International Journal of Innovative Research and Advanced Studies (IJIRAS)
Volume 3 Issue 8, July 2016

ISSN: 2394-4404

# Effect Of Population Density Of Sweet Potato And Cropping System On The Yield Of Sweet Potato- Soybean Intercrop In The Southern Guinea Savannah Agro-Ecological Zone Of Nigeria

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***Abstract:*** ***The effect of population density of sweet potato and cropping system on the yield of sweet potato intercropped with soybean was studied; the objectives were to determine the effect of population density on the growth, yield and yield components and to investigate possible differences in the response of the two crops to various population densities and cropping system. Field experiments were conducted at the University of Agriculture teaching and research farm during 2011 and 2012 cropping seasons in a split plot laid out in a randomized complete block design replicated three times. Three population levels (50,000plants/ha; 33,333plants/ha and 25,000plants/ha) and two cropping systems (sole and intercropping) were used. Result showed that in sweet potato, number of branches, vine length and leaf area were significantly (P<0.05) influenced by intercropping. Number of branches increased with decreased in population density, population density one (50.000plants/ha) significantly differed from population densities two and three (33,333 plants/ha and 25,000 plants/ha). Yield and yield components of sweet potato (excerpt root length and harvest index) were significantly influenced by cropping system; there was 47.04% and 56.46% reduction in net yield in 2011 and 2012 in intercropping. Significant effect of population density was only observed on number of roots per plant, unmarketable root number and net yield. There was decreased in net yield and unmarketable root number as population density was decreased. Result on soybean showed that all parameters excerpt number of pods per plant and net yield were not significantly affected by cropping system. Soybean number of pods per plant and net yield were significantly (P>0.05) higher in sole cropping than intercropping. Population density had no significant effect on any soybean parameters observed. Land Equivalent Ratio (LER) values irrespective of the population density tested were greater than unity (LER>1.0). Higher LER values of 1.46 and 1.48 were obtained at 33,333 plants /ha. Competitive Ratio (CR) values of intercropped soybean were higher than its associated crop, for sweet potato, higher CR values of 0.56 and 0.70 were obtained from population density of 25,000 plants /ha.***

***Keywords: Cropping system, population density, sweet potato, soybean, yield advantage.***



## I. INTRODUCTION

Sweet potato has become an attractive crop among farmers due to its high productivity, universal uses, calorie content and good taste. It tolerates adverse environmental conditions such as drought, low soil fertility and it require very little labor and care compared to other crops (Abdissa, 2011). It is one of the cheapest potential sources of vitamin A to alleviate problem of night blindness and infant mortality (Terefe and Geleta, 1994; Korieocha *et al*., 2009). Researchers revealed sweet potato as a weapon against diabetes as a result of its low glycemic index (Bradley, 2009; Zakir *et al*., 2008). It serves as cover crop which prevent run off, therefore controlling erosion in farmers plots (Janssens, 2001). The crop has a short duration (3-4 mouths) and could be cropped more than once in the year (Nwauzoe *et al*., 2006) and once fully established, it suppresses weeds and reduces cost of production compared to cassava and yam (Chukwu, 2001;

Antiabong *et al*., 2008). It is also becoming popular as a substitute for yam; it can be reconstituted into fofoo or blended with other flour sources such as wheat, cassava or even maize for baking of bread, biscuit and other confectioneries (Wooife, 1992).

Soybean (*Glycine max* (L) Merr.) is an integral component of the traditional cropping system of the Southern Guinea Savanna agro- ecological zone due to its beneficial effect on sustainability and as a source of nutritious food *(*Henriet *et al., 1997).* The importance of soybean is predicated on its high nutritious quality with respect to its protein and oil. From the nutritional standpoint, it ranks high in the protein quality index as ascertained by Food and Agricultural Organization (Langer and Hill, 1991). Soybean ranks below fish, beef muscle and whole egg, but above other legumes and cereal proteins. In developing countries, it is an important industrial crop especially in the manufacture of non-food and as a food crop in the making of confectionaries and main dishes is currently being extensively exploited *(*Atteh *et al., 1990*). Oil from soybean is of high quality, being 85 percent unsaturated and cholesterol free and hence is suitable for heart disease patients (Onochei, 1975). In Nigeria, soybean is chiefly grown in Benue state as a cash crop by small farmers who majorly grow it in sole plots or simultaneously with cereals.

Plant population density has a pronounced effect on the growth of crops, when plant population is too high, it encourages interplant competition for resources which affects crops net yield (Muuoneke *et al.*, 2007 and *Sharifi et al.*, 2009). Ennin *et al (*2002) showed that inappropriate plant populations or wide spacing could limit crop yield due to inefficient use of solar energy. Workatyehu (2001) recommended optimum population levels so as to exploit maximum natural resources such as nutrients, sunlight, and soil moisture and to ensure satisfactory yield.

Plant population is one of the most important factors contributing to high yield of sweet potato crop (Abdisa *et al*., 2011), It has been observed that as plant population per hectare increases, the number of storage roots per plant decreases, the mean weight per root decreases and the final yield per plant tends to decrease as well (Bianco, 1975; Farooque *et al*., 1983; Sharifi *et al*., 2009; Osom *et al*., 2009), while weight , sizes, and root number per plant increases with decreased in population (Sokoto *et al*.,2007; Abdisa *et al*., 2011). Bouwkamp and Scoot (1980) investigated the effect of plant population on yield component of sweet potato, they observed yields to be highest at the closest spacing and decreased linearly with wider spacing and believed this was apparently due to an increased number of roots/plant with increase plant density. However, Baker (1981) and Santoso *et al* (1996) reported no effect of intra row spacing on total root yield or yield of marketable root. Similarly, there have been differential recommendations for plant population density in sweet potato production. Mortley *et al* (1991); Sokoto *et al* (2007) and Onunka *et al* (2011) recommend 50,000 plants /ha, while Nkambule and Ossom (2010) gave 33,333.33 plants / ha and Belehu (2003) reported 55,555 plants / ha as optimum for sweet potato.

