of specie b (maize) in intercrop with species a (groundnut);
Zab = ratio (%) of species a (groundnut) to specie b (maize) in intercrop;
Zba= ratio (%) of specie b (maize) to species a (groundnut) in intercrop.

According to Willey (1979) both species have their own relative crowding coefficient within the intercropping system. Higher level of Kab shows the predomination of species a (groundnut) over the other species with lower relative crowding coefficient.

The product of Kab and Kba (K=Kab·Kba) is interpreted as follows:
if K is greater than 1, there is a yield advantage,
if K is equals to 1, there is no yield advantage,
if K is less than 1, there is a yield disadvantage (Ghosh, 2004).

Competition ratio (CR)

Willey and Rao (1980) suggested competition ratio (CR) instead of "aggressivity" to indicate the degree that one species competes with the other in an intercrop system. The CR represents the ratio of individual LERs of the two intercropped components and takes into account the proportion of the crops in which they are initially planted.

The CR was calculated as:

$$CRa = \frac{LERa}{LERb} x \frac{Xba}{Xab}$$

When CR is below 1 there is a positive benefit and the species can be grown in a mixture.

The monetary advantage index (MAI)

The monetary advantage index (MAI) was calculated as described by Ghosh (2004).

$$MAI = \frac{Value\ of\ combined\ intercrops\ x\ (LER-1)}{LER}$$

The higher the index value, the more profitable is the cropping system (Dhima et al., 2007).

RESULTS AND DISCUSSION

Physico-chemical Properties of the Study Area for 2018 and 2019 Cropping Seasons

The physic-chemical properties of the study area for the two years (2018 and 2019) is presented in Table 1. The pH (in water) was slightly acidic. The pH was 5.12 and 6.26 in 2018 and 2019, respectively. The soil textural class for the study area was sandy loam with organic carbon content ranging from 0.24 and 0.42 for 2018 and 2019, respectively. Organic matter increased from 0.41 in 2018 to 0.55 in 2019; and total nitrogen increased from 0.14 in 2018 to 0.35 in 2019. This increase may be due to nitrogen fixation by the legume crop (groundnut) planted in the previous cropping cycle. The experimental area had a low level of available phosphorus 2.4 cmol kg^{-1} and 3.5 cmol kg^{-1} for 2018 and 2019 respectively, and potassium 0.284 cmol kg^{-1} and 0.29 cmol kg^{-1} for the two years of the study. The exchangeable base (EB) ranged from 6.43 to 6.53 for 2018 and 2019 respectively. Exchangeable acidity (EA) and cation exchange capacity (CEC) declined slightly from 1.3 cmol kg^{-1} in 2018 to 1.2 cmol kg^{-1} in 2019 and 7.53 cmol kg^{-1} in 2018 to 6.69 cmol kg^{-1} in 2019 respectively. Generally, the soil in the study area was more fertile in 2019 than 2018. (NMA, 2018/2019). This probably could be as a result of decomposition of organic matter.

Meteorological Information for Makurdi, Nigeria (April - December) for 2018 and 2019 Farming Seasons

The meteorological information for Makurdi during the study period is presented in Table 2. The average minimum and maximum temperatures ranged from 22.08 ºC to 22.69 ºC in 2018 and 32.03 ºC to 32.75 ºC in 2019. Rainfall was regular from the month of April to October for both years. Average relative humidity ranged from 72.13% in 2018 to 76.26% in 2019 with average solar radiation of 552.75 wm^{-2} in 2018 and 320.38 wm^{-2} in 2019.

Table 1: Physico-Chemical Properties of the Experimental Soil (0-30 cm) for 2018 and 2019 Farming Seasons

Parameters	2018	2019
Sand (%)	70.5	65.85
Clay (%)	18.2	18.85
Silt (%)	13.0	12.2
Ph	5.12	6.26
Textural class	Sandy loam	Sandy loam
Organic carbon (%)	0.24	0.42
Organic matter (%)	0.41	0.55
Total Nitrogen (%)	0.14	0.35
Available P (cmol kg^{-1})	2.4	3.5
Available K (cmol kg^{-1})	0.28	0.29
Na^{+} (cmol kg^{-1})	0.25	0.27
Mg^{+} (cmol kg^{-1})	2.8	2.6
Ca^{2+} (cmol kg^{-1})	3.1	3.2
Exchangeable Base (cmol kg^{-1})	6.43	6.53
Exchangeable Acidity (cmol kg^{-1})	1.30	1.20
CEC (cmol kg^{-1})	7.53	6.69
Base saturation, BS (%)	85.4	86.2

Source: Advance Soil Science Laboratory, JOSTUM

The average number of rainy days during the study period under review was 9.56 in 2018 and 10.89 in 2019.

The Main Effect of Growth Parameters of Groundnut Varieties as Influenced by Time of Introduction of Maize in Groundnut-Maize Intercrop at Makurdi

Plant Height

The main effects as well as interaction effects of variety and time of introduction on the height of Groundnut plant are presented in Tables 3 and 5. Both the variety and time of introduction had significant effects on groundnut plant height, Heights attained by groundnut largely dependent on the variety of groundnut in question and the time maize was planted relative to groundnut in the intercropping system. SAMNUT 26 groundnut variety significantly exceeded the other varieties in height where as SAMNUT 24 had the shortest height in both years.

Groundnut planted in sole cropping attained significantly (P≤0.05) heights plant height compelled to those in intercropping maximum plant height of groundnut in intercropping was recorded at 4 weeks of planting maize while at simultaneous planting of maize and groundnut, groundnut height was observed to be shortest and differed significantly (P≤0.05) compared to other timing of maize planting.

The interaction Table 4 is a clear expression of groundnut SAMNUT 25 been significantly taller than other varieties both in sole cropping and in intercropping irrespective of levels of time of introduction of maize in both years. Delayed time of introducing maize significantly (P≤0.05) favored growth in groundnut height.

On the other hand, height of groundnut variety SAMNUT 24 compare to height of other varieties at all levels of time of introducing maize in intercropping or in sole cropping was shortest, with significant difference.

Table 2: Main Effect of Variety and Time of Introduction on Plant Height of Groundnut in a Groundnut-Maize Intercrop at Makurdi

Variety	Plant Height (cm)					
	6 WAP		8 WAP		10 WAP	
	2018	2019	2018	2019	2018	2019
SAMNUT 24	9.86[b]	10.35[c]	18.27[b]	20.18[c]	37.60[b]	39.96[b]
SAMNUT 25	9.97[b]	10.65[b]	18.40[b]	20.66[b]	37.18[c]	39.69[c]
SAMNUT 26	10.59[a]	10.98[a]	18.89[a]	21.58[a]	38.60[a]	40.85[a]
P – Value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Time of Introduction						
Sole	10.94[a]	11.51[a]	20.36[a]	23.64[a]	43.21[a]	45.68[a]
Simultaneous	8.72[c]	9.36[d]	15.44[d]	16.89[d]	33.03[d]	35.06[d]
2 WAP	10.01[b]	10.41[c]	18.36[c]	20.40[c]	36.30[c]	38.59[c]
4 WAP	10.88[a]	11.36[b]	19.92[b]	22.29[b]	38.62[b]	41.34[b]
P – Value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Means within the same column with different letters are significantly different at P≤0.05; WAP = weeks after planting

Table 3: Main Effect of Variety and Time of Introduction on Reproductive and Growth Parameters of Groundnut in a Groundnut-Maize Intercrop at Makurdi

Variety	Days to 50 % flowering		Number of leaves at 50% Flowering		Number of branches at 50 % flowering	
	2018	2019	2018	2019	2018	2019
SAMNUT 24	33.38[c]	33.58[c]	118.18[c]	120.68[c]	10.74[b]	11.09[c]
SAMNUT 25	43.19[b]	43.03[b]	128.48[a]	129.80[a]	11.5 5[a]	12.00[a]
SAMNUT 26	43.75[a]	43.83[a]	128.33[b]	129.66[b]	10.48[c]	11.16[b]
P–value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Time of Introduction						
Sole	43.21[a]	45.68[a]	131.26[a]	133.26[a]	13.01[a]	13.12[a]
Simultaneous	33.03[d]	35.06[d]	117.73[d]	119.50[d]	8.48[d]	9.04[d]
2 WAP	36.30[c]	38.59[c]	123.62[c]	125.58[c]	10.21[c]	11.03[c]
4 WAP	38.62[b]	41.34[b]	127.38[b]	128.71[b]	11.90[c]	12.47[b]
P – value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Mean within the same column with different alphabets are significantly different at P ≤ 0.05.

Table 4: Interaction Effects of Variety and Time of Introduction on Plant Height of Groundnut in a Groundnut-Maize Intercrop at Makurdi

Variety	Time	6 WAP		8 WAP		10 WAP	
		2018	2019	2018	2019	2018	2019
SAMNUT 24							
	Sole	10.67^{bc}	11.40^{b}	20.57^{a}	23.67^{b}	40.57^{c}	42.03^{c}
	Simultaneous	8.73^{e}	9.60^{d}	15.43^{e}	16.57^{g}	33.70^{i}	35.73^{f}
	2 WAP	9.56^{d}	9.73^{d}	17.53^{d}	19.77^{e}	36.53^{g}	38.67^{e}
	4 WAP	10.47^{c}	10.67^{c}	19.53^{b}	20.73^{d}	37.63^{f}	40.70^{d}
SAMNUT 25							
	Sole	10.80^{b}	11.50^{ab}	19.77^{b}	22.73^{c}	45.53^{a}	48.67^{a}
	Simultaneous	8.73^{e}	8.80^{e}	15.40^{e}	16.53^{g}	33.60^{i}	35.70^{f}
	2 WAP	9.80^{d}	10.67^{c}	18.77^{c}	20.70^{d}	`36.63^{g}	38.50^{e}
	4 WAP	10.53^{c}	11.63^{ab}	19.67^{b}	22.67^{c}	38.63^{e}	40.53^{d}
SAMNUT 26							
	Sole	11.37^{a}	11.63^{ab}	20.73^{a}	24.53^{a}	43.53^{b}	45 73^{b}
	Simultaneous	8.70^{e}	9.67^{d}	15.50^{e}	17.57^{j}	31,80^{j}	33.73^{g}
	2 WAP	10.67^{bc}	10.83^{c}	18.77^{c}	20.70^{d}	35.73^{h}	38 60^{e}
	4 WAP	11.63^{a}	11.77^{a}	20.67^{a}	23.47^{b}	37.60^{d}	42.80^{c}
P-Value		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Mean within the same column with different alphabets are significantly different at P ≤ 0.05 WAP= Weeks after planting

Days to 50% Flowering

The effect of variety and time of introducing maize and their interaction on the days to 50% flowering of groundnut is as presented in Tables 4 and 5. Variety, time of introduction of maize and their interactions had significant effects (P≤0.05) on days to groundnut 50% flowering in both years.

Days to 50% flowering declined significantly (P≤0.05) in intercropping compare to sole cropping. SAMNUT 24 groundnut variety took relatively shortest number of days to attain 50% flowering compare to the longest days observed in SAMNUT 26 (43.75 and 43.85) in 2018 and 2019 respectively.

Significantly shorter days to attain 50% flowering in intercropping compare to sole cropping was a common feature among the groundnut varieties. Equally common among the groundnut varieties is the fact that delay in time of introducing maize imposed significant (P≤0.05) decreasing effect on days to 50% flowering. All groundnut varieties intercropped with maize had their shortest days to 50% flower when sown simultaneously with maize. The shortest number of days to attain 50% flowering was observed in SAMNUT 24 (35.50 and 36.53) in 2018 and 2019 respectively. On the other hand the longest days to attain 50% flowering among the groundnut varieties in intercropping was SAMNUT 26 (42.67 and 42.50) in 2018 and 2019 respectively.

Number of leaves at 50% flowering

The main effects and interaction effects of variety and time of introducing maize on number of leaves at 50% flowering are as presented in Tables 4 and 5 respectively.

