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EVALUATION OF SPATIAL ARRANGEMENT OF LEGUMES ON WEED SUPPRESSION IN CASSAVA PRODUCTION

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ABSTRACT

Cassava, the most important root crop in the tropics, is intercropped with legumes due to the early growth of the legumes to suppress weeds. Field experiments were carried out from September, 2013 to September, 2014 to evaluate the effects of spatial arrangement of legume intercrop on the suppression of weeds in cassava cropping system. Randomized complete block design (RCBD) with three replications was used. Treatments consisted of combinations of five spatial arrangements of three legumes (cowpea, groundnut and soybean). Spatial arrangement of one row of cassava alternating with two rows of legumes controlled weeds more efficiently and also gave the best yields of both cassava and legumes. The results also indicated that spatial arrangement is important in determining the productivity of the cassava-legume intercrop system. Since subsistence farmers are resource poor and weeds are a major problem in crop production systems, intercropping cassava with legumes will improve productivity of the system and improve the diet of the farmers from the associated legumes.

Keywords: cassava, legume, intercropping, weeds, spatial arrangement.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz, family Euphorbiaceae) is a major staple crop in farming systems of Ghana as it serves as the main carbohydrate source to meet the daily requirement needs and as source of income for most resource-poor, smallholder, rural farmers. Cassava is easy to grow in poor soils, with few inputs and has long been an important and cheap source of food. "Cassava provides a source of livelihood to about 300 million people in sub-Saharan Africa".

Intercropping, an agricultural practice of cultivating two or more crops in the same space at the same time is an old and commonly used cropping practice which aims to match efficiently crop demands to the available growth resources and also maximize the chances of productivity by avoiding dependence on only one crop (Sullivan, 2003).

Intercropping has several socio economic, biological as well as ecological advantages Chemeda (1996) relative to sole cropping for smallholder farmers. It is also a principal means of intensifying crop production to improve returns from limited land holdings. The most common advantage of intercropping is the production of higher yield on a given piece of land by making more efficient use of the available growth resources using a mixture of crops of different rooting ability, canopy structure, height and nutrient requirements based on the complementary utilization of growth resources by the component crops.

Intercropping plays a significant role in integrated weed management and improvement of soil fertility. Weeds are found in cropping systems and they make up part of the agro-ecosystems in field crop production. All farmers in their different languages and cultures know the negative effect of weeds and hence device ways and means of adequately controlling them to increase crop yield. The maintenance of a complete crop canopy over the soil inhibits weed seed germination and reduces the need for weeding. Early canopy development, inhibits early weed development and reduces weed-crop competition, particularly for soil nutrients and water. Benefits from intercropping for weed control are particularly evident under low input conditions and increases in component crop yields that have been attributed to improved weed control. Baumann *et al*., (2001) also reported that intercropping increased light interception by the weakly competitive component and can, therefore, shorten the critical period for weed control and reduce growth and fecundity of late-emerging weeds.

In cassava, poor timing of hoe weeding resulting from other farm demands on the farmers' time during the first 3 months accounts for most of the yield losses associated with weeds in the crop. The recommended hand weeding regime for cassava is 3, 8 and 12 weeks after planting (WAP) (IITA, 1990). However, the use of legumes such as cowpea intercropped with cassava could reduce the three suggested weeding regimes in cassava at 3, 8 and 12 WAP to two weeding regimes at 3 and 8 WAP by manipulating the plant population of the cassava and legumes.

To reduce the use of herbicides to control weeds, the use of legumes that suppress weed growth and fix nitrogen is important as it provides the farmer with pulses which serve as rich sources of cheap protein in their diets.

A serious disadvantage in intercropping is thought to be the difficulty with practical management, especially where there is a high degree of mechanization or when the component crops have different requirements for fertilizers, herbicides and pesticides. Moreover, main crop yields can be reduced by intercropping techniques, both as a result of loss of land to the legume and also competition for growth resources (Waddington *et al.,* 2007).

Important factors affecting competition between the intercrop components for water, sunlight, space and

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nutrients and hence input use efficiency are the crop density, the relative proportion of component crops, the spatial arrangement and time of intercropping. According to Ghosh (2004), spatial arrangements of plants, planting rates and maturity dates must be considered when planning intercrops because they are some of the most important factors for better yield advantage. However, selection of an appropriate intercropping system for each case is quite complex as the success of intercropping systems depend much on the interactions between the component crops and the available management practices.

According to Olasantan (2005) cassava and legumes such as soybean make efficient and compatible mixtures. This could be due to cassava being a long duration crop (9 - 18 months) and being ideal for intercropping with short duration (2 - 3 months) crops, which are often harvested before the cassava canopy closes. However most agronomic research works in Ghana have been on legume intercrop with cereals but few with root and tuber crops such as cassava. Among the various legumes; groundnut, soybean and cowpea are the recommended legume crops for intercropping with cassava but not much work has been done on the combination of the three legumes (groundnut, soybean and cowpea) as intercrop with cassava at the same time even though the different legumes have been evaluated separately.