Intercropping is the cultivation of two or more crops at the same time in the same field and is one way to increase the diversity of farming systems (Van Wolfswinkel, 2010). Advantages of intercropping include increased crop diversity which helps to protect crops from insect pests and diseases and if well done, may allow for more efficient use of limited soil and water resources and crop yields are improved (Andersen *et al*., 2007). When two or more crops with different rooting systems, a different pattern of water and nutrient demand, are planted together, water, nutrients and sunlight are used more efficiently (Nkambule and Ossom 2010). It is understood that the farmer choice of intercropping is based on diversity of diet and income source, stability of production with limited resources (Francis *et al*., 1976; Jornsguard, 2005; Lichtfouse *et al* ., 2009). In intercropping there is insurance against crop failure while at the same time spreading labour peaks and extending the growing period (Willey, 1985; Ofori and Stern, 1987; Onduru and Dupreez 2007). Therefore, the combined yields of two crops grown in intercrops can be higher than the yield of the same crop grown as pure stand (Ennin *et al*.,2002).

Intercropping sweet potato with soybean would not only ensure better environmental resource utilization but would also provide better yield sustainability, reduce pests and diseases and diversify rural income (Egbe and Idoko, 2009). Previous studies on sweet population density were based on sole cropping (Mortley *et al.*,1991; Sulaiman and Sasaki, 2001; Belehu,2003; Sokoto *et al*., 2007, and Onunka et al., 2011) and on sweet potato intercropping on crops such as sweet potato/maize (Ossom, 2010; Udealor *et al.*, 2006), sweet potato- pigeon pea (Egbe and Idoko, 2009); sweet potato/ jugo bean(Nkambule and Ossom, 2010); sweet potato - okra (Njoku *et al.*, 2007; Ijoyah and Jimba, 2011) and sweet potato - cowpea (Alhassan, 1988). These authors had recommended various population densities in sole cropping and intercrops and reported yield advantages of intercropping sweet potato with some of the associated crops. Though works have been obtained as it relates to intercropping sweet potato with other associated crops, however, there is dearth of information as it relates to optimum population density of sweet potato with soybean crop. The objectives of this study were therefore to identify the optimum plant population that will maximize the intercrop yields of sweet potato-soybean, to investigate the effect of intercropping on the performance of sweet potato and soybean crops and to assess the yield advantages of intercropping sweet potato with soybean.

## II. MATERIALS AND METHODS

Field trials were conducted during 2011 and 2012 cropping seasons at the Teaching and Research Farm of the University of Agriculture Makurdi, Nigeria to evaluate Effect of population density of sweet potato and cropping system on the yield of sweet potato-soybean intercrop in Makurdi Nigeria. The study location ($7^o$ $14^1$ N and $8^o$ $37^1$ E) is at an altitude of 228m above sea level in the Southern Guinea Savannah agro-ecological zone of Nigeria. The texture of the top soil (30 cm) of the experimental site was sandy loam (Table 1).

**Physical and Chemical Properties of the soil of the experimental site in 2011 and 2012**

| S0il parameters | Method of analysis | 2011 | 2012 |
|---|---|---|---|
| %sand | Hydrometer | 84.4 | 85.02 |
| %silt | ,, | 8.45 | 7.88 |
| %clay | ,, | 7.15 | 7.10 |
| Textural class | | Sandy loam | Sandy loam |
| pH (1:1soil/$H_2$o) | pH meter | 6.2 | 6.3 |
| pH (1:1 soil/kcl) | ,, | 4.6 | 4.8 |
| organic matter | Walkley black | 2.62 | 2.44 |
| Exchangeable catio | A A S | 3.46 | 2.92 |
| Available P mg/kg | Bray-1 | 6.5 | 5.8 |
| Total Nitrogen g/kg | Kieldahl | 0.96 | 0.88 |
| Exchangeable Mg | flame photometer | 1.0 | 1.02 |
| Exchangeable K | ,, | 0.32 | 0,30 |

*Table 1*

The experiment was a 2x3 split plot laid out in a randomized complete block design replicated three times. Main plot consisted of the cropping system (sole sweet potato, sole soybean and the intercrop of sweet potato and soybean). Sub plot consisted of Population density (50,000plants/ha; 33,333plants/ha and 25,000 plants/ha). Sweet potato variety (NRSP/05/007c) was obtained from National Root Crop Research Institute sub- station Otobi while soybean variety TGX 1448-2E was obtained from National Cereal Research Institute sub – station Yandev, Gboko. The land was manually cleared and ploughed, the gross plot consist of 4 ridges 3m long ($12m^2$) while the net plot had 2 ridges, each 4m long. Planting was done on the $7^{th}$ and $9^{th}$ of July 2011 and 2012 respectively. Sweet potato vines of 30cm with at least 4 nodes were planted by the side of the ridge spaced- 100cm x 20cm (50,000plants/ha); 100cm x 30cm (33,333plants/ha) and 100cm x 40cm (25,000plants/ha) while soybean was sown on top of the ridge with seeds drilled which were later thinned to one plant per stand in sole and intercrop at a spacing of 100cm x 5cm (200.000plants/ha). Fertilizer was applied based on recommendation of Benue state (Makurdi), soybean – 10kg N/ha; 36kg $p_2o_5$/ha and 20kg $k_2o$/ha. Sweet potato – 34kg N/ha; 50kg $p_2o_5$/ha and 80kg $k_2o$/ha (Kalu, 1993).Weeding was carried out manually twice before the crops matured; soybean was harvested when it was fully matured and the leaves have turned brown and sweet potato when the leaves were turning yellowish.

The following parameters were taken: sweet potato – number of branches, leaf area, vine length, fodder weight per plant, fodder weight per tonne, number of roots per stand, root length, root girth, marketable root number (comprised of tuberous roots > 150g which are not infested or disease attacked), unmarketable root number (comprised of roots < 150g) and net yield. Soybean – plant height, number of days to 50% flowering, number of branches per plant, number of pods per plant, number of empty pods per plant, number of seeds per pod, biomass weight t $ha^{-1}$, weight of 100 seeds, harvest index and net yield tone per hectare.

All data were statistically analyzed using GENSTAT Release (Rothamsted Exptal station) copy right 2011. Least Significant Difference (LSD) at P<0.05 was used for means separation when ever difference between means were significant following the procedure of Obi (1990). Land Equivalent Ratio (LER) as described by Willey (1985), Competitive Ratio (CR) as proposed by Willey and Rao (1980) and percentage (%) land saved as calculated by Willey (1985) were used to determine the productivity of the intercropping system.

## III. RESULT AND DISCUSSION

### SWEET POTATO

*NO. OF BRANCHES*

Plant population density affected the number of branches of sweet potato crop. The initial period of primary branch formation was 4 weeks after planting regardless of density. From $8^{th}$ week after planting, number of branches responded significantly to the population density. Lower numbers of branches were produced by plants grown at 20cm (50000plants/ha) and 30cm (33,333plants/ha) plant spacing than 40cm (25,000plants/ha) spacing (table 2). Increasing population density reduced the number of branches per plant which showed that the total number of branches per plant is inversely related to population density, this relationship indicates that branch formation in sweet potato plant is highly plastic, responding to space available during the growing season (Somda and Kay, 1990). Similarly, intercropping influenced sweet potato branching there was decreased in number of primary branches as sweet potato plant was intercropped. The lower number of primary branches observed in the intercropping was probably because of high inter-species competition for soil nutrients and light that the sweet potato crop experienced.

| | No of branches | | Vine length | | leaf area | | fodder wt /plant | | fodder wt t/ha | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| | Wks | wks | wks | wks | wks | wks | | | | |
| | 8 12 | 8, 12 | 8, 12 | 8, 12 | 8, 12 | 8, 12 | | | | |
| CROPPING SYSTEM(C) | | | | | | | | | | |
| $C_1$ | 4.28, 6.06 | 2.89, 4.05 | 2.73, 3.52 | 2.53, 3.18 | 66.09, 135.4 | 79.3, 137.4 | 0.59 | 0.72 | 17.84 | 17.02 |
| $C_2$ | 2.36, 3.64 | 0.70*, 1.21 | 1.96, 2.57 | 1.25, 1.57 | 46.06, 77.1 | 64.6, 87.9 | 0.35 | 0.35 | 15.94 | 8.27 |
| $LSD_{05}$ | 1.34*2.13* | 1.93*, 2.87* | NS 0.91* | NS 1.05* | NS 18.34* | NS, 40.43* | NS | NS | NS | NS |
| POPULATION DENSITY (P). | | | | | | | | | | |
| $P_1$ | 3.00, 4.18 | 1.53, 2.06 | 2.20, 3.02 | 1.65, 2.15 | 57.84,108.4 | 71.80,111.1 | 0.44, 0.51 | | 22.39, 16.82 | |
| **$P_2$** | **3.31, 4.56** | **1.75, 2.46** | **2.46, 3.10** | **1.94, 2.46** | **56.13, 104.6** | **72.5,111.9** | **0.48, 0.53** | | **15.78, 12.01** | |
| $P_3$ | 3.65, 5.81 | 2.10, 3.37 | 2.46, 3.01 | 2.08, 2.52 | 54.25, 105.7 | 71.5,115.0 | 0.48 | 0.56 | 12.51, 9.10 | |
| $LSD_{0.05}$ | NS, 0.98* | 0.43* 0.61* | NS NS | 0.51*0.45* | NS NS | NS NS | NS | NS | 4.47* | 4.83* |

*$LSD_{05}$ = Least significant difference at 5%, *=significant, **= highly significant.*

*Table 2: Effect of population density, cropping system on the vegetative component of sweet potato*

*VINE LENGTH*

The result obtained in this study showed that vine length was influenced by cropping system (table 2). There was a significant difference (P<0.05) between sole cropping and intercropping, vine length decreased drastically as sweet potato was intercropped; this could be as a result of reduced solar radiation received by the sweet potato crop. Chipungahello *et al (2007)* observed increased in main vine length, stem and leaf weight as shading was reduced and light intensity increased and Nkambule and Ossom ( 2010) also observed significant differences in vine length among cropping systems with positive correlation of vine length to tuber yield.

*LEAF AREA*

There was increase in leaf area (table 2) from $8^{th}$ weeks to $12^{th}$ weeks after planting in all cropping systems. There was significant difference between Sole crop and intercrop on leaf area, while no significant difference was observed among the population densities. Nkambule and Ossom (2010) recorded significant influence of cropping system on leaf area and also observed no significant differences in densities used as against Sokoto *et al* (2007) who observed significant effect of density on leaf area.

FODDER WEIGHT PER PLANT

Fodder weight per plant was not significantly influence by cropping system. However, there was reduction in fodder weight per plant as sweet potato was intercropped. Similarly, population density did not significantly influenced fodder weight per plant, although there were no significant differences between the densities used, 33,333plants /ha and 25,000plants /ha were higher in fodder weight per plant than 50,000plants /ha.

FODDER WEIGHT TONS PER HECTARE

The result on fodder weight t/ha was not significantly influenced by cropping system. Fodder weight decreased as sweet potato was intercropped (table 2). However, for population density, 50,000plants/ha was significantly (P<0.05) higher (22.39t/ha) than 33,333plants/ha (15.78t/ha) and 25,000plants/ha (12.51t/ha). Although there was no significant difference between 33,333plants/ha ($P_2$) and 25,000plants/ha ($P_3$), $P_2$ was higher than $P_3$. Generally, fodder weight t/ha increased with increased in population density. Sokoto *et al* (2007) attributed this increase to the larger numbers of plants per unit area in closer intra row spacing which even though the fodder weight per plant was lower at closer spacing, the higher population density compensate the total fodder weight per tons.

NUMBER OF ROOTS PER PLANT

Cropping system significantly affected number of roots per plant (table 3). There was significant difference (P< 0.01) between sweet potato planted sole and the intercropped. Sole planted sweet potato had higher number of roots (3.8 and 4.02) than when sweet potato was intercropped (1.96 and 1.98) for 2011 and 2012 cropping seasons. Belehu (2003) had attributed the reduction in fresh roots per plant of sweet potato to reduction in solar radiation and competition for nutrient in intercrop which affects the formation of preformed root premodial.

On population density as shown on table 3, Population density of 25.000plants/ha (3.17 and 3.20) was significantly different from 33,333plants/ha (2.79 and 3.01) and 50,000plants/ha (2.71 and 2.80) for the two cropping seasons. There was an increase in number of roots per plant as population density was reduced. Similar findings were observed by Sulaiman and Sasaki (2001) and Njoku *et al* (2007).

ROOT GIRTH

Root girth varied markedly among the cropping systems (table 3). Root girth in sole cropping (3.38 and 4.08) significantly (P< 0.05) differed from intercropping (2.62 and 2.80) in 2011 and 2012 respectively. The decrease in root girth in intercropping could be attributed to reduction on photosynthate as a result of shading effect of soybean. This finding was also reported by Van De Fliert and Bran (1999) who revealed that any interference in partition of assimilates during period of bulking and root enlargement will affect the root sizes. There was no significant influence of population density on root girth. However, 25.000plants/ha (3.19 and 3.68) showed larger average root girth than 50,000plants/ha (2.88 and 3.19) and 33,333plants/ha (2.92 and 3.48) for the two seasons. Mortley *et al* (1991) on effect of plant spacing on yield and linear growth rate of sweet potato observed no significant effect on vine girth while Wilson and Lowe (1973) maintained that the potential for growth in girth is not affected by intra row spacing but is greatly influenced by cultivar.

ROOT LENGTH

The effect of population density and intercropping on sweet potato root length is as shown on table 3. Cropping system had no significant effect on root length. Similarly, density did not significantly affected root length in the two seasons. Sulaiman and Sasaki (2001) reported no significant influence on root length under different planting densities.

| | No of root.plt | | root girth | | root length | | unmarketable rt no | | marketable rt no | | harvest index | | net yield t/ha | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| CROPPING SYSTEM (C). | | | | | | | | | | | | | | |
| $C_1$ | 3.8a | 4.02a | 3.38a | 4.08a | 9.99 | 11.0 | 19.04 | 23.11 | 6.93a | 4.11 | 0.54 | 0.57 | 18.39a | 17.34 |
| $C_2$ | 1.96b | 1.98b | 2.62b | 2.80b | 7.26 | 9.0 | 9.48 | 9.63 | 0.74b | 1.15 | 0.50 | 0.53 | 9.47b | 7.55 |
| $LSD_{05}$ | 0.2** | 0.75* | 0.59* | 1.18* | NS | NS | 4.54* | 8.38* | 3.59* | 3.10* | NS | NS | 5.63* | 3.30* |
| POPULATION DENSITY (P) | | | | | | | | | | | | | | |
| $P_1$ | 272, | 2.80 | 2.88, | 3.19 | 8.61, | 8.74 | 16.83, | 19.67 | 0.55, | 0.47 | 0.50, | 0.51 | 16.33, | 15.14 |
| $P_2$ | 2.79, | 3.01 | 2.92, | 3.48 | 8.42, | 9.14 | 14.50, | 16.28 | 0.51, | 0.42 | 0.56, | 0.57 | 14.82, | 12.96 |
| $P_3$ | 3.17, | 3.20 | 3.19, | 3.65 | 8.84, | 8.69 | 11.44, | 13.17 | 0.45, | 0.38 | 0.55, | 0.56 | 11.05, | 9.24 |
| $LSD_0$ | 0.23** | 0.23* | NS | NS | NS | NS | 3.22* | 3.70* | NS | NS | NS | NS | 2.73* | 4.37* |

*$LSD_{05}$ = Least significant difference at 5%,*
**=significant, **= highly significant.*

*Table 3: Effect of population density, cropping system on the yield and yield component of sweet potato*

International Journal of Innovative Research and Advanced Studies (IJIRAS)
Volume 3 Issue 8, July 2016

ISSN: 2394-4404

## MARKETABLE AND UNMARKETABLE ROOT NUMBER

The unmarketable root number was significantly influenced by population density, while no significant effect was observed on marketable root number. Unmarketable root number increased with increased in population density with 50,000plants/ha having the highest unmarketable root number (16.83 and 19.67) and 25,000plants/ha having the least (11.44 and13.17). Although, there was no significant differences, marketable root number increased with increased in population density. The result was similar to those of Talleyrand (1981); Farooque *et al* (1983) and Sarkar (1985) who obtained higher salable and unsalable yields at closer spacing, which was observed to be as a result of the number of plants involve per unit area than the potentials of individual plants. This result is not in harmony with Onunka *et al* (2011) who observed decreased in total salable root number as a result of increase in population density. Marketable and unmarketable root numbers were depressed by intercropping system. Intercropping significantly (P< 0.05) lowered the number of marketable root (89.32% and72.02%) and unmarketable root (51.21% and 58.33%) in 2011 and 2012 cropping seasons. The reduction could be due in part to increase shading effect on sink establishment and to inter plant competition for soil nutrient, similar findings were reported by Basuca *et al* (1990); Hossain and Mondol (1994) and Tahan and Saddique (2001).

## FRESH NET ROOT YIELD

Fresh total root yield (table 3) was significantly (P< 0.05) higher in sole cropped sweet potato (18.39 and 17.34 t/ha) and lower (9.74 and 7.55 t/ha) when sweet potato was intercropped with soybean in the two seasons. A decrease in yield of 52.94% and 43.54% was recorded in 2011 and 2012 seasons. Reduction in yield in intercrop was consistent with several previous reports. (Sullivan, 2000; Egbe and Idoko, 2009; Ossom, 2010; Ijoyah and Jimba, 2011). Fresh root yield was significantly (P<.0.05) influenced by population density, fresh root yield increase with increase in population density (table 3). 50,000plants/ha and 33,333plants/ha yielded significantly higher fresh roots (16.33, 15.14 and 14.82, 12.96 t/ha) than 25,000plants/ha (11.05 and 9.24t/ha). The increase in yield as a result of increase in density could be due to the large number of plants per unit area because of closer intra row spacing. Sokoto *et al* (2007) in their work observed higher yield at closer spacing and Belehu (2003) and Onnuka *et al* (2011) observed increased in fresh storage roots per hectare as plant population was increased.

## SOYBEAN

Vegetative and flowering parameters of soybean were not significantly influenced by intercropping system or population density (Table 4). Similarly, yield and yield component were not significantly influenced by population density. However, cropping system only affected number of pods and net grain yield.

| | Plant height (cm) | | | | leaf area | | | | no of branches | | fodder weight (t/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4wk | | 8wk | | 4wk | | 8wk | | | | | |
| | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| CROPPING SYSTEM (C) | | | | | | | | | | | | |
| $C_1$ | 44.30, | 38.52 | 62.22, | 57.5 | 38.81 | 33.45 | 52.08 | 47.33 | 8.25 | 3.92 | 3.86 | 3.63 |
| $C_2$ | 42.04, | 38.84 | 60.98 | 58.8 | 40.44 | 31.64 | 50.99 | 48.78 | 7.70 | 3.68 | 3.55 | 3.19 |
| $LSD_{0.05}$ | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns |
| POPULATION DENSITY (P) | | | | | | | | | | | | |
| $P_1$ | 41.16, | 39.4, | 61.58, | 57.8 | 39.72, | 31.61 | 51.85, | 48.07 | 7.89, | 3.90 | 3.70 | 3.61 |
| $P_2$ | 43.57, | 38.11, | 61.14, | 59.2 | 40.28, | 33.16 | 51.46, | 48.56 | 7.94, | 3.72 | 3.67, | 3.45 |
| $P_3$ | 43.90, | 38.89, | 62.08, | 57.4 | 38.88, | 32.86 | 51.30, | 48.59 | 8.10 | 3.76 | 3.68, | 3.17 |
| $LSD_{0.05}$ | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns |

*$LSD_{0.05}$ = Least significant difference at 5% level, ns = Non significant.*

*Table 4: Main effect of population density and cropping system on soybean vegetative component in the year 2011 and 2012*

## NUMBER OF PODS PER PLANT

Table 5 Shows number of pods per plant, there was significant (P< 0.05) influence of cropping system on number of pods per plant. Number of pods was higher in sole cropping than intercropping by 34.88% in 2011 and 27.02% in 2012. Pod yield attained in this experiment was consistent with previous findings of Babatunde *et al (2011)*; Njoku *et al* (2007); Ijoyah and Jimba (2011); Nkambule and Ossom (2010) who reported generally that intercropping with sweet potato reduces number of pods per plant.

| | 50% flowering | | No of pod/plant | | No empty pod/plt | | No of seed/pod | | 100 seed wt | | H.I | | Net yield (t/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| CROPPING SYSTEM (C) | | | | | | | | | | | | | | |
| $C_1$ | 41.30 | 42.02 | 86.30a | 74.40a | 10.18 | 2.86 a | 2.12 | 2.15 | 12.96 | 12.89 | 0.28 | 0.28 | 1.57a | 1.33a |
| $C_2$ | 41.69 | 43.22 | 56.2b | 51.30b | 11.50 | 2.96b | 2.09 | 2.12 | 12.93 | 12.06 | 0.28 | 0.27 | 0.94b | 0.69b |
| $LSD_{0.05}$ | ns | ns | 16.68* | 19.54* | ns | ns | ns | ns | ns | ns | ns | ns | 0.40* | 0.60* |
| POPULATION DENSITY (P) | | | | | | | | | | | | | | |
| $P_1$ | 40.83, | 45.5 | 74.4, | 66.1 | 11.12, | 2.86 | 2.15, | 2.15 | 13.06, | 12.83 | 0.27 | 0.26 | 1.29, | 1.03 |
| $P_2$ | 41.67, | 42.61 | 58.0, | 60.3 | 10.81, | 2.71 | 2.06, | 2.11 | 12.78, | 13.11 | 0.27 | 0.27 | 1.23, | 0.96 |
| $P_3$ | 42.56, | 42.78 | 71.4, | 62.2 | 10.58 | 3.19 | 2.11, | 2.14 | 13.00, | 12.50 | 0.28 | 0.26 | 1.24, | 1.06 |
| $LSD_{0.05}$ | | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns |

*$LSD_{0.05}$ = Least significant difference at 5% level, * = significant, ns = Non significant.*

*Table 5: Main effect of population density and cropping system on soybean yield and yield component in the year 2011 and 2012*

## GRAIN YIELD

Grain yield in soybean was significantly influenced by cropping system (Table 5). Net yield was significantly (P< 0.05) higher in sole crop than in intercrop. Increase in grain yield in sole crop in this study could be due to increase in number of pods in sole crop, as number of pods is said to significantly influence yield (Adeniyan and Ayoola, 2006). The decrease in net yield in intercrop could be as a result of competition between component crops and this is in line with the work of Alhassan (1995) and Babatunde *et al (2011*) who reported significantly higher grain yield in sole crop over intercrop. A percentage reduction of 40.13% and 48.12% grain yield was observed in intercropping in 2011 and 2012 respectively.

## IV. LAND EQUIVALENT RATIO (LER), COMPETITIVE RATIO (CR) AND PERCENTAGE OF LAND SAVE

Land Equivalent Ratio (LER), Competitive Ratio and Percentage of Land Save are as presented in Table 6. The result showed that all the intercrop combinations had LER values greater than unity (LER>1) under all the sweet potato plant population tested, signifying yield advantage in intercropping various plant populations of sweet potato with soybean. However, higher yield advantages were obtained (1.46 and 1.48) when 33,333plants/ha of sweet potato was intercropped with soybean in the two cropping seasons.

The competitive ratio values of intercrop soybean were higher than its associated crop, indicating that soybean was more competitive than sweet potato and this could be as a result of the soybean being the taller crop. This view agreed with Palaniappan (1985) who stated that taller component crops intercept major share of the solar radiation thereby reducing the competitive ability of the other crop.

Percentage of land save is an indicator of the percentage of land a farmer saved from intercrop if the same yield were to be obtained in sole plot. This work indicated that it is advantageous to have the crops in mixture since the farmer would need as much as 1.46 to 1.48 hectare of land when crops are grown sole in order to achieve the same yield level from one hectare of land when crops are grown in mixture, thereby saving 31.51% to 32.57% of land. Ijoyah and Jimba (2011) also observed 49.2% to 50% of land saved in intercrop.

| LER | | | | CR | | | % LAND SAFE | | |
|---|---|---|---|---|---|---|---|---|---|
| Sweet potato | Soybean | | | | | | | | |
| CS/Pop. | 2011 | 2012 | mean | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| Pop 1 /soybean | 1.27 | 1.36 | 1.32 | 0.67 | 0.56 | 1.49 | 1.78 | 21.26 | 26.47 |
| Pop 2/soybean | 1.46 | 1.48 | 1.47 | 0.74 | 0.51 | 1.36 | 1.96 | 31.51 | 32.43 |
| Pop 3/soybean | 1.31 | 1.26 | 1.29 | 0.56 | 0.70 | 1.79 | 1.42 | 23.66 | 20.64 |

*CS = Cropping system.*
*Pop. = Population density.*
*% land saved =* $100 - \frac{1}{LER} \times 100$

*Table 6: Land equivalent ratio (ler) competitive ratio (cr) and percentage land safe of sweet pot population densities intercropped with soybean in the year 2011 and 2012.*

## V. CONCLUSION

From this work it can be observe that population density had significant influence on sweet potato fresh root production, increasing plant density increase both marketable roots and net yield. Land Equivalent Ratio (LER) has been used to evaluate intercropping systems. The LER in this work in all combinations showed yield advantages but higher advantages were obtained from population density of 33,333plants/ha. Based on yield advantage, it can be concluded that in Makurdi, a location in southern guinea savannah ecological zone of Nigeria, if sweet potato is to be intercrop with soybean, a plant population of 33,333plants/ha should be adopted. It is also suggested that further investigation to be conducted across different locations in southern guinea savannah ecological zone of Nigeria.

## REFERENCES


[1] Abdissa, T; chali, A; ents Telessa, K; Tadese, F and Awas, G (2011) Yield and yield components of sweet potato as influenced by plant density. In Adami Tulu jido Kombolcha District, central rift valley of Ethiopia. Am. J. Expt. Agric 1(2) 40-48.

[2] Alhassan, A. A. (1988) A study of the effect of intercropping sweet potato (Ipomoea batatas) with maize (Zea mays) or cowpea (vigna) on tuber and grain yield. Online Agris Repository Research.

[3] Antiabong, E. E. and Bassey, E. E. (2008) Constraints and prospect of sweet potato (Ipomoea batata (L) Lam) production in humid environment of southern Nigeria. Proceedings the 2nd Africa regional conference on sustainable development, held at the governor Office annex, Uyo Nigeria. 2(3) 68-72.

[4] Abolaji, J. O. and Olsen F. T. (1988) Effect of plant density on maize (Zea mays L.) intercrop with soybean Glycine max(L) Merr). Nig. J. Agric. 3: 104-107.