The number of leaves among groundnut varieties differ significantly (P≤0.05) with SAMNUT 26 recording the highest and SAMNUT 24 the least in both years. All groundnut varieties responded significantly (P≤0.05) differently to cropping systems and time of introducing maize in intercropping. Whether in intercropping or in sole cropping, SAMNUT 25 variety had the highest number of leaves compared to other varieties across levels of time of introducing maize in intercropping as shown in the interaction Table 6.

Intercropping negatively impacted number of leaves in all groundnut varieties compare to sole cropping. On the other hand, delay in time of introducing maize in intercropping had significantly (P≤0.05) positive impact on the number of leaves among all groundnut varieties in intercropping had their highest number of leaves when maize time of introduction was delayed to 4 weeks after planting groundnut (4DAP) and least in simultaneously planting.

Number of branches at 50% flowering

Table 4 presents data on the effect of variety and time of introducing maize on number of branches at 50% flowering. Groundnut varieties varied significantly (P≤ 0.5) in number of branches in both years with SAMNUT 25 leading (11.55 and 12.00) in 2018 and 2019 respectively.The number of branches in sole cropping among all the groundnut varieties with the shortening time of introducing maize.

Groundnut varieties combined with maize introduced simultaneously affected number of branches in groundnut most negatively while 4 weeks delay (4WAP) in introducing maize best favored branching in groundnut.

Table 5: Interaction Effects of Variety and Time of Introduction on Reproductive and Growth Parameters of Groundnut in Groundnut-Maize Intercrop at Makurdi

Variety	Time	Days to 50% flowering		Number of leaves at 50% flowering		Number of branches at 50 % flowering	
		2018	2019	2018	2019	2018	2019
SAMNUT 24							
	Sole	32.47^{j}	32.63^{j}	125.67^{f}	128.63^{e}	12.53^{c}	12.67^{c}
	Simultaneous	35.50^{h}	36.53^{h}	110.73^{j}	112.6 0^{j}	8.50^{i}	8.87^{h}
	2 WAP	34.80^{i}	34.57^{i}	115.63^{i}	118.77^{i}	10.27^{f}	10.83^{f}
	4 WAP	30.73^{k}	30.60^{k}	120.70^{h}	122.70^{h}	11.67^{d}	12.00^{d}
SAMNUT 25							
	Sole	40.60^{g}	40.70^{g}	135.67^{a}	136.73^{a}	13.63^{a}	13.83^{a}
	Simultaneous	46.80^{b}	46.37^{b}	120.67^{h}	131.73^{c}	9.30^{h}	9.70^{g}
	2 WAP	46.67^{d}	46.37^{d}	130.88^{c}	131.73^{c}	12.87^{b}	12.87^{b}
	4 WAP	41.70^{f}	41.67^{f}	132.43^{b}	133.80^{b}	12.57^{c}	12.80^{c}
SAMNUT 26							
	Sole	40.40^{g}	40.77^{g}	126.77^{e}	128.20^{f}	10.70^{e}	11.67^{e}
	Simultaneous	47.20^{a}	47.50^{a}	121.80^{g}	123.33^{g}	7.63^{j}	8.57^{i}
	2 WAP	44.73^{c}	44.57^{c}	128.47^{d}	129.77^{d}	9.67^{g}	10.60^{f}
	4 WAP	42.67^{e}	42.50^{e}	130.63^{c}	131.70^{c}	11.73^{d}	12.60^{c}
P- Value		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Mean within the same column with different alphabets are significantly different at P≤0.05; WAP = Weeks after planting
Number of pods per plant (NPDPPL)

Groundnut pod response to variety and time of introducing maize in intercropping in the two years of field experiment is presented in Table 7.Pod number per plant varied significantly (P≤0.05) among varieties. SAMNUT 25 produced higher numbers of pods per plant compare to other varieties. SAMNUT 26 variety had the least number of pods/plant.

Number of pods per plant of each variety declined significantly (P≤0.05) in intercropping compare to sole cropping (Tables 7). Intercropping maize simultaneously with groundnut supported the least number of pods per plant. Number of pods/plant of each groundnut varieties improved significantly (P≤0.05) in a progressive manner with increasing delay in time of introducing maize. The highest pod producing groundnut variety in intercropping was SAMNUT 24 at 4WAP of maize introduction. SAMNUT 25 variety at corresponding levels of time of introducing maize gave the least number of pods per plant. SAMNUT 26 equally recorded significantly (P≤0.05) less number of pods per plant in sole cropping compare to other varieties.

Pod yield/weight (Kg/ha)

Pod yield (Kg/ha) responses of groundnut varieties in sole and to time of introduction of maize component in intercropping is as presented in Tables 6 and 7. Pod yield differences among groundnut varieties were significant (P ≤ 0.05). Variety SAMNUT 25 significantly had the highest pod yield and SAMNUT 26 the least (1399.00 kg/ha and 1495.00kg/ha) in 2018 and 2019 respectively. (Table 6). All groundnut varieties had significantly (P≤0.05) lower pod yields in intercropping compare to sole cropping (Table 7). All groundnut varieties recorded least pod yields in simultaneous intercropping and progressively increased significantly as the time of introducing maize delayed to peak at 4WAP. However, SAMNUT 25 recorded the highest pod yield (1582kg/ha and 1589kg/ha) in 2018 and 2019 respectively at 2WAP, a development which was a little different from other varieties.Variety x time of introduction interaction had significant effect on groundnut pod yield (kg/ha). SAMNUT 25 was most superior in terms of pod yield (kg/ha) at 2WAP compared to other varieties at corresponding levels of time of introducing maize in intercropping.

Maize Component

Plant height (cm)

Effects of variety and time of introducing maize on plant height as presented in Table 9, is significant (P≤0.05) irrespective of the time the observation was made. Maize plant combining with groundnut SAMNUT 26 in intercropping were significantly taller than heights of maize plants in combination with other two groundnut varieties. Maize plants in combination with SAMNUT 25 groundnut in intercropping was in turn significantly (P≤0.05) taller than maize plants that were in combination with SAMNUT 24 groundnut variety. The height of maize was a product of the associating groundnut varieties in intercropping (Table 9).

