Journal of Agricultural Science; Vol. 8, No. 5; 2016
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Influence of Groundnut Populations on Weed Suppression in Cassava-Groundnut Systems

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Received: December 3, 2015 Accepted: March 2, 2016 Online Published: April 15, 2016

doi:10.5539/jas.v8n5p72 URL: http://dx.doi.org/10.5539/jas.v8n5p72

Abstract

Cassava was grown in sole cropping and intercropping with groundnut to determine the performance of associated crops and weed control at three different groundnut populations in southern Guinea ecology of Nigeria. The experiment consisted of three planting arrangements: 1 row of cassava:3 rows of groundnut, 1 row of cassava:2 rows of groundnut, and 1 row of cassava:1 row of groundnut, sole groundnut at the three planting populations and sole cassava. The groundnut treatments suppressed weeds considerably when compared to sole cassava. This resulted from the vegetative production of groundnut which increased up to 8 weeks after planting (WAP) in 2001 and 12 WAP in 2002. More vegetative growth in 2002 led to lower groundnut yield. Intercropping significantly ($p < 0.05$) reduced leaf area of cassava, groundnut and cassava yields. Cassava/groundnut system reduced cassava yields by 26 to 74% in 2001 and by 15 to 19% in 2002. The LER values were greater than 1.0 but cassava intercropped with groundnut population of 40,000 plants/ha has a value of 1.89, which was highest. This offers a good weed control as well as the best crop yield advantage. Therefore, groundnut population of 40,000 plants/ha was most ideal population for cassava/groundnut intercrop.

Keywords: cassava, groundnut population, weed management, intercropping

1. Introduction

Intercropping is the cultivation of two or more crops simultaneously on the same piece of land during the same season (Ofori & Stern, 2000; Sullivan, 2000). The benefits associated with intercropping includes increased soil fertility (Shen & Chu, 2004), reduced risk of crop failure (Mutsaers et al., 1993), decreased disease severity (Zinsou et al., 2005), reduced weed pressure (Hernández et al.,1999; Amanullah et al., 2007) and efficient utilization of environmental resources (Francis, 1989; Zhang & Li, 2006).

Cassava (*Manihot esculenta* Crantz) is an annual crop grown widely in the tropics as food and cash crop. Cassava-based cropping systems are prevalent as cassava is one of the major staple foods grown in most sub-Saharan African countries (Mkamilo & Jeremiah, 2005). It is Africa's second most important food staple, after maize, in terms of calories consumed. Intercropping cassava is widely practiced among small-scale farmers in the humid and sub-humid tropics. Okigbo and Greenland (1976) estimated that 50% of cassava grown in tropical Africa is intercropped with cereals, grain legumes, leafy vegetables, fruits and tree crops. Cassava is commonly grown in association with a short duration crop such as maize or melon in Nigeria. According to Mutsaers et al. (1993), intercropping of cassava with legumes could increase land equivalent ratios as compared to the pure stand. For instance, intercropping cassava with groundnut increases the productivity by land equivalent ratio of 1.27 to 1.85 (Osiru & Hahn, 1998).

Weed infestation is a major constraint in cassava production and the crop is susceptible to weed competition because of its initial slow growth. Competition from weeds can occur at any period of growth in cassava, but the most damaging effect of weeds have been reported to occur during the early canopy formation and the third month after planting when tuberization commences (Onochie, 1975). Cassava competes well with weeds once canopy is fully formed. However, its ability to compete with weeds depends to some extent on how long after planting the crop stays weed free before canopy completely covers the ground. Traditionally, handweeding is the major weed control measure used in cassava production. Intercropping cassava with maize or melon is a popular cropping practice among farmers in the southwestern part of Nigeria. In intercropping, the crops are selected to take advantage of different nutrient requirements and differences in plant architecture so as to maximize resource use. Agronomic practices such as plant densities, crop arrangement and relative planting times can increase productivity in cassava-legume intercropping systems (Pypers et al., 2011). Appropriate modification of plant population and crop arrangement is a long recognized weed control strategy (Akobundu, 1984). Hence, the use of low growing crops like 'egusi' melon and cowpea as a weed management strategy in various cropping systems have been extensively studied (Amanullah et al., 2006; Ayoola & Agboola, 2001; Akinyemi & Makinde, 1999; Anuebunwa, 1991; Akobundu, 1980; Unamma et al., 1986; Wahua, 1985). In intercrops, intra and/or inter specific competition between crops may occur (Zhang & Li, 2003). This increased competitiveness of intercropping systems makes them potentially useful for adoption into low input farming systems in which options for chemical weed control are reduced or non-existent (Szumigalski & Van Acker, 2005). Intercropping strategies can reduce weed population density and biomass production (Liebman & Dyck, 1993).