Intercropping could result in competition for growth resources when the component crops are in intimate contact, especially with increasing planting density of any of or all the crops in the mixture (Muoneke and Asiegbu, 1997). According to Ikeorgu and Odurukwe (1990), the performance of cassava-legume association is dependent upon the population of the legume and they suggested that there is need to determine the optimum population density of these legumes in cassava based intercropping system. Several authors have also reported that intercropping cassava with legume crops did not show any significant effect on cassava yield but reduced weed growth relative to spatial arrangement of the legumes. There is limited research on the effect of double and triple rows arrangements on weed suppression and the yield of cassava.

This research, therefore, seeks to evaluate the effects of cassava based cropping systems with legumes (cowpea, groundnut, and soybean) with different spatial arrangements on weed suppression.

General objective

The main objective of this study was to evaluate the effects of spatial arrangement of legumes on the suppression of weeds in cassava cropping system.

Specific objectives

Specifically, this research seeks:

a) To identify the weed flora in a legume-cassava cropping system
b) To determine effects of spatial arrangement of legume intercrop on weed suppression in cassava fields
c) To determine effects of spatial arrangement on the yield of cassava and the legume intercrops
d) Compare the effects of the three different legumes and their spatial arrangement in a cassava intercropping system.

MATERIALS AND METHODS

Site description

The experiment was carried out at the Asuansi Farm Institute located in the Abura-Asebu-Kwamankese District in the Central Region of Ghana. The area lies in the southern fringes of the semi deciduous forest with a mean annual rainfall of about 980 mm and a mean monthly temperature of about 26.9^0C. The soil type is Acrisol (FAO-UNESCO classification) and belongs to the Asuansi series of the Asuansi-Kumasi/Nta-Ofin compound association.

Planting material

Cassava (*Manihotesculenta* Crantz)

The cassava variety used was 'Capevarsbankye'. It is high yielding and is ready for harvest within 9 to 12 months.

Cowpea (*Vignaunguiculata*)

The cowpea variety '*Asetenapa*' was used is this work because it is early maturing and it has an erect growth habit. It matures between 67 to 74 days after germination.

Groundnut (*Arachishypogea*)

The groundnut variety '*Yenyawoso*' literally means "None like you," has an erect growth habit and is high yielding. It matures within 90-95 days after germination.

Soybean (*Glycine max*)

The soybean variety '*Anidaso'*has erect growth habit, resistant to shattering and matures in 105-115 days after germination.

EXPERIMENTAL PROCEDURE

Land preparation

The land was manually cleared preparation and the woody parts of the debris removed but the leaves were left as mulch. The field was thereafter marked out into blocks and plots for planting.

Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 19 treatments and 3 replications. Each plot measured 5m x 4 m with a space of 0.5 m between plots and 1.0 m between blocks. There was a 1.0 m border around the experimental area; this gave a total of 1598 m^2 or 0.16 ha. The treatment details are shown in Table-1.

Agronomic practices

Apart from variegated grasshoppers (*Zonocerusvariegatus*) which were controlled with "Pawa" (Lamdacyhalothrin 2.5% EC) 5 weeks after planting (probably due to the debris left as mulch) no other agrochemical (herbicide or weedicide) was applied since the study involved weed management without fertilizer and herbicides.

Table-1. Treatment combinations in relation to spatial arrangement.

Treatment code	Descriptions
C_1C_{o1}	1 row of cassava alternating with 1 row cowpea
C_1C_{02}	1 row of cassava alternating with 2 rows cowpea
C_1C_{o3}	1 row of cassava alternating with 3 rows cowpea
C_2C_{o2}	2 rows of cassava alternating with 2 rows cowpea
C_2C_{o3}	2 rows of cassava alternating with 3 rows cowpea
C_1G_1	1 row of cassava alternating with 1 row groundnut
C_1G_2	1 row of cassava alternating with 2 rows groundnut
C_1G_3	1 row of cassava alternating with 3 rows groundnut
C_2G_2	2 rows of cassava alternating with 2 rows groundnut
C_2G_3	2 rows of cassava alternating with 3 rows groundnut
C_1S_1	1 row of cassava alternating with 1 row soybean
C_1S_2	1 row of cassava alternating with 2 rows soybean
C_1S_3	1 row of cassava alternating with 3 rows soybean
C_2S_2	2 rows of cassava alternating with 2 rows soybean
C_2S_3	2 rows of cassava alternating with 3 rows soybean
C_0	Sole cowpea
G	Sole groundnut
S	Sole soybean
C	Sole cassava

C - cassava, C_o- cowpea, G - groundnut, S - soybean
Subscripts 1, 2, and 3 indicate the number of rows of main or component crop on a plot

Weed identification

Weed identification is typically determined by botanic characterization and counting the number of individual weeds within a quadrat. A quadrat with the dimension of 50 cm^2 was used for sampling weeds diagonally on the experimental plots. For each quadrat, the major weed species were identified using handbook of West African weeds (Akobundu and Agyakwa, 1987). All weed species within the quadrat were counted and identified according to species type.

Weeding and weed weight measurement

Weeding was done twice with a hoe at 4 and 8 weeks after planