EFFECT OF POPULATION DENSITY OF SWEET POTATO ON THE YIELD OF MAIZE-SWEET POTATO INTERCROP FOR WEEDS SUPPRESSION IN SOUTHERN GUINEA SAVANNAH NIGERIA

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DOI: https://doi.org/10.28941/pjwsr.v26i2.836

ABSTRACT

Maize–sweet potato intercropping often results in weed suppression and increased crop productivity. This study was designed to determine the appropriate planting time and optimal density of sweet potato in a maize-sweet potato intercropping system that will minimize weed infestation and improve yield of the component crops in a drought-prone southern Guinea savanna of Nigeria. The experiment was laid as a randomized complete block design with a split-plot arrangement and 3 replications in 2018 and 2019 growing seasons. The main plots were planting time (May, June and July) while the sub-plots consisted of 3 maize-sweet potato intercropping populations(maize at 53,333 plants/ha + 33,333 plants/ha of sweet potato, maize at 53,333 plants/ha + 66,666 plants/ha of sweet potato and maize at 53,333 plants/ha +99,999plants/ha of sweet potato), sole maize at 53,333 plants/ha and sole sweet potato at 33,333 plants/ha. The results revealed that, 7 weed species were the most prevalent and there was inconsistent effect of planting date on weed flushes while weed smothering efficiency of intercropping was between 31 to 49 % and 48 to 73% for weed density and weed biomass, respectively. Intercropping resulted in land equivalent ratios (LER) of 1.29 to 1.74 while the competitive ability of maize was increased with an increase in sweet potato density. Planting in the month of June had significantly higher tuber yield of 9.56 t/ha of sweet potato and maize grain yield of 3.28 t/ha while intercropping 33,333 plants/ha of sweet potato (1 vine of sweet potato planted at 0.40m apart on the ridge and 0.75m between ridges) and maize at 53,333 plants/ha (0.25m x 0.75m) gave an intercrop yield of 7.32 t/ha tubers and 3.46 t/ha grain yield with highest LER of 1.74, a net profit of ₦566,435.00 and benefit cost ratio of 1.44 was relatively similar to sole sweet potato. Therefore, the above intercropping pattern established in the month of June will minimize weed infestation and improve productivity of maize and sweet potato in the southern Guinea savanna of Nigeria.

Keywords: Intermittent drought, planting time, optimal density, weed suppression ,maize-sweet potato

Citation: Takim , F.O., G.Z. Nayan, O.O. Osatuyiand I.O. Olayiwola. 2020. Effect of Population Density of Sweet Potato on The Yield of Maize-Sweet Potato Intercrop For Weeds Suppression in Southern Guinea Savannah Nigeria. Pak. J. Weed Sci. Res., 26(2): 215-230.

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INTRODUCTION

Maize (*Zea mays* L.)cultivation in sub-Saharan Africa faces difficult environmental stresses. Drought is one of the most serious stresses which occurs intermittently and has led to a decreased maize production in Nigeria (Takim *et al*., 2017).According to Fisher *et al*. (2015), occasional drought stress affects about 40% of Africa's maize growing areas, leading to 10-25%maize yield reduction while Bamikole (2018) reported that recurring droughts drastically affecting the livelihoods of the subsistence farmers and reduces yield by as much as 15% annually, representing crop loss of more than 20 million tons of grain (CGIAR, 2009).

To mitigate the intermitted drought effects on small-scale maize production in the savannah region of Nigeria, alteration of some cultural practices such as planting dates, row spacing, planting population and intercropping of drought-tolerant crops such as sweet potato (*Ipomoea batata* L.) with maize could improve maize ability to establish dominance over stresses (weeds and drought) and increase grain yield. Likewise, Kolo *et al*. (2012) also reported reduction in maize yield with delay in planting while maize contributed distinct competitive advantages over weeds when planted early in southern Guinea of savannah of Nigeria. In similar way, Fanadzo *et al.* (2010) also revealed that sowing of maize with high population (60000plants/ha) in narrow rows reduced weed competition and optimize maize yield. Khan *et al.* (2012) communicated that intercropping of legume with maize was more successful to suppress weeds. Islam *et al.* (2014) revealed that maize paired rows could increase crop productivity and profitability for small-holders while Ossom (2010) recommended sweet potato at 33,333 plants/ha and maize at 40,000 plants/ha as the best intercropping combinations that will cope the menace of drought on maize yield. The uncertainty in the onset of rain in the region, intermitted drought and high weed infestation during the growing season which are some of reasons for low maize grain yield and poor economic return prompted this study. Therefore it is expected that this study willfind out the best planting time and optimal density of sweet potato in a maize-sweet potato intercropping system that will minimize weed infestation and increase productivity.

MATERIALS AND METHODS

Description of Study Site

The trial was conducted at the Teaching and Research Farm, Landmark University, Omu-Aran, Nigeria during 2018 and 2019 cropping seasons. The farm is located at latitude 8^0 $9'$ 0 N and longitude 5^0 $6'$ 0 E in the southern Guinea savanna ecology of Nigeria. The soil of the experimental field was sandy loam in texture and strongly acidic in reaction (pH 4.56), medium in organic matter content (2.23 %), low in status in total Nitrogen (0.15 %), medium in P (9.55 mg/kg), low in K (0.13 cmol/kg), Ca (2.15 cmol/kg) and Mg (0.34 cmol/kg). The temperature ranged between 22^0C -28^0C, relative humidity was 43% - 47% except January while the means average total rainfall received over the two years of study was 1,042.72 mm.

Experimental Design and Field Establishment

The experiment was laid out in randomized complete block design with a split-plot arrangement with three replications. The main plots were three planting times (May, June and July) while the sub-plots consisted of intercropping pattern and these were: maize (53,333 plants/ha) + 1 vine of sweet potato (33,333 plants/ha); maize (53,333 plants/ha)+ 2 vines of Sweet potato (66,666 plants/ha), maize (53,333 plants/ha)+ 3 vines of sweet potato (99,999 plants/ha), sole maize (53,333 plants/ha) and sole sweet potato (33,333 plants/ha). The land was ploughed, harrowed and ridged. Maize variety (Oba super 6) released in Nigeria in 2009, more adapted to savanna ecology, high yielding, drought tolerant and low Nitrogen efficient was sown at a spacing of 0.25m x 0.75m to give an approximate population of 53,333plants/ha. Orange fleshed sweet potato (OFSP) variety UMUSPO/4is a rainforest and savanna region variety with high root carotenoid and dry matter content. OFSP was planted in between the maize stands and the vine cuttings were planted at 0.40m x 0.75m at 1,2, and 3 vines per stand to give an approximate plant population of 33,333, 66,666 and 99,999 plants/ha. The sweet potato was planted a day after maize was sowed. Hoeing weeding was done at 3 and 6 WAP. Fertilizer (NPK 15:15:15) was applied 3WAP (200kg/ha) and 150 kg N/haas urea at 6-7 WAP.

Data Collection

The weed parameters were estimated using a quadrat (25cm x 25cm) placed randomly at 5 positions within each sub plot (30 m^2) at 3,6, 9, and 12 WAP. At each assessment period, emerged weeds were counted, pulled and identified into species level using weed identification Manual by Akobundu, *et al*. (2016). The harvested weeds were oven dried to a constant weight. At harvest, grain row per cob, number of grains per row, number of grains per cob and the grain yield per plot were estimated on maize while root length, and yield of root per plot were taken on sweet potato. Weekly rainfall data for 2018 and 2019 were obtained from the Weather Station of Teaching and Research Farm, Landmark University, Omu-Aran. The Weather Station is about 1km away from the study site.

Data Analyses

Land equivalent ratio (LER) was estimated through the following relationship (Saad *et al*., 2016):

LER = (LERa + LERb) = (Yab/Yaa) + (Yba/Ybb)

Where LERa and LERb are the partial LER of maize and sweetpotato, respectively, and Yab = Yield of maize under intercropping conditions Yba = Yield of sweet potato under intercropping conditions Yaa = Yield of maize under sole crop conditions Ybb = Yield of sweet potato under sole crop conditions.

Competitive ratio (CR) gives more desirable competitive ability for the crops. The CR index was calculated using the following formula (Takim, 2012):

CRa = (LERa / LERb) (Zlb / ZIa)

CRb = (LERb / LERa) (ZIa / ZIb).

where ZIa and ZIb were proportions of maize and sweet potato in the intercrops, respectively

Weed smothering efficiency (WSE) can be defined as follows (Hasanuz zaman *et al*., 2008):

WSE = (W1− W2) / W1× 100

Where, W1: Weed population or weed biomass in sole maize and

W2: Weed population or weed biomass in intercropping system.

The importance value index (IVI) of weed species encountered was evaluated, which numerically expresses the importance of a particular species in a community (Mueller-Dombois & Ellenberg,1974).

$$IVI = RD + RD_O + RF$$

Where,

Relative density (RD) = Density of weed species A /Total density of all species X 100

Relative frequency (RF) = Frequency value for species A / Total of all frequency values for all species X 100

Relative dominance (RD_O) =Dominance for species A/Total dominance of all species X 100

A is one of any of the weed species encountered on the experimental fields.

Theoretically, the most important species in terms of IVI is the one that presents the greater success in exploiting its habitat resources.

The output of the production was computed by the use of benefit cost ratio (BCR) of the orange-fleshed sweet potato production. According to Aiyeloja (2007) the methodology of interpreting benefit cost ratio indicates that BCR greater than 1, means that the Net Profit Value (NPV) of the project benefits outweigh the Net Profit (NPV) Value of the costs. Therefore, the project should be considered if the value is significantly greater than 1. If the BCR is equal to 1, the ratio indicates that the NPV of expected profits equal the costs. If a project's BCR is less than 1, the project's costs outweigh the benefits and it should not be considered. This helps the entrepreneur to know if he remains in business or out of it.

The benefit cost ratio (BCR) is given as:

$$BCR = \sum B / \sum C$$

Where, ∑B = Total net benefit and ∑C = Total cost of production of the enterprise.

Statistical Analysis

Data collected were subjected to analyses of variance (ANOVA) for each year before a combined ANOVA performed for pooled means due to insignificant year effect. Percentage data were arc-sine transformed to stabilise variances. Significant means were separated using Fishers Least Significant Difference (LSD) at $p<0.05$.

RESULTS

Pattern of Rainfall

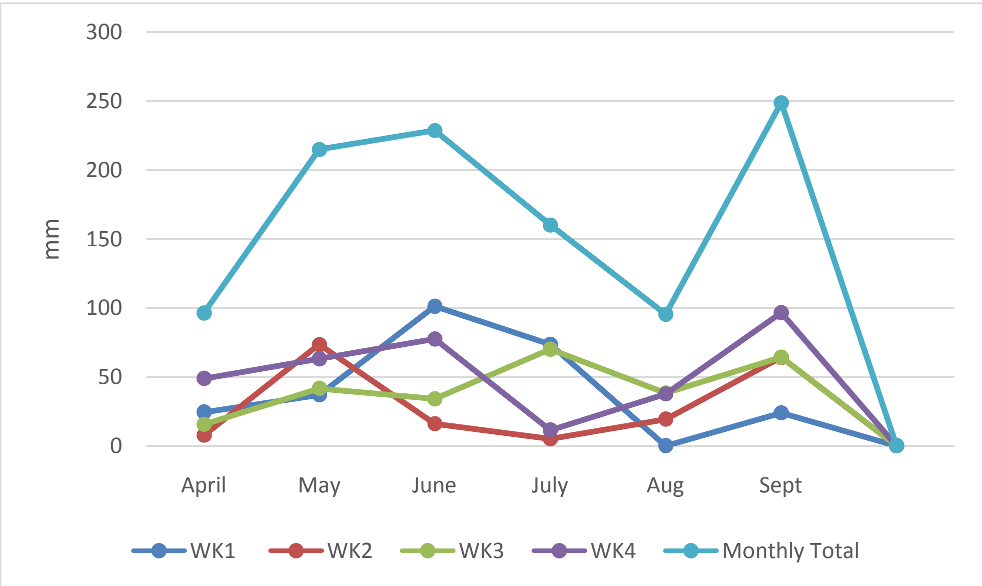
The pattern of rainfall in the study area shows that rainfall stabilized in April and increased gradually, peaked in June (228.61mm), declined in July-August and another peak in September (248.74mm). The decrease in rainfall in July was pronounced during 4th week and continue to the first week in August where no rainfall was recorded in both seasons (Fig. 1). The highest amount of rainfall per week was obtained in the first week of June (101.10 mm) follow by 96.5 mm recorded in the 4th week of September.

Weed Composition and Structure

Twenty five weed species belonging to 24 genera within 15 families were identified throughout the study period. Broadleaves made up of 76 % of the total weed spectrum while grasses and sedges were 20 % and 4 %, respectively. The fields are dominated with annual weed species (68 %) while 32 % were perennial or annual/perennial weed species.

In 2018 season, 23 weed species were identified in the month of May, 21 in June and 20 in July cultivated plots. Fifteen weed species were emerged in all fields. Two broadleaves (*Euphorbia hirta* L. and *Boerhavia erecta*L.) and two grasses [*Cynodon dactylon*L. and *Rottboellia cochinchinensis*(Lour.) W.D. Clayton] were identified in May and June plots while *Bidens pilosa*L. emerged only on plots cultivated in May. *R. cochinchinensis* dominated the plots cultivated in May, *Stachytarpheta jamaicensis* (L.)Vahl and *Spilanthes costata*Benthwere highly abundant in June and July plots, respectively (Table 1).

During the 2019 season, 24 weed species were encountered in May, 20 in June and 23 in July (Table 1). *S. jamaicensis* and *Lindernia crustacea* L. were dominated May plots, *Melochia corchorifolia*L., *Digitaria.Horizontalis*Willd., *Spilanthes costata* and *S. jamaicensis, D. horizontalis, Tithonia diversifolia*(Hemsl.) A. Gray, *R. cochinchinensis* dominated June and July plots, respectively.



WK1= first week of the month, WK2=second week, WK3=third week, WK4=forth week

Figure 1: Pattern and amount of rainfall in the study site

Weed seedlings emerged throughout the season. The weed seedling population increased gradually and peaked at 9 WAP and declined (Table 2). The influence of time of planting was significant ($p<0.05$) on weed seedling population and biomass across the sampling periods. Plots cultivated in the month of May had significantly ($p=0.05$) high weed density follow by June plots while plots established in the month July had significantly ($p<0.05$) low weed seedling population. At 6 and 9 WAP, plots cultivated June had significantly($p=0.05$) high weed biomass compared to other plots. Although, weed biomass did not differed significantly at 12 WAP, plots cultivated in July had higher weed biomass.

Similarly, intercropping pattern significantly ($p=0.05$)affected weed seedling population and weed biomass (Table 2). Sole maize plots had significantly ($p<0.05$) higher weed seedling population followed by plots where maize and single vine sweet potato (M1S) were planted per stand. Other 2 intercropping pattern had similar weed seedling population while the sole sweet potato plots had significantly ($p=0.05$)lower weed seedling population. Conversely, sole sweet potato plots had significantly lower weed biomass, intercrop plots had similar weed biomass while significantly ($p<0.05$) higher weed biomass was observed on sole maize plots at all sampling periods.

The weed smothering efficiency is presented in Table 3. The number of vines of sweet potato planted significantly ($p\leq0.05$) influenced weed density and biomass thus differences in smothering effects. Three vines of sweet potato planted in between maize significantly ($p\leq0.05$) had greater weed smothering efficiency except at 3WAP where similarities were observed with other plots. The smothering effect decreased as the crops ages. The weed smothering efficiency ranged between 31-49% for weed density and 48-73% for weed biomass.

Crops Yield (t ha^{-1})

There was no seasonal effect on the root yield of sweet potato. The average vine and root length was 240.44 cm and 15.81cm, respectively while the tuber yield ranged between 7.68 and 7.79 t/ha (Table 4). Time of planting sweet potato significantly ($p<0.05$)influence number of leaves per stem, vine length, root length and root yield. Plots established in May had significantly lower root length (13.42 cm) compared with late sowing. Sweet potato planted in June following July had similar root length although significantly($p<0.05$) higher than root length obtained in May plots.

Similarly, sweet potato planted in June had significantly($p<0.05$) higher root yield (9.56 t/ha) while other plots had lower root yields. Root length was not affected by intercropping pattern although root length ranged between 14.89 cm and 16.67 cm across intercropping patterns. Sole sweet potato plots had significantly ($p<0.05$) higher root yield of 9.13 ton/ha follow by plots where 1 vine of sweet potato were intercropped with maize (8.12 t/ha) while other plots had root yields which ranged between 5.23 and 6.05 t/ha.

Maize yield and yield components were not significantly ($p<0.05$) affected by season although 2018 had better grain yield (3.33 t/ha) compared to 2.31 t/ha obtained in 2019 cropping season (Table 5). Whereas, time of planting significantly ($p<0.05$) influenced yields of maize. Maize plots established in June had significantly ($p<0.05$) higher grain yield (3.28 t/ha follow by maize plots sown in the month of May with 3.13 t/ha of grain yield while 2.05 t/ha was obtained from maize plots established in July. The intercropping pattern did not affect yield and yield components of maize although high grain yield (3.40 t/ha) was obtained from the sole maize plots while the intercropped plots had grain yield ranged between 2.45 and 2.89 t/ha.

The land equivalent ratio values (Table 6) for all the intercropped patterns were greater than unity. The plots with the highest number of planted sweet potato vines had lower LER value of 1.29 compared to others. The maize had higher competitive ratio for the intercropped patterns except M3S where sweet potato was observed to be more competitive (1.05). The increased in number of vines to intercropped plots increases the competitive ability of maize and vice versa for sweet potato. The interaction between planting dates and intercropping was significant ($p<0.05$)on maize grain and sweet potato tuber yields (Table 7). While sole maize yield was significantly higher when sown in May or June, sole sweet potato tuber yield was significantly better if planted during the month of June or July. Relatively, the month of June had better grain and tuber yields.

The Net profit generated from the enterprise was highest at intercrop of maize + 1 vine of sweet potato giving ₦566,435.00 while the lowest the net profit of ₦ 29,970.00 was obtained from intercrop of maize + 3 vines of sweet potato. The economic analysis showed that, intercropping maize and sweet potato at 53,333 and 33,333 plants/ha, respectively in June had benefit cost ratio (BCR) of 1.44as compared BCR of 1.43 and 1.55obtained sole sweet potato established in June and July, respectively (Table 7).

DISCUSSION

This study shows that there was a pronounced decrease in amount and days of rainfall during the fourth (4^{th}) week of July and no rainfall was recorded during the first week of August of each study season. This implies that there was intermittent drought during the above stated periods in the crops life cycles in the experimental area. To mitigate the above effect, Amede (2001) recommended intercropping sweet potato between maize rows in regions with intermittent drought, frequent terminal drought and relatively longer growing periods. Ossom (2010) concluded that, there is a need to produce and consume more drought-tolerant crops such as sweet potato under intercropping with the staple crops in Swaziland.

In this study, weed seedlings emerge throughout the growing periods of crops but majority of the weed species encountered in this study at their high emergence in May but there was inconsistent effect of planting date on weed flushes which may be due to high number of weed seeds in the seed bank ready to germinate likely because the few rainfalls might have softened the seed coat to overcome seed dormancy. While the relatively lower number of weed species emergence in June and July might be due to lower number of weed seeds in the seed bank as of that time. In other words, the potential emergence might have occurred in May thus, the importance of delay planting. Seven weed species were most prevalent in the maize-sweet potato intercrop fields and these include: *Stachytarpheta jamaicensis;Lindernia crustacea; Melochia corchorifolia; Digitaria horizontalis; Spilanthes costata; Tithonia diversifolia;* and *Rottboellia cochinchinensis*.

Weed seedling emergence (infestation) was affected by time of planting in a consistent manner. This is in agreement to the results of Bonic *et al.* (2010) who reported that weed infestation was significantly affected by sowing date of wheat in Hungary and in contrast to Kolo *et al.* (2012) who reported inconsistency in weed seedling emergence across planting dates of maize. The relatively high period of weed emergence falls between 6 and 9WAP. Similar observation was reported on maize-cowpea intercropping system (Takim *et al.,* 2014).

Intercropping helps to increase weed suppression relative to sole cropping (Baumann *et al.,* 2000; Workayehu, 2014; Takim *et al.,* 2014)). In this study, weed smothering efficiency was between 31 to 49 % and 48 to 73% for weed density and weed biomass, respectively and the smothering effect depends on the number of sweet potato vine planted between maize plants. Similarly, Hussain *et al.* (2013) reported that maize-French bean intercropping reduced weed population by 35 to 56%, Omov bude *et al.* (2017) showed that the highest weed smothering efficiency was in maize intercropped with egusi-melon (84.15%) while the lowest was in maize intercropped with pumpkin (60.37 %) while Saad *et al*. (2016) reported WSE of 31 to 38.5 % where lettuces were cropped simultaneously with cauliflowers.

It was observed that weed growth suppression was mainly due to increased shading of within-rows. The competitive effect of weeds was reduced when the vine number planted increased from one to three (higher density and closer spacing). Evidently, crop canopy closure developed much earlier in plots where the sweet potato was planted at higher density leading in shading that reduced weed density and biomass. This probably explains why the intercropping had significant effect on weed biomass only at 6 and 9 WAP in this study. Other studies (Mashingaidze, 2004; Singh and Singh, 2006) have reported weed suppression with high plant populations, Amosun & Aduramigba-Modupe (2016) also reported a reduction in weed pressure in the groundnut-cassava intercropped compared to sole cassava which was due to high plant population of the component crops that led to better ground cover.

Planting sweet potato in the month of June had significantly higher tuber yield of 9.56ton/ha of sweet potato compared to other planting months. The variation in rainfall during the months of planting could be the reason for differences in yield. The month of June during this study had the highest amount of rainfall (228.61 mm) and evenly distributed although similar to the month of May compared to July that had 160.20 mm of rainfall with intermittent drought at the last week of the month. This variation in the moisture and likely plant population per plot may have contributed to the variation in sweet potato yield. The maximum yield of sweet potation in the intercrop was obtained from 1 vine of sweet potato (33,333 plants/ha) planted between maize stands (8.12 ton/ha) while 6.05 ton/ha from a two vines of sweet potato (66,666plants/ha) planted between maize stands was the lowest compared to 9.13 ton/ha obtained from sole sweet potato plots. The difference in yield occurred due to variation in plant population as well as other yield attributes not reported. It was observed that, the number of vines planted determined the number of plants per plot also each stem at full establishment behaves as separate sweet potato plant since each has its own root and shoot system (Akintoye *et al.* 2009; Islam *et al.* 2014; Ogbologwung *et al*. 2016 and similar observation were reported on yams (Okpara *et al.,* 2013; Ikoro *et al.,* 2014) but sweet potato at plant population above 33,333 plants/ha probably had reached the carrying capacity, thus additional seedlings are destroyed through allelopathy, competition (self – thinning), shading effects provided by the previously emerged stems, or any combination of the above factors might have led to low tuber yield.

The plant population of maize in the intercropping of maize-sweet potato did not differed, the reduction in grain yield of the intercropped maize might be associated with inter-specific competition between the intercrop components for growth resources and the depressive effects of sweet potato. Dasbak and Asiegbu (2009) explained that sharing of growth resources among components crops under intercropping can limit growth and accumulation of dry matter compared to sole cropping where competition exists and in this study, the competitive ability of maize increased with an increased in number of sweet potato vines planted. When 3 vines of sweet potato were intercrop between maize stands, the competitive ability of the maize (3.78) was higher than 0.42 obtained for sweet potato. Although, the yield of maize varieties was depressed in intercropping compared to sole cropping, the sweet potato yield compensated for this depression and the higher LER recorded in intercropping plots indicated yield advantage over sole cropping which demonstrated a better land utilization and cumulative yield. This findings agreed with the reports of Saad *et al,* (2016)that LER were highest from plots where cauliflowers and lettuces were intercropped at different plating populations as compared with monocropping patterns. Nedunchezhiyan *et al,* (2011) viewed that, a strip intercropping system involving sweet potato + pigeon pea resulted in a higher land equivalent ratio (1.31) and net return ($623.9) compared to the other forms of intercropping and to monocropping; Workayehu (2014) reported that intercropping was more effective and efficient than sole crops in the use of environmental resources as demonstrated by higher LER. Asiimwe *et al*. (2016) observed that, LER >1.2 obtained at maize-sweet potato intercrop with maize densities of 41,666 and 55,555 plants/ha in northern Uganda and Idoko *et al.* (2018) in Makurdi-Nigeria concluded that LER values for all the intercrop combinations have shown that it is advantageous to intercrop maize with sweet potato.