Cassava/groundnut intercropping is practiced in many parts of Central Africa and the two crop species are highly compatible (Lutaladio et al., 1987). Groundnut is grown throughout the tropics but it predominates in the seasonally arid areas. It is produced in large quantities in Northern Nigeria; and is gradually being introduced into the farming systems of south western Nigeria for intercropping with crops such as cassava, maize, rice, and vegetables. Groundnut is used as a live mulch since it spreads and covers the ground and suppresses weeds, reducing the impact of raindrops on the soil and thus help in checking both water and wind erosion (Dung et al., 2005). However, there is a need to establish the appropriate plant population of groundnut in cassava/groundnut system. The objective of this study is to determine the effect of different population mixtures on the agronomic characteristics of crops and weed management in cassava/groundnut intercrop.

2. Materials and Methods

Field trials were conducted in 2001 and 2002 cropping seasons at Ballah outstation (southern Guinea savanna ecology) of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria. The soil of the site was loamy sand with 83.6% sand, 13.9% silt and 2.5% clay; pH, 6.8; organic C, 1.1%; and N, 0.1%. The experimental area was ploughed and harrowed for both years to provide a seed bed of fine tilt.

Treatments were groundnut densities: sole groundnut 1 (160,000 plants/ha), sole groundnut 2 (80,000 plants/ha), sole groundnut 3 (40,000 plants/ha), cassava + groundnut 1, cassava + groundnut 2, cassava + groundnut 3, and sole cassava (10,000 plants/ha). Cassava was planted at 1 m × 1 m while groundnut was sown at the three different population densities in 10 m × 5 m plots. A local cassava variety 'oko iyawo' and groundnut variety RRB were planted. Groundnut 1 (160,000 plants/ha) was spaced at 25 cm × 25 cm, groundnut 2 (80,000 plants/ha) at 50 cm × 25 cm and groundnut 3 (40,000 plants/ha) at 100 cm × 25 cm. These spacings gave planting arrangements of 1 Cassava:3 Groundnut rows, 1 Cassava:2 Groundnut rows and 1 Cassava:1 Groundnut row, respectively. The two crops were planted simultaneously in a Randomized Complete Block Design (RCBD) with four replications, and the plots were weeded at 3 and 9 weeks after planting (WAP).

Plant growth and yield were measured by plant height, vine length, leaf area, number of leaves, number of pods, seed and tuber yields. Weed samples were collected with a 50 cm × 50 cm quadrat at two spots in each plot for weed density and weed dry weight at 3 and 8 WAP. The weeds were cut above soil level and oven-dried at 80 ^{o}C and then weighed. Land equivalent ratio (LER) values were calculated as:

$$LER = YMC/YSC + YMG/YSG \tag{1}$$

Where, YMC and YMG are yields of cassava and groundnut in mixtures while YSC and YSG are yields of sole cassava and groundnut. Data was analyzed using Analysis of Variance (ANOVA) and treatment means were compared at P = 0.05 using Standard Error (SE).

3. Results

3.1 Weed Interference

Predominant weeds of the fallow land included *Cleome viscosa* L., *Euphorbia heteropyhlla* Linn., *Brachiaria deflexa* (Schum.) C. E. Hubbard & Robyns, *Vernonia galamensis* (Cass.) Less., *Hyptis suaveolens* Poit, *Panicum maximum* Jacq. Table 1 shows the effect of groundnut population on weed dry weight of sole crops and intercrops. There was a general flush of weed emergence at 3 WAP. This was observed in both years just before the first weeding operation in all groundnut treatments. Sole cassava deviated from this trend with significantly higher weed biomass than the groundnut treatments because there was less ground cover. Weed dry weights were higher in sole cassava than in sole groundnut populations and in the mixtures at 3 WAP and 8 WAP in 2001 and 2002, respectively. At 8 WAP, in 2001, weed dry weight reduces with decrease in groundnut population in sole groundnut and intercrop. The effect of treatments on incidence of weed species is shown in Table 2. The most dominant weed species in all plots were *C. viscosa* (30.3% relative abundance), *P. maximum* (23.4% relative abundance) and *V. galamensis* (20.6% relative abundance). The results of weed species densities for both years did not differ significantly, hence the data were merged. Total weed number indicated that weeds were better controlled in all groundnut treatments (sole and intercrops) than sole cassava with the highest of 176 weeds/m^2. Greater weed control was observed in the highest groundnut population of 160,000 plants/ha in both sole and intercropped groundnut treatments. It was also observed that the higher the groundnut population, the better the weed control in sole and intercropped groundnut treatments.