Maize also responded significantly (P≤0.05) different to time of sowing in association with groundnut varieties in intercropping. Maize plant were significantly (P≤0.05) taller in sole cropping than intercropping with any of the groundnut varieties. The shortest height was observed in maize planted 4 weeks late than groundnut. This was significantly (P≤0.05) different from heights of maize planted simultaneously and 2 weeks later than groundnuts (2WAP). Maize planted simultaneously with groundnuts in intercropping were tall next to the heights of maize planted in sole cropping. The tallest maize plants were observed in association with SAMNUT 25 while the shortest in intercropping were the associates of SAMNUT 26.

Table 6: Main Effects of Variety and Time of Introduction on Yield and Yield Components of Groundnut in Groundnut-Maize Intercrop at Makurdi

Variety	NPDPPL		STOV WT (g)		PD WT (Kg/ha)		100 SD WT (g)	
	2018	2019	2018	2019	2018	2019	2018	2019
SAMNUT 24	32.18[b]	34.15[b]	34.63[b]	36.95[b]	1474.50[b]	1538.30[b]	34.62[b]	36.20[a]
SAMNUT 25	34.58[a]	37.13[a]	35.11[a]	37.80[a]	1554.40[a]	1603.60[a]	36.39[a]	37.59[a]
SAMNUT 26	30.06[c]	31.52[c]	31.96[c]	34.52[c]	1399.00[c]	1495.00[c]	33.29[c]	34.59[c]
P– Value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Time of Introduction								
Sole	39.23[a]	40.88[a]	38.40[a]	40.69[a]	1633.40[a]	1704.60[a]	36.94[a]	38.60[a]
Simultaneous	24.58[d]	26.71[d]	31.18[d]	31.90[d]	1309.60[d]	1399.20[d]	31.93[d]	33.19[d]
2 WAP	28.60[c]	30.60[c]	32.02[c]	33.92[c]	1515.60[b]	1578.80[b]	36.30[b]	37.39[b]
4 WAP	36.67[b]	38.89[b]	36.00[b]	39.19[b]	1445.30[c]	1500.00[c]	33.87[c]	35.33[c]
P- value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Mean values within the same column with different alphabets are significantly different at P≤0.05. WAP = weeks after planting, NPDPPL = Number of pods per plant; STOVWT = Stover weight; PD WT = Pod weight; SD WT = Seed weight

Table 7: Interaction Effects of Variety and Time of Introduction on Yield and Yield Components of Groundnut in Groundnut-Maize Intercrop at Makurdi

Variety	Time	NPDPP		PDWGT(Kg/Ha)		100 SDWT (g)	
		2018	2019	2018	2019	2018	2019
SAMNUT 24	Sole	39.70[b]	41.53[b]	1518[d]	1558[d]	35.53[d]	36.77[d]
	Simultaneous	23.53[k]	25.80[i]	1255.30[h]	1360.00[i]	30.67[i]	32.20[i]
	2 WAP	28.77[h]	30.73[f]	1373.70[f]	1488.70[f]	32.40[g]	33.80[g]
	4 WAP	36.70[d]	38.53[c]	1449 .00[e]	1533.30[dc]	34.50[e]	35.60[e]
SAMNUT 25	Sole	41.70[a]	42.70[a]	1760 .00[a]	1846.70[a]	38.70[a]	40.30[a]
	Simultaneous	26.50[i]	29.97[g]	1366.70[f]	1453.30[g]	33.60[f]	34.67[f]
	2 WAP	38.60[c]	41.33[b]	1582.00[c]	1589.70[c]	37.63[b]	38.80[b]
	4 WAP	31.50[g]	34.53[e]	1509.00[d]	1524.70[e]	35.63[d]	36.60[d]
SAMNUT 26	Sole	36.30[e]	38.40[c]	1622.30[b]	1709.00[b]	36.60[c]	38.73[b]
	Simultaneous	23.70[k]	24.37[j]	1306.70[g]	1384.30[h]	31.53[h]	32.70[h]
	2 WAP	25.53[j]	26.53[h]	1455.30[e]	1486.70[f]	33.37[f]	35.60[e]
	4 WAP	34.70[f]	36.80[d]	1515.70[d]	1573.30[d]	36.77[c]	37.77[c]
P –value		<0.001	<0.001	<0.001	<0.001	< 0.001	<0.001

Mean values within the same column with different alphabets are significantly different at P≤0.05. WAP = weeks after planting, N PD P PL= Number of pods per plant, PD WT = Pod weight, SD WT = Seed weight

Days to 50% Tasseling

The length of time it took 50% of maize plants to tassel depended on the variety of the associating groundnut in intercropping maize after groundnut sowing. The differences in days to 50% tasselling of maize as a result of differences in groundnut varieties and time of introduction were significantly (Table 10). Maize sown simultaneously along with groundnut attained 50% tasseling significantly (P≤0.05) earlier than those sown 2WAP or 4WAP. In this was observes in intercropped with all the groundnut varieties.Significantly(P≤0.05) shorter days to 50% maize tasselling was observed in association was SAMNUT 24 compared with other Groundnut Varieties.

Number of Cobs/Plant (N Cobs/PL)

Sole crop maize had significantly (P≤0.05) higher number of cobs per plant compared to maize intercropped with any of the varieties of groundnut across the two years of observations. Significantly (P≤0.05) more number of cobs/plants was recorded when maize were sown simultaneously in intercrop with all the groundnut varieties than in delayed planting after groundnut sowing. Significantly (P≤0.05) higher population of maize intercropped at 4WAP produced the least number of cobs per plants. Intercropping produced the highest (1.55 and 1.76) number of cobs/plant at simultaneous level of planting with SAMNUT 24 and least (1.36 and 1.43) at 4WAP with SAMNUT 25.

Cobs Weight Per Plant (COBWT/P)

Cobs weighed per plant was significantly high (P≤0.05) in sole compared to intercropping maize. Weights of cobs per maize plants declined most significantly (P≤0.05) in 4 weeks of delayed planting (4WAP). Maize intercropping with all the groundnut varieties weighed significantly (P≤0.05) higher in intercropping with SAMNUT 24 compared with intercropping with other groundnut varieties.