[5] Basuca, M. B; Badol, E. O; Bascas, Z. J and Tandang, L.L (1990) Preliminary yield trial on Sweet potato. Northern Philippines Root Crops Res. And training centre (NPRCRTC), Research results presented in a series of working papers, BSU NPRCRTC. pp 53-62.

[6] Belehu, T. (2003) Agronomical and physiological factors affecting growth, development and yield of Sweet potato in Ethiopia. PhD thesis, dept. of plant production and soil science University of Pretoria, Pretoria.

[7] Babatunde, F. E; Dantata, I. J. and Olawuyi, O. J. (2012) Perfromance of sweet potato and soybean as Affected by cropping sequence in the Northern Guinea Savannah of Nigeria. J. Agron. 11: 22-26.

[8] Baker, M. A (1981) Effect of harvest date and intra-row spacing on yield and quality of three sweet Potato cultivars. Dissertation Abstract Int. B4; 4335-4338.

[9] Biaco, V. V (1975) Effect of weight of seed tubers and planting density on yield of potato tubers. Rivista Di Agromisa, 9: 197-203.

[10] Bouwkamp, J. C and Scoot, L. E (1980) Effe3ct of plant density on yield of sweet potato. Ann. Trop. Res. 2, 1-11.

[11] Bradley, D. (2009) Diabetes forcast. A healthy living magazine, American Diabetes Association. April 21, 2009.

[12] Chemeda, F. (1997) Effects of planting pattern, relative planting dates and intra row spacing with beans Devis, J. and Smithson, J. B. (eds) CIAT, Cali. Columbia.

[13] Chipungahelo, G. s; Ngereza, A; Kawamala, P; and Kwileka, T (2007) Effects of light regimes on different Crops, sweet potato( Ipomoea batatas L. lam), Cowpea (Vigna unguculata l walp) and Pineapple (Ananas comosus L. merr) Afr. Crop Sci. Conf. 8: 467-471.

[14] Chukwu, G. O. (2001) Seasonality and climatil period effects on crop evapoutranspiration of Sweet potato,

Akoroda, M. O. and Ngeve, J.M (eds). In: Root crops in Century, proceedings of the7th Triennial symposium of the int. soc. For trop.

[15] Root crops- Africa branch held at the centre international des conference, Cotonuo, benin. 11-17 oct. 1998. Pp 280-284.

[16] Egbe, O. M. and Idoko, J. A. (2009). Agronomic assessment of some sweet potato varieties for intercropping with pigeonpea in southern guinea savanna of Nigeria: ARPN J. Agric. Biol. Sc. 4(4) 23-32.

[17] Ennin, S. A; Ciegg, M. D and Francis, C. A (2002) Resource utilization in soybean/maize intercrop. Africa Crop Sci. J 10(3):251-261.

[18] Farooque, A M; Rahim, M. A and Maruf, M. G (1983) Effect of planting methods and spacing on growth and yield of sweet potato. Bangladesh Hort. 11: 11-14.

[19] GENSTAT (2011) GENSTAT release 10.3DE, Lowes Agric. Trust Rothamsted experimental station.

[20] Henriet, J. G. A; Van, E. K; Blade, S. F and Singh, B. B (1997) Quantitative assessment of traditional Cropping systems in Sudan Savannah of Nigeria 1: Rapid survey of prevalent cropping Systems, Savanna J. of Agric. Res. 14: 27-45.

[21] Hossian, M. M and Mondol, M. A. A (1994) Effect of vine parts on the growth and yield of three swee Potato varieties. Bangladesh J. Sci. and Indust. Res. 29(3) 181-184.

[22] Ijoyah, M. O and Jimba, J (2011) Effects of planting methods, planting dates and intercropping systems on sweet potato-okra yields in Makurdi, Nigeria.

[23] Jahan, M.M.A; and Siddique, M.A (2001) Studies on growth and yield and storage of sweet potato As influenced by variety and time of harvest, M Sc. Thesis, Dept of Hort. Bangladesh Agric. Univer. Mymensingh, pp 1-84.

[24] Janssens, M (2001) Sweet potato. In: crop production in tropical Africa. Raemakers, R. H. ed. DGIC, Brussels, Belgium. 205-221.

[25] Kalu, B. A. (1993) Crop recommendation for Benue State. BNARDA Ext. Bult. No. 2, 42pp.

[26] Korieocha, D. S; Ogbonna, M. C; Nwokocha, C.; Echendu, T. N. C and Okoriecha, E. O. A (2009) Effect of time of herbicide application and sweet potato morpho – types on the Effectiveness of herbicide on weeds. Proceedings of the 43th annual conference Of agricultural commission, Abuja, Tuesday 20th –Friday 23rd Oct. pp 12 – 16.

[27] Langer, R. H. M and Hill, G. B (1991) Agricultual plants. Cambridge university press, UK. 431pp.

[28] Mortley, D. G; Loretan, P. A; Bonsi, C. K; Hill, W. A and Morris, C. E (1991) Plant spacing influences yield and linear growth rate of sweet potatoes grown hydroponically, Hort. Sci. 26(10): 1274-1275.

[29] Muoneke, C. O; Ogwuche, M. A. O; and Kalu, B. A (2007) Effect of maize planting density on the Performance of maize/soybean intercropping system in Guinea Savannah Agro ecosystem. Afri. J Agric. Res. 2(12) 667-677.

[30] Njoku, S. E., Muoneke, C. O., Okpara, D. A. and Agbo, F. M. O. (2007) Effect of intercropping varieties of sweet potato and okra on ultisol of south eastern Nigeria. Africa J. Biotech. 6(14) 1560-1654.