CONCLUSION

It was therefore concluded that, planting in the month of June had significantly higher tuber yield of 9.56 t/ha of sweet potato and maize grain yield of 3.28 t/ha while intercropping 33,333 plants/ha of sweet potato (1 vine of sweet potato planted at 0.40m apart on the ridge and 0.75m between ridges)and maize at 53,333 plants/ha (0.25m x 0.75m) gave an intercrop yield of 7.32 t/ha tubers and 3.46 t/ha grain yield with highest LER of 1.74, a net profit of ₦566,435.00 and benefit cost ratio of 1.44 was relatively similar to sole sweet potato. Therefore, the above intercropping pattern established in the month of June will minimize weed infestation and improve productivity of maize and sweet potato in the southern Guinea savanna of Nigeria.

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Table 1: Importance Value Index of weed species encountered across time of planting in 2018 and 2019 seasons

		LC	MG	MAY	JUNE	JULY	MAY	JUNE	JULY
Family	**Weed species**				**2018 Season**			**2019 Season**	
Asteraceae	*Ageratum conyzoides* L.	A	B	3.73±0.75	4.30±0.86	3.59±0.62	7.06±1.42	4.80±0.74	3.33±0.51
	Aspilia africana (Pers.) C. D. Adams	P	B	2.02±0.31	1.50±0.43	2.88±0.83	2.11±0.47	1.42±0.32	2.83±0.51
	Bidens pilosa L.	P	B	1.96±0.26	-	-			
	Tithonia diversifolia (Hemsl.) A. Gray	P	B				2.49±0.99	-	10.80±2.40
	Spilanthes costata Benth.	A	B	8.63±1.57	3.49±0.51	15.30±2.1	4.58±0.66	10.66±1.54	4.66±0.95
	Vicoa leptoclada (Webb) Dandy.	A	B	0.84±0.17	2.86±0.73	0.54±0.13	1.17±0.28	2.00±0.38	1.02±0.19
Convolvulaceae	*Ipomoea involucrate* P. Beauv.	AP	B	1.01±0.14	2.34±0.73	1.52±0.21	2.05±028	0.18±0.02	2.22±0.43
Cyperaceae	*Cyperus rotundus* L.	P	S	4.12±0.79	1.96±0.32	0.68±0.18	2.05±0.54	-	1.39±0.21
Euphorbiaceae	*Euphorbia heterophylla* L.	A	B	3.28±0.42	0.99±0.12	0.76±0.09	2.05±0.21	5.52±0.76	2.30±0.29
	Euphorbia hirta L.	A	B	0.86±0.11	2.18±0.22	-	2.05±0.42	2.60±0.89	1.36±0.19
Hydrophyllaceae	*Hyptis suaveolens* Poit	A	B	-	3.75±0.54	0.76±0.09	2.05±0.53	0.93±0.49	-
Leguminosae	*Indigofera hirsute* L.	A	B	1.75±0.29	-	1.58±0.23	2.41±0.29	-	1.07±0.13
	Tephrosia linearis (Willd.) Pers.	A	B	-	0.10±0.01	0.52±0.08	2.48±0.34	-	0.51±0.08
Nyctaginaceae	*Boerhavia erecta* L.	P	B	1.08±0.02	1.14±0.15	-	4.83±0.65	2.05±0.38	0.88±0.12
Onagraceae	*Ludwigia hyssopifolia* (G. Don) Exell	A	B	8.53±1.15	4.97±0.78	4.56±0.54	5.44±0.85	0.99±0.13	2.21±0.29
Poaceae	*Cynodon dactylon* L	P	G	0.61±0.11	1.54±0.24	-	0.55±0.07	-	-