Cob length (cm)

Intercropping effect of variety x Time on cob length as presented in Table 11was significantly (P≤0.05). Cob length suffered significant decline in intercropping compare to sole cropping except at simultaneous planting where cob lengths

were at par across groundnut variety lines. Length of maize cobs in intercropping declines significantly with delay in maize planting compare to length of cobs planted earlier. Irrespective of Groundnut varieties with which maize associated in intercropping, the least cob lengths were recorded in 4 weeks delay (4WAP) in maize planting. and longest in simultaneous planting.

Other yield components (Cob girth, Number of seeds/Cob, Number ofseeds/rows, and 100 seed weight (g))

Yield components response as presented on Variety x Time Interaction Table 11 shows significant differences. Yield component of maize were reduced at significantly varying rates by the associated Groundnut varieties i intercropping as compared to sole maize yield components except in SAMNUT 25 at Simultaneous planting of maize relative to Groundnut varieties where the seed number per row were significantly more than in sole cropping. Yield components of ma maize recorded least performance at four weeks delayed planting of maize in all cases of intercropping among groundnut varieties. Highest Yield Component were observed in simultaneous planting compared to other levels of intercropping.

Grain Yield (Kg/ha)

Variety x Tine interaction effect on maize grown yield as presented on Table 11 is significant. Maize grown yield declined significantly in the intercropping environment of all groundnut varieties compare to grain yield of maize in sole cropping.Grain yield in sole did not respond significantly ($P \leq 0.05$) different to time of introduction. However, delaying the planting of maize relative to any of the groundnut varieties resulted in significant decline of maize grain yield. Maize planted simultaneously with groundnut gave significantly ($P \leq 0.05$) highest grain yield performance compare to all other levels of time of introduction. Delaying the time of planting of maize by four weeks relative to groundnut gave the least grain yield in intercropping with all the groundnut varieties.Highest maize grain yield was recorded in intercropping with SAAMNUT 24 across all levels of introduction and the least grain was in SAMNUT 26.

Land Productivity evaluation

The productivity of the experimental land was evaluated by calculating total land equivalent ratio (LER), Percentage of Land saved (%LS) and Competitive Ratio (CR).

Land Equivalent Ratio (LER)

The total land equivalent ratio (LER) was calculated by adding land equivalent ratio of maize and groundnut. Total Land Equivalent Ratio (LER) of maize and groundnut intercrops were significantly ($P \leq 0.05$) affected by time of intercropping.

However, the interaction of variety and time intercropping and main effect of variety had no significant effect on total Land equivalent ratio. In all the intercrops, the LER was more than unity, which showed that land utilization efficiency of maize-groundnut intercropping was of more advantage than for sole cropping. In other words, more lands will be required in the monoculture of either of the component crops to produce the same yield obtained from their intercropping.

The higher LER (1.90 and 1.88) was obtained at simultaneous intercropping of groundnut with maize followed by intercropping at two weeks after groundnut emergency (1.68 and 1.64) on SAMNUT 24 and 25 respectively (Table 12). This result agrees with the report of Lulieet al., 2016 where the LER of maize- common beans ranged from 1.26-1.69. Similarly Habte et al., 2016 reported LER of 1.40-1.42 from maize- common beans intercropping. SimilarlyHirpa, 2013 observed LER of 1.43-1.54 for maize-common beans intercropping.

Percentage of Land Saved (%LS)

Percentage of Land saved is an indicator of the percentage of land a farmer saved from intercrop of the same yield was to be obtained in the same plot. This work indicated that it is of advantage to have the crops in mixture since the farmer would save as much as 32.44% - 47.37% of land. Ijoyah and Jimba(2011) also observed 49.2% to 50% of land saved in intercrop.

Competitive Ratio (CR).

The competitive ratio (CR) values of intercrop in the associated crops were higher at four weeks after planting in all the treatments indicating that groundnut was more competitive than the maize and this could be as a result of groundnut being the taller crop at 4WAP. This view agreed with Palaniaffan (1985) who stated that taller component crops intercept major share of the solar radiation thereby reducing the competitive ability of the other crop.

Table 8: Interaction Effect of Variety and Time of Introduction on Growth Parameters of Maize in a Groundnut-Maize Intercrop at Makurdi

Variety	Time	Plant Height (cm)						Number of Leaves		Leaf Area (cm^2)	
		6 WAP		8 WAP		10 WAP					
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
SAMNUT 24	Simultaneous	33.93^{b}	37.50^{ab}	97.73^{b}	99.63^{6}	160.13^{bc}	162.83^{b}	15.77^{a}	15.80^{a}	315.47^{f}	330.40^{c}
	2 WAP	31.53^{def}	32.76^{d}	95.30^{d}	96.30^{f}	145.60^{g}	150.43^{g}	14.70^{c}	15.27^{bcd}	309.55^{h}	315.50^{f}
	4 WAP	3040^{fg}	32.16^{e}	92.30^{g}	94.63^{h}	140.67^{h}	1454.60^{h}	12.63^{e}	13.20^{f}	304.04^{j}	306.47^{h}
SAMNUT 25	Simultaneous	35.63^{a}	37.30^{b}	99.36^{a}	101.70^{a}	162.10^{a}	163.86^{a}	15.33^{ab}	15.50^{ab}	323.00^{c}	326.80^{d}
	2 WAP	32.30^{bcde}	33.40^{c}	96.80^{c}	98.73^{d}	158.50^{d}	160.36^{d}	13.77^{d}	14.83^{e}	319.15^{e}	321.53^{e}
	4 WAP	31.30^{efg}	31.80^{ef}	94.70^{e}	96.46^{f}	150.23f	155.53^{e}	12.93^{e}	13.40^{f}	306.15^{i}	311.50^{g}
SAMNUT 26	Simultaneous	35.53^{g}	37.73^{ab}	95.30^{d}	97.70^{e}	157.40^{e}	160.46^{d}	15.53^{ab}	15.50^{ab}	321.55^{d}	323.19^{e}
	2 WAP	31.67^{cdef}	33.46^{c}	93.30^{f}	95.53^{g}	145.70^{g}	152.63^{f}	15.80^{c}	15.00^{de}	310.98^{g}	322.54^{e}
	4 WAP	29.73^{g}	31.63^{f}	90.23^{h}	92.66^{i}	130.53^{i}	142.40^{i}	12.90^{e}	12.77^{g}	300.35^{k}	304.33^{h}
Sole maize	Simultaneous	33.37^{bc}	37.66^{ab}	99.33^{a}	99.73^{b}	160.43^{b}	162.73^{b}	15.13^{bc}	15.37^{bc}	323.58^{b}	337.20^{a}
	2 WAP	32.80^{bcde}	37.53^{ab}	99.06^{a}	99.16^{cd}	150.73^{c}	162.56^{b}	15.17^{bc}	15.03^{cde}	324.50^{a}	331.63^{bc}
	4 WAP	33.23^{bcd}	37.93^{a}	99.20^{a}	99.53^{bc}	160.20^{bc}	161.93^{c}	15.17^{bc}	15.80^{a}	323.45^{b}	333.85^{b}