Table 1. Effect of groundnut population on weed dry weight of sole crop and intercrop

Treatment	Weed dry weights (g m^{-2})			
	2001		2002	
	3 WAP	8 WAP	3 WAP	8 WAP*
Sole G1	35.25	3.21	21.06	14.20
Sole G2	33.78	7.03	28.36	19.46
Sole G3	34.54	10.88	29.28	21.98
Cassava + G1	30.76	6.68	25.06	8.86
Cassava + G2	34.66	12.65	22.50	17.68
Cassava + G3	33.32	10.16	21.76	23.46
Sole cassava	43.17	22.12	43.14	18.14
SE	3.67	6.39	6.16	5.18

Note. *WAP – Weeks after planting; G1 = Groundnut at 160,000 plants/ha; G2 = Groundnut at 80,000 plants/ha; G3 = Groundnut at 40,000 plants/ha.

Table 2. Effect of groundnut population on density of weed species in cassava/groundnut intercrop, 12 WAP

Treatments	*Panicum maximum*	*Rottboellia cochinchinesis*	*Cleome viscosa*	*Euphorbia heterophylla*	*Bracharia deflexa*	*Vernonia galamensis*	Total weed number
	---------number/m^2---------						
Sole G1	8	-	4	6	-	4	22d
Sole G2	10	-	2	7	2	5	26d
Sole G3	16	5	18	11	15	3	68bc
Cassava + G1	27	1	9	8	4	10	59c
Cassava + G2	2	-	30	5	-	21	58c
Cassava + G3	12	4	34	8	10	28	96b
Sole Cassava	43	10	56	25	9	33	176a

Note. Means followed by the same letters are not significantly different; *WAP: Weeks after planting; G1 = Groundnut at 160,000 plants/ha; G2 = Groundnut at 80,000 plants/ha; G3 = Groundnut at 40,000 plants/ha.

3.2 Vegetative Growth of Groundnut

Figure 1 shows the effect of intercrop on groundnut leaf number in 2001 and 2002. Leaf production increased from 4 to 8 WAS after which there was a decline in the number of leaves in 2001. In contrast, number of leaves increased steadily from 4 to 12 WAS in 2002. Vegetative production of groundnut leaves was higher in 2002 due to increased nitrogen released by nodules hence lower groundnut yield and higher cassava yield.

Figure 2 shows the effect of intercrop on groundnut vine length in 2001 and 2002. In the first year, groundnut had an initial slow growth between four and eight weeks after sowing (WAS). The intercrops did not have any significant effect on the growth of groundnut. This is obvious as the vine length did not differ among the treatments during the period of growth. But in the second year, 2002, growth of groundnut vines was three times better than it was between 4 and 8 WAS in 2001.