	Digitaria horizontalis Willd.	A	G	4.86±0.66	4.72±0.87	8.93±1.66	2.53±0.47	11.72±1.83	10.15±1.21
	Paspalum scrobiculatum L.	P	G	1.23±0.19	6.79±0.92	1.46±0.27	3.87±0.58	1.01±0.13	7.51±1.32
	Rottboellia cochinchinensis (Lour.) W.D. Clayton	A	G	19.51±2.87	3.51±0.73	-	0.88±0.15	2.14±0.27	9.84±1.26
	Brachiaria deflexa (Schumach.) Robyns	A	G	3.71±0.42	2.64±0.69	1.42±0.43	3.37±0.68	2.93±0.17	0.52±0.08
Rubiaceae	*Mitracarpus villosus* (Sm.) DC.	A	B	0.59±0.09	-	0.40±0.07	-	3.22±0.37	2.44±0.31
	Oldenlandia corymbosa L.	A	B	6.60±1.14	10.23±1.16	10.77±1.58	6.71±1.07	9.86±1.35	4.36±0.74
Scrophulariaceae	*Lindernia crustacea* L.	A	B	5.98±0.76	16.41±2.08	14.90±1.25	13.70±1.39	8.02±1.17	6.93±0.87
Spigeliaceae	*Spigelia anthelmia* L.	A	B	6.07±1.03	-	5.92±0.67	3.15±0.54	6.72±0.85	2.99±0.43
Sterculiaceae	*Melochia corchorifolia* L.	A	B	6.99±1.43	6.79±0.76	9.80±1.24	5.62±0.57	16.66±1.68	5.75±0.73
Verbenaceae	*Stachytarpheta jamaicensis* (L.) Vahl	P	B	5.91±0.75	18.17±1.83	13.46±2.29	21.33±2.16	2.02±0.41	15.40±1.73

LC=life cycle, A=annuals, P=perennials, MG=morphological group, , B=broadleaves, S= sedges, G=grasses

Table 2: Effect of time of planting and intercropping pattern on weed density and biomass

	Weed density (Seedling/m^2)				Weed Biomass (g/m^2)			
Season (S)	3WAP	6WAP	9WAP	12WAP	3WAP	6WAP	9WAP	12WAP
2018	24^b	36	24	36	0.65^b	12.91	16.05	25.45
2019	12^a	28	32	32	0.06^a	4.04	8.94	12.91
Time of Planting (T)								
May	24^c	56^c	56^c	52	0.38	16.84^b	24.84^b	24.74
June	20^b	24^b	28^b	20	0.39	4.73^a	6.85^a	14.58
July	12^a	20^a	20^a	32	0.30	3.86^a	5.82^a	18.32
Cropping System (C)								
M1S	20^b	32^b	44^c	36^c	0.33	10.04^b	11.81^b	15.18
M2S	16^a	32^b	40^c	32^b	0.27	5.51^{ab}	11.92^b	20.37
M3S	16^a	32^b	32^b	29^b	0.32	5.32^{ab}	8.65^{ab}	14.04
SMZ	24^c	50^c	58^d	48^d	0.43	19.46^c	27.97^c	41.06
SSP	16^a	18^a	22^a	14^a	0.43	1.97^a	2.24^a	5.52
Interaction								
S x T	NS	NS	NS	NS	NS	*	*	*
S x C	NS	NS	NS	NS	NS	*	NS	NS
T x C	NS	NS	NS	NS	NS	NS	NS	NS
S x T x C	NS	NS	NS	NS	NS	NS	NS	NS

M1S=maize@1seed/hill + vine/stand, M2S=maize@1seed/hill + 2vines/stand, M3S=maize@1seed/hill + 3vines/stand, SMZ=sole maize, SSP=sole sweet potato, *=significant at 0.05

Means followed by the same letter within the column are not significantly different at P≤0.05

Table 3. Weed smothering efficiency (WSE) based on weed density and biomass over sole maize in maize-sweet potato intercropping

	WSE (%) Weed Density				WSE (%)Weed Biomass			
Intercropping	**3WAP**	**6WAP**	**9WAP**	**12WAP**	**3WAP**	**6WAP**	**9WAP**	**12WAP**
M1S	17^b	36	24^c	25	23^c	48^b	58^b	63^b
M2S	33^a	36	31^b	33	37^a	72^a	57^b	50^c
M3S	33^a	36	49^a	40	26^{bc}	73^a	69^a	66^a

M1S=maize@1seed/hill + vine/stand, M2S=maize@1seed/hill + 2vines/stand, M3S=maize@1seed/hill + 3vines/stand, WAP=weeks after planting.

Means followed by the same letter within the column are not significantly different at P≤0.05

Table 4: Effect of time of planting and intercropping pattern on yield of sweet potato

Season (S)	**Vine Length (cm)**	**Number of Leaves per stem**	**Tuber length (cm)**	**Tuber Yield (t/ha)**
2018	270.43	46	15.81	7.79
2019	270.46	48	15.87	7.68
Time of Planting(T)				
May	290.87^a	44^b	13.42^b	6.95^b
June	203.24^b	41^b	17.83^a	9.56^a

July	317.29^{a}	56^{a}	16.17^{a}	7.19^{b}
Intercropping Pattern (I)				
M1S	287.84	48	16.67	6.05^{c}
M2S	300.27	47	14.89	7.12^{b}
M3S	254.19	46	15.56	5.23^{d}
SMZ	-	-	-	-
SSP	239.67	47	16.11	9.13^{a}
Interaction				
S x T	NS	NS	NS	NS
S x C	NS	NS	NS	NS
T x C	NS	NS	NS	NS
S x T x C	NS	NS	NS	NS