[31] Nkambule, B. s and Ossom, E. M. (2010) Effects of jugo bean [Vigna subterrenea (L) verdc] plant Population on physiological growth indices and yield under intercropping with sweet Potato [Ipomoea batatas (L) lam] Adv. Environ. Biol. 4(2), 201-215.

[32] Nwanga, R m and Zamora, O. b (1989) Agronomic response of sweet potato (Ipomoea batatas (L)) to Varying levels of shades. Phillipines J. crop Sci. 14(2) 83 – 90.

[33] Nwauzor, E. C; Afuape, S. O; Korieocha, D. S and Ezulike, T. O (2006) Studies on the use of neem leaf preparation for the control of Cylas puncticollis. damage of sweet potato root tubers. In; Sweet potato production. NRCRI, Umuduke Annual report 2006 , 67-72

[34] Obi, I. U (1990) Statistical method of detecting differences between treatment means. SNAPP press (Nig) Ltd Enugu, Nigeria. Pp 1-14.

[35] Oleary, N and Smith M. E (2004) uncovering corn adaptation to intercropping with bean by selecting for System yield in the intercrop environment. J. Sustain. Agric. 24: 109-121.

[36] Onochei, B. E (1975). The potential value of soybean supplement in Nigeria diet. Proc. 3rd ann. Conf. Agric. Soc. Of Nigeria 41:43-45.

[37] Onnunka, N. A; Antai, G; Onunka, B. N and Njoku, S. c (2011) Effect of plant density and land race on the Growth and yield of sweet potato in Northern Guinea Savanna of Nigeria. J. Agric. and Soc. Res. (JASF) V. 11, 1.

[38] Ossom, E. M. (2010) Influence of sweet potato/ maize association on ecological properties and crop yields in Swaziland. Int. J. Agric. Biol. 12: 481-488.

[39] Ossom, E. M; Kuhlase, L. M and Rhykerd (2009) Effects of plant population on yield component and yield Of intercropped sweet potato [Ipomoea batatas (L) Lam] and Groundnut (Arachis Hypogaea L) American-Eurasian journal of Agronomy, 2(1): 01-06

[40] Palaniappan, S. P (1985) Cropping systems in the tropics: Principles and management, Willey Easter Limited, India pp 215.

[41] Santoso, B; Soemo, D; Rewarin, J and Sutiharni, (1996) Sweet potat and Soybean production in an Intercropped system. Hyphere. 1(1):22-32.

[42] Sarkar, A. K (1985) Effect of planting density on yield of sweet potato. ARC Training, sweet potato, pp; 1-4, http//www.arc-avrdc.org/pdf-files/Asit(3-N).pdf 19/10/14.

[43] Sokoto, M. B; Magayi, M. O and Sinhh, A (2007) Growth and yield of irrigated sweet potato (Ipomoea Batatas (L) ) as influenced by intra row spacing and potassium. J. Plant Sci. 2:54-60.

[44] Somda, Z. C andKay, S. J (1990) Sweet potat canopy Arcitecture: Branching pattern. J Amer. Soc. Hort. Sci. 115(1): 33-38

[45] Sulaiman, H and Sasaki, O. (2001) Studies on effect of planting density on the growth and yield of sweet Potato (Ipomoea batatas (L)) Mem. Fac. Agric. Kayoshima University. 37: 1-10.

[46] Sullivan, P. (2000) Intercropping principles and production practices — Agronomy system guide.

Appropriate technology transfer for rural areas, http//www.attra.neat.orgAttar-pub/intercrop html@24/06/14.
[47] Sweet potato htm (2002) http:/www.ci potato.org/sweet potato/sweet potato htm.
[48] Terefe, B. and Geleta, L. (1994) Agronomic studies. In: proceedings of the 2nd National Horticultural Workshop in Ethiopia, 1-3 Dec. 1992. Addis Ababa, Ethiopia.
[49] Udealor, A; Ezulike, T. O; Nwauzor, E. C; Asumugha, G. N and Amaefula A. (2006) Evaluation of different Sweet potato varieties under different intercropping systems. Annual report of the National Root crops Research Institute (NRCRI) Umudike, Nigeria. 226-228.
[50] Van De Fliert, E and Braun, A (1999) Farmer field guide, school for intergrated crop management of Sweet potato. Field guides and technical manual, International sweet potato centre, Lima Peru 266p.
[51] Van Wolfswinkel, M (2010) Intercropping of annual food crops.http:www.agromisa.org/agrobrief/AB-4%2Intercropping.pdf. 19/10/14.
[52] Willey, R. W (1985) An evaluation and presentation of intercropping advantage. Exptal. Agric. 21: 115-155.
[53] Willey, R. W. and Rao, M. R. (1980) A competitive ratio for qualifying competition between intercrops Exptal. Agric. 16: 117-125.
[54] Wooife, J. A (1993) Sweet potato: An untapped food resources. In collaboration with international Potato centre, Peru (pp16-19) Cambridge University press.
[55] Workayehu, T; Mazengia, W and Hidoto,.L (2011) Growth habit, plant density and weed control on weed and root yield of sweet potato (Ipomoea batatas L.) Areka Southern Ethiopia. J Hort. And for. 3(8) pp 251-258.
[56] Zakir, S; Allen, J. C; Sarwar, M. U; Nisa, S. A; Chaudhry, U; Arshad A. J and Islam-Ud-Din (2008) Sweet Potato Glycemic index in relation to serum glucose level in human partition. Int. J. Agric. Biol. 1: 152-153.