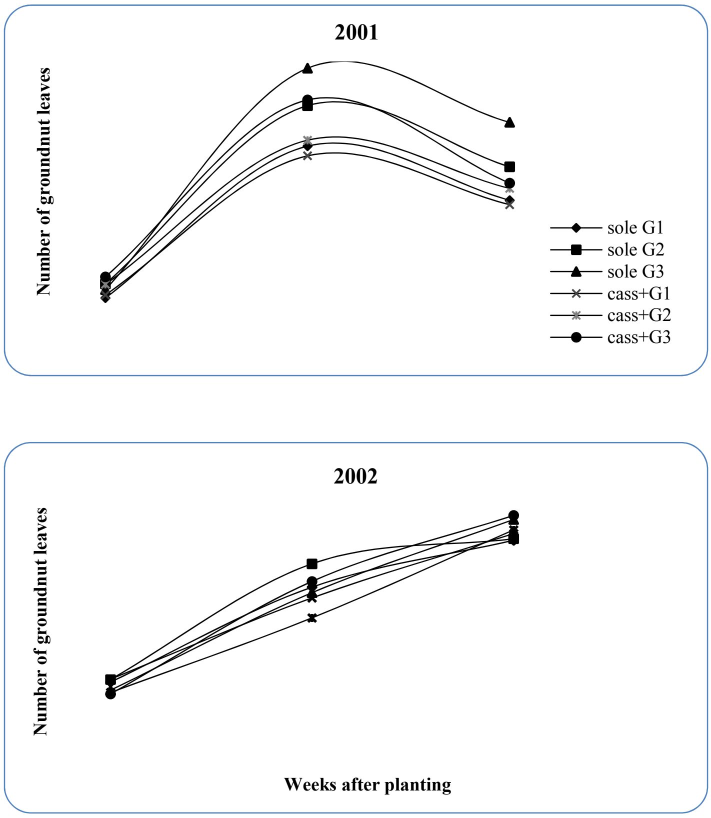

Figure 1. Effect of cassava/groundnut intercrop on groundnut leaves

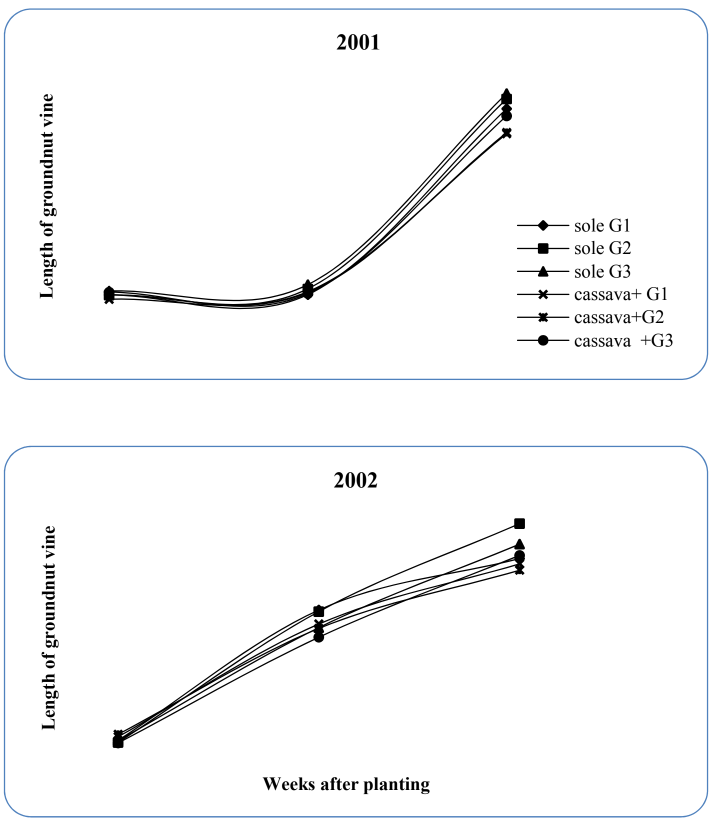

Figure 2. Effect of cassava/groundnut intercrop on groundnut vine length

3.3 Yield and Yield Attributes

Groundnut pod numbers decreased as groundnut population reduces in sole crops and the intercrops (Table 3). Intercropping significantly ($p < 0.05$) reduce groundnut yield compared to sole groundnut of each population. Maximum grain yields of groundnut (1120 and 739 kg ha^{-1}) were recorded in sole G1 in 2001 and 2002, respectively; with lower yields produced in 2002 than 2001 season. 1000-seed weight showed a level of significance but with no visible trend, with groundnut yielding more in 2001 than 2002 season. More vegetative growth in 2002 led to lower groundnut yield than the previous year. Groundnut yield decreased as plant population reduced in both the sole and intercropped groundnut treatments, and this trend was obvious in both years.

Intercropping significantly ($p < 0.05$) reduced leaf area in cassava (Table 4). Leaf area of cassava was greater in sole crop than in the intercrops in 2001 and 2002. Sole cassava produced more leaves than intercropped cassava for both years (Table 4). Sole cassava out yielded the intercrops, but in 2002, there was an increase of 5% cassava yield above sole cassava in cassava + groundnut at 160,000 plants ha^{-1} intercrop. Cassava/groundnut intercrop reduced cassava yields by 26 to 74% (12.9 to 4.6 t ha^{-1}) in 2001 and by 15 to 19% (10.9 to 10.4 t ha^{-1}) in 2002. Cassava yield of the intercrops increases with reduction in groundnut population. Land equivalent ratio values (average of the two seasons) for the intercrops are: 1.21 for cassava + groundnut at 160,000 plants ha^{-1}, 1.43 for cassava + groundnut at 80,000 plants ha^{-1}, and 1.76 for cassava + groundnut at 40,000 plants/ha.