M1S=maize@1seed/hill + vine/stand, M2S=maize@1seed/hill + 2vines/stand, M3S=maize@1seed/hill + 3vines/stand, SMZ=sole maize, SSP=sole sweet potato, *=significant at 0.05
Means followed by the same letter within the column are not significantly different at P≤0.05

Table 5: Effect of times of planting and intercropping pattern on yield of maize

Season (S)	Row per Cob	Seeds per Row	Seeds per Cob	1000 Seed Weight (g)	Grain Yield (ton/ha)
2018	14	31	436	191.16	3.33
2019	14	26	362	200.84	2.31
Time of Planting (T)					
May	14^{b}	24^{bc}	345^{b}	165.85^{c}	3.13^{a}
June	15^{a}	32^{a}	482^{a}	229.93^{a}	3.28^{a}
July	13^{c}	28^{ab}	370^{b}	192.10^{b}	2.05^{b}
Intercropping Pattern(I)					
M1S	14	27	413	192.82	2.89^{ab}
M2S	14	28	385	187.23	2.53^{b}
M3S	14	29	399	192.85	2.45^{b}
SMZ	14	28	399	207.95	3.40^{a}
SSP	-	-	-	-	-
Interaction					
S x T	NS	*	*	NS	NS
S x C	NS	NS	NS	NS	NS
T x C	NS	NS	NS	NS	NS
S x T x C	NS	NS	NS	NS	NS

M1S=maize@1seed/hill + vine/stand, M2S= maize@1seed/hill + 2vines/stand, M3S= maize@seed/hill + 3vines/stand, SMZ=sole maize, SSP=sole sweet potato, *=significant at 0.05
Means followed by the same letter within the column are not significantly different at P≤0.05

Table 6. Land equivalent ratio and competitive ratio sole stands and intercrop of maize and sweet potato

Cropping System	LER	CRa	CRb
M1S	1.74[a]	0.95[c]	1.05[a]
M2S	1.40[b]	2.29[b]	0.56[ab]
M3S	1.29[c]	3.78[a]	0.42[b]
SMZ	1.00[d]	-	-
SSP	1.00[d]	-	-

M1S=maize@1seed/hill + vine/stand, M2S= maize@1seed/hill + 2vines/stand, M3S= maize@seed/hill + 3vines/stand, SMZ=sole maize,, SSP=sole sweet potato, LER= Land Equivalent Ratio, CRa = Competitive Ratio for maize, CRb= Competitive Ratio for sweet potato.

Means followed by the same letter within the column are not significantly different at $P \leq 0.05$

Table 7. Benefit cost ratio analysis of maize-sweet potato intercrop

Planting Date	Intercropping	Grain Yield (kg/ha)	Tuber Yield (kg/ha)	Vine Yield (bundle/ha)	Total Cost (₦)	Total Revenue (₦)	Net Profit (₦)	Benefit Cost Ratio
May	M1S	2390[e]	4530[d]	225[de]	392,865	530,200[bc]	137,335[c]	0.35
	M2S	2280[ef]	5030[d]	310[d]	559,330	588,900[b]	29,570[d]	0.05
	M3S	3320[bc]	4120[e]	287[d]	724,530	615,100[ab]	-109,430[e]	-0.15
	SMZ	3940[a]	0	0	161,200	315,200[dc]	154,000[c]	0.96
	SSP	-	6230[c]	539[bc]	303,665	581,000[b]	277,335[b]	0.91
June	M1S	3460[b]	7320[b]	633[ab]	392,865	959,300[a]	566,435[a]	1.44
	M2S	3770[ab]	6050[c]	430[c]	559,330	819,100[a]	259,770[b]	0.46
	M3S	3320[bc]	5230[c]	594[a]	724,530	824,100[a]	99,570[c]	0.14
	SMZ	4290[a]	0	0	161,200	343,200[dc]	182,000[c]	1.13
	SSP	-	9130[a]	564[ab]	303,665	738,500[a]	434,835[a]	1.43
July	M1S	2220[ef]	3560[e]	198[e]	392,865	454,600[c]	61,735[d]	0.16
	M2S	2280[ef]	3760[e]	210[e]	559,330	475,400[c]	-83,930[e]	-0.15
	M3S	2060[f]	4220[d]	340[cd]	724,530	545,800[bc]	-178,730[e]	-0.25
	SMZ	2660[d]	0	0	161,200	212,800[d]	51,600[d]	0.32
	SSP	-	8740[a]	674[a]	303,665	774,000[a]	470,335[a]	1.55

M1S=maize@1seed/hill + vine/stand, M2S= maize@1seed/hill + 2vines/stand, M3S= maize@seed/hill + 3vines/stand, SMZ=sole maize, SSP=sole sweet potato, Cost: Farm gate prices at Ilorin (₦80/kg of maize;₦50/kg of sweet potato; ₦500/bundle of vine).