Mean values within the same column with different alphabets are significantly different at P≤0.05. WAP= Weeks after planting

Table 9: Effect of Variety and Time of Introduction on Yield Parameter in Groundnut-Maize Intercrop at Makurdi

Variety	Time	DAY 50% FL.		N COBS/PL.		COB WT(Kg/P)		N SD/COB)		N SDs/ROW)	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
SAMNUT 24	Simultaneous	50.27^{g}	50.00^{e}	1.66^{bc}	1.76^{a}	0.1350^{b}	0.1383^{c}	499.47^{ab}	505.30^{b}	34.46^{c}	38.77^{bc}
	2 WAP	51.57^{de}	50.90^{d}	1.60^{cde}	1.63^{b}	0.1267^{e}	0.1310^{e}	480.60^{d}	490.57^{d}	30.66^{e}	36.93^{cd}
	4 WAP	54.33^{b}	55.17^{a}	1.40^{f}	1.60^{c}	0.1137^{f}	0.1150^{f}	368.60^{i}	420.43^{h}	25.40^{f}	3087^{e}
SAMNUT 25	Simultaneous	50.73^{fg}	50.70^{d}	1.53^{c}	1.63^{b}	0.1323^{c}	0.1350^{d}	502.43^{a}	510.33^{a}	4063^{a}	45.87^{a}
	2 WAP	51.87^{d}	51.70^{c}	1.33^{f}	1.46^{c}	0.1250^{e}	0.1353^{d}	474.83^{e}	485.53^{e}	34.80^{c}	40.47^{b}
	4 WAP	55.47^{a}	55.03^{a}	1.20^{g}	1.23^{d}	0.0999^{g}	0.1073^{g}	386.75h	399.57^{i}	30.93^{e}	35.30^{d}
SAMNUT 26	Simultaneous	51.10^{ef}	50.43^{de}	1.53^{de}	1.66^{b}	0.1387^{a}	0.1437^{a}	468.73^{f}	481.23^{f}	38.33^{b}	39.53^{bc}
	2 WAP	52 73^{c}	52.67^{b}	1.53^{de}	1.46^{c}	0.1297^{d}	0.1342^{d}	400.73^{g}	428.67^{g}	31.63^{d}	36.73^{cd}
	4 WAP	55.40^{a}	54.63^{a}	1.36^{f}	1.43^{c}	0.0967^{h}	0.0989^{h}	360.70^{j}	370.60^{j}	30.96^{e}	31.80^{e}
Sole Maize	Simultaneous	50.33^{g}	51.60^{c}	1.76^{a}	1.76^{a}	0.1423^{ab}	0.1423^{ab}	498.00^{bc}	505.23^{b}	38.43^{b}	39.53^{bc}
	2 WAP	50.50^{fg}	51.67^{c}	1.73^{b}	1.80^{a}	0.1420^{ab}	0.1420^{ab}	496.43^{bc}	502.50^{c}	38.73^{b}	39.50^{bc}
	4 WAP	51.13^{ef}	52.07^{bc}	1.63^{cd}	1.83^{a}	0.1413^{b}	0.1413^{b}	494.27^{c}	501.53^{c}	38.36^{b}	39.40^{bc}

Mean values within the same column with different alphabets are significantly different at P≤0.05.

Table 10: Effects of Variety and Time of Introduction on Yield Parameters of Maize in a Groundnut-Maize Intercrop at Makurdi

Variety	Time	Cob Length (cm)		Cob Girth (cm)		No. of Seed/ Cob		No of Seed/ Row		Grain Yield (t/ha)		100-Seed Weight (kg)	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
SAMNUT 24	Simultaneous	20.93^{a}	23.90^{a}	5.76^{ab}	6.50^{ab}	499.47^{ab}	505.30^{b}	34.47^{c}	38.77^{bc}	2.951^{b}	3.133^{a}	30.60^{a}	31.47^{c}
	2 WAP	18.47^{c}	21.43^{c}	4.70^{d}	5.20^{c}	480.60^{d}	490.57^{d}	30.67^{e}	36.93^{cd}	2.419^{e}	2.681^{d}	28.53^{c}	30.70^{d}
	4 WAP	17.43^{d}	18.83^{e}	3.57^{e}	4.30^{d}	368.60^{i}	420.43^{h}	25.40^{f}	30.87^{e}	1.749^{j}	1.911^{h}	22.77^{g}	22.97^{h}
SAMNUT 25	Simultaneous	20.57^{b}	23.43^{b}	5.83^{a}	6.87^{a}	502.43^{a}	510.33^{a}	40.63^{a}	45.87^{a}	2.819^{c}	3.005^{c}	30.60^{a}	32.67^{a}
	2 WAP	18.77^{c}	20.63^{d}	5.33^{bc}	5.33^{c}	474.83^{e}	485.53^{e}	34.80^{c}	40.47^{b}	2.363^{f}	2.494^{e}	26.63^{e}	29.60^{e}
	4 WAP	15.43^{e}	17.07^{g}	3.53^{e}	4.40^{d}	386.75^{h}	399.57^{i}	30.93^{e}	35.30^{d}	1.832^{i}	1.833^{i}	23.50^{f}	25.73^{f}
SAMNUT 26	Simultaneous	20.70^{ab}	23.63^{ab}	5.67^{b}	6.70^{b}	468.73^{f}	481.23^{f}	38.33^{b}	39.53^{bc}	2.793^{d}	3.079^{b}	30.57^{a}	31.67^{bc}
	2 WAP	18.53^{c}	20.73^{d}	4.73^{d}	5.30^{c}	400.73^{g}	428.67^{g}	31.63^{d}	36.73^{cd}	2.149^{g}	2.287^{f}	27.67^{d}	30.63^{d}
	4 WAP	15.47^{c}	17.40^{f}	3.40^{e}	4.43^{d}	360.70^{j}	370.60^{j}	30.97^{e}	31.80e	2.017^{h}	2.147^{g}	23.70^{f}	24.67^{g}
Sole Maize	Simultaneous	19.63^{bc}	23.90^{a}	5.83^{a}	6.50^{ab}	494.27^{c}	501.53^{c}	38.73^{b}	39.50bc	3.084^{a}	3.088^{b}	30.40^{a}	31.73^{bc}
Sole Maize	2 WAP	19.63^{c}	23.93^{a}	5.13^{c}	6.17^{b}	498.00^{bc}	505.23^{b}	38.43^{b}	39.53bc	3.081^{a}	3.088^{b}	29.53^{b}	32.47^{a}
Sole Maize	4 WAP	19.47^{bc}	23.90^{a}	5.50^{ab}	6.27^{ab}	496.43^{bc}	502.50**c**	38.37^{b}	39.40^{bc}	3.085^{a}	3.087^{b}	30.73^{a}	31.87^{b}