Table 3. Yield of groundnut in sole crop and in mixture with cassava

Treatment	No of pods (m^{-2})		Groundnut Yield (kg ha^{-1})		1000-seed weight (g)	
	2001	2002	2001	2002	2001	2002
Sole G1	235	137	1120	739	317.50	387.04
Sole G2	201	105	900	497	322.50	391.24
Sole G3	153	42	660	297	318.75	385.26
Cassava + G1	154	136	740	510	323.75	401.09
Cassava + G2	137	79	660	441	325.00	378.43
Cassava + G3	117	37	587	249	322.50	368.96
±SE	32	8	107	57	3.18	11.18

Note. G1 = Groundnut at 160,000 plants/ha; G2 = Groundnut at 80,000 plants/ha; G3 = Groundnut at 40,000 plants/ha.

Table 4. Selected growth attributes of cassava in mixture with groundnut

Treatment	No of leaves 8 WAP*		Leaf area (cm^2) 8 WAP		Cassava yield (ton ha^{-1}) Harvest		LER	
	2001	2002	2001	2002	2001	2002	2001	2002
Cassava + G1	16	17	24.02	44.05	4.6	10.4	1.0	1.50
Cassava + G2	16	22	31.60	52.95	6.9	10.9	1.13	1.74
Cassava + G3	18	21	40.64	46.30	12.9	13.5	1.63	1.89
Sole cassava	22	23	73.82	57.80	17.4	12.8	-	-
±SE	1.2	1.8	5.6	3.2	3.7	1.4		

Note. *WAP: weeks after planting; G1 = Groundnut population at 160,000 plants/ha; G2 = Groundnut population at 80,000 plants/ha; G3 = Groundnut population at 40,000 plants/ha.

4. Discussion

The reduction in weed pressure in the groundnut treatments compared to sole cassava was due to high plant population that led to better ground cover which inhibited weed germination and growth. Increased cassava tuber yields in the second season could be adduced to improved soil nitrogen. The beneficial effect of groundnut on cassava yield was mainly due to its ability to fix atmospheric N and produce N-rich residues that may be returned to the soil. Previous studies have reported the advantages of cassava/legume mixture in improving the N content of the soil through fixation of atmospheric nitrogen (Bianteau, 2004; Kim, 2005; Aigh, 2007; Osundare, 2007). Hence, cassava benefited immensely from this association in terms of plant growth and root yield in the second season. This means there was more competition in the crops for soil nutrients in the first season, hence the poor yield. Whereas the yield of groundnut was better in 2001, cassava yielded more in 2002. The LER values were one or higher than one, indicating that intercropping has advantage over sole cropping.

Hypothetically, it is expected that the highest groundnut population (160,000 plants/ha) would yield four times more than the lowest groundnut population (40,000 plants/ha). But the result obtained is far from this expectation. This is because more plant population translates to more competition. The land equivalent ratio values (average of both seasons) were higher than one in all intercropped plots indicating an optimum use of available resources. Hence, the groundnut population of 40,000 plants/ha with the highest LER value of 1.76 was found to be the ideal population for cassava/groundnut intercrop.

The critical period of weed control in cassava is during the first 10-12 weeks of growth before canopy closure. Therefore, the improved weed control in the intercrops was offered by groundnut, a low growing crop, which covers the ground and impedes weed growth and establishment. The significant increase in yield of cassava in cassava/legume intercrop relative to sole cassava was ascribed to less incidence of weed infestation by the legume (Mutsaers et al., 1993). Similarly, Zoufa et al. (1992) found 16 to 40% weed reduction in cassava intercropped with smother crops such as groundnut, cowpea and melon.

5. Conclusion

This study has established that intercropping cassava and groundnut at different populations reduced tuber and grain yields compared to the respective sole crops due to competition between the two crops. However, the yields were improved in the second season due to the ability of groundnut in fixing N into the soil. The use of groundnut intercropping with cassava can serve as a weed control strategy for reducing weed problems by resource poor farmers and as an alternative to chemical weed control. Groundnut can be introduced into cassava-based cropping system because it offers the advantage of weed suppression, improved soil fertility and gave an initial N boost to the succeeding crop as well as increased yields to the farmers.

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