Mean values within the same column with different alphabets are significantly different at P≤0.0

Table 11: Land Equivalent Ratio (LER) and Percentage Land Saved on Groundnut-Maize Intercrop at Makurdi

Treatment		2018 Season				2019 Season				Competitive Ratio (CR)	
		Partial LER		Total LER G + M	% Land Saved	Partial LER		Total LER G + M	% Land Saved	2018	2019
SAMNUT 24	Simultaneous	G=0.85	M=0.95	1.80	45.45	G=0.90	M=0.98	1.88	40.48	0.89	0.93
	2 WAP	G=0.78	M=0.78	1.56	35.90	G=0.81	M=0.87	1.68	35.07	1.0	0.93
	4 WAP	G=0.89	M=0.57	1.46	31.51	G=0.92	M=0.62	1.54	47.37	1.56	1.48
SAMNUT 25	Simultaneous	G=0.90	M=0.91	1.81	44.76	G=0.93	M=0.97	1.90	40.12	0.99	0.96
	2 WAP	G=0.86	M=0.77	1.63	38.66	G=0.83	M=0.81	1.64	32.44	1.11	1.06
	4 WAP	G=0.98	M=0.59	1.57	36.31	G=0.93	M=0.59	1.52	45.49	1.66	1.51
SAMNUT 26	Simultaneous	G=0.86	M=0.94	1.80	44.45	G=0.84	M=0.97	1.81	45.49	0.91	0.87
	2 WAP	G=0.83	M=0.70	1.53	34.65	G=0.81	M=0.74	1.55	35.49	1.19	1.01
	4 WAP	G=0.93	M=0.65	1.58	36.71	G=0.92	M=0.70	1.62	38.28	1.43	1.31

Discussion

Effect of Groundnut Variety on Time of Introduction of Maize in Groundnut-Maize Intercrop at Makurdi

Interaction effect of varieties and time of introduction of maize over two cropping seasons was significant on groundnut plant height (Table 2). The lowest groundnut height was observed in simultaneous planting with significant improvement at each successive two weeks of delay planting of maize. The highest plant height was observed in sole cropping. However, in intercropping, four weeks of delayed planting maize recorded the highest groundnut plant height. The trend was similar in all the groundnut varieties. The tallest groundnut plant height was observed in SAMNUT 26 at 4WAP (41.34 cm) while the shortest groundnut plant height in intercropping was SAMNUT 26 at 4 WAP. The variation in plant height could be as a result of genotypic attributes and competition for resources among the component crops. Similar results were reported by Gatehum and Abady (2016).

Days to 50% Flowering

The effect of interaction between varieties and time of introduction of maize was significant on the days to 50% flowering (Table 5). It took between 30.73 – 47.20 days for 50% flowering to appear in both cropping systems. The variety to first attain 50% flowering was SAMNUT 24 in intercropping at four (4) weeks delayed maize planting, whereas SAMNUT 26 was the last variety to attain 50% flowering in intercropping at simultaneous planting. On a general note, days to 50% flowering response to cropping systems and days to introduction of maize varied significantly among groundnut varieties. Intercropping resulted in longer days in attainment of 50% flowering.

Number of Leaves at 50% Flowering

Effect of variety and time of interactions on number of leaves at 50% flowering is significant ($P \leq 0.05$). Number of leaves per plant in each variety was higher in sole cropping compare to inter-cropping. Each two (2) weeks delayed introduction of maize resulted in significant increase in number of leaves per plants in the intercrop. SAMNUT 25 had significant more number of leaves per plan (135.67 and 136.73) in 2018 and 2019 respectively in sole cropping compared to intercropping. Number of leaves at 50% flowering in SAMNUT 25 and SAMNUT 26 at four (4) weeks delayed planting was at par and significantly higher than those of SAMNUT 24 at corresponding period of delayed maize planting. Every two (2) weeks delay in planting of maize witnessed a significant improvement in number of leaves close or equal to what is obtained in sole cropping. This could be as a result of decrease in inter-specific competition in terms of light which might have favored the groundnut to establish. This finding is consistent with Idoko et al., (2018) who reported improved maize performance when cowpea planting was delayed in intercropping.

Yield and Yield Components of Groundnut

Number of pods per plant (NPDPP), pod weight (PDWT) and 100 seed weight of groundnut as influenced by varietiesand time of planting maize are presented in Table 7. Yield and yield component of groundnut generally decline in intercropping as compared to sole cropping which was most probably due to interspecific competition and shading during pod filling stage (Akpan et al., 2016).

Delay introduction of maize in already established groundnut stands resulted in progressive increase in yield and yield components of groundnut. This probably could be due to reduced inter specific competition, especially reduced shading effect. With regards to cropping system, the highest number of pods per plant (41.70 and 42.70) in 2018 and 2019 respectively were obtained from sole SAMNUT 25, while intercropping system had the lowest; SAMNUT 24 (23.53), SAMNUT 26 (23.73) respectively in 2018; and SAMNUT 26 (24.37) in 2019, all at simultaneous planting. The decrease in yield component, particularly in simultaneous planting might be due to competition effect of maize component. Caruthers et al., 2000) explained this to be as reduction in photosynthesis occasioned by shading of associated crops to a level that legume plants compensated by decreasing the amount of assimilate allocation to reproductive growth or grain production. Similarly, there was a reduction in pod weigh and seed weight of groundnut.

Pod Yield (Kg/ha)

Groundnut pod yield (kg/ha) in sole and intercropping is presentedin Table 7.

Effect of cropping systems, variety and time of introduction as well as interaction with time of introduction on pod yield was significant ($P \leq 0.05$). The highest pod yield was recorded in sole cropping in both cropping seasons. SAMNUT 25 in sole cropping gave the highest (1760 and 1846.70kg/ha) pod yield in 2018 and 2019 respectively. This was followed by SAMNUT 26 sole (1622.30kg/ha/ and 1709kg/ha) in 2018 and 2019 respectively. The differences in the pod yield among groundnut varieties could be due to the inherent genetic make –up. Mariga, (1990) reported yield variations and crop varieties and ascribed it to their genetic traits. The lowest pod yield in inter cropping for each variety occurred in simultaneous planting. This could be as a result of temporal complementarity among the component crops, a situation which leads to stiffer competition for growth resources. However, successive delay in maize introduction by a space of two weeks each led to progressive increase in pod yield of all varieties in intercropping.

Maize Growth Characteristics, Yield and Yield Attributes

The effect of time of introduction of maize on maize plant height was significant in intercropping with all groundnut varieties in both cropping systems. Height of maize intercropped with SAMNUT 26 were significantly lower than maize plant height in sole cropping. SAMNUT 24 and 25 plant of maize height introduced simultaneously with groundnuts was at par with those of maize plants in sole cropping. However further delay in introduction of maize to two or four weeks after planting groundnut amounted to significant decrease in maize plant height when compare to height of sole maize plant. Therefore, significant negative effect on maize plant height can be avoided when maize is introduced simultaneously into SAMNUT 24, but irrespective of the time of introduction into the remaining two groundnut varieties, maize plant height will still suffer significant decline. Number of leaves per maize plant suffered significant decline in intercropping with all the groundnut varieties only when maize planting was delayed beyond simultaneous level. The number of leaves per plant in intercropping were comparable with those in sole cropping at simultaneous planting of maize.

Days to 50% Flowering

Maize planted simultaneously with groundnut experienced 50% tasselling almost at the same time with sole crop maize. However, delayed introduction of maize in intercrop more than two weeks significantly affect the attainment of 50% tasselling as the case in sole maize cropping. Maize in intercrop had significantly reduced number of cobs per plant.

In 2019, planting maize simultaneously with groundnut recorded higher number of maize cobs per plant as compared with number of cobs per plant in sole cropping. However, in 2018 there was significant reduction in number of cobs per plant in simultaneous maize planting compare to sole cropping of maize.

As there was more delay in maize planting after two weeks, there was more reduction in number of cobs per plant. This is consistent with Amujoyegbe and Elemo (2013) who reported that the delay in introducing cowpea beyond 14 days after sowing caused significant decrease in cowpea canopy, yield and yield attributes, and there was steady decrease as the delay in planting cowpea was prolonged.

The lower leaf area for maize when introduced at 4 weeks could be reasoned to the fact that at this period, groundnut plants could have made efficient utilization of solar radiation, resulting to the larger leaf area.

Effect of Groundnut Varieties and Time of Introduction of Maize on Groundnut in Groundnut-Maize Intercrop on growth and yield of maize

The highest number of pods per plant, highest number of seeds per plant and highest number of seeds per pod obtained from SAMNUT 25 intercropped with maize introduced 4 weeks later can be linked to the highest number of branches obtained at that treatment. In addition, the reduced competition for nutrients achieved in the SAMNUT 25 intercropped with maize introduced 4 weeks later could have induced the highest number of pods, highest number of seeds per plant and highest number of seeds per pod.

The lower competition for available nutrient for sole cropping of maize could be responsible for the least number of days taken to attain 50 % flowering in maize. The report that maize height decreased as time of introducing maize into groundnut advanced agreed with the finding of Fakorede (1985) but contradicted that of Kalu et al (1986) where maize height increased as the season advanced. The conflict in result could be due to differences in environmental conditions and genetic potential of the maize variety used. The lowest competition for growth resources achieved from groundnut with maize planted simultaneously could be attributed to the highest cob weight and yield. This result agreed with Unamma (1989) who reported that best yield of maize was obtained when planting is done at the same time as cassava in a cassava-maize intercrop.

CONCLUSION

From the result obtained, it can be concluded that the highest groundnut grain yield of 1582 kg/ha and 1589.7 kg/ha in intercropping were obtained in SAMNUT 24 when maize was introduced at 4 weeks into groundnut in 2018 and 2019 respectively. The highest average pod yield of 2.951 t/ha and 3.133 t/ha were obtained at simultaneous planting. Maize introduced simultaneously with SAMNUT 25 gave the highest land equivalent ratio of 1.8 and 1.90 in 2018 and 2019 respectively. Highest percentage of land saved of 44.76 % and 47.37 % in 2018 and 2019 respectively. The lowest land equivalent ratio (LER) of 1.46 and 1.52, lowest percentage of land saved of 31.51 % and 32.44% in 2018 and 2019 respectively.

RECOMMENDATIONS

The following recommendations are made:

i. Introduction of maize into groundnut production system should be done simultaneously.
ii. SAMNUT 25 is recommended for groundnut-maize intercrop in Makurdi.
iii. Much economic benefits are derived from groundnut-maize intercrop due to high land equivalent ratio, high percentage of land saved and high gross monetary returns at simultaneous planting in SAMNUT 25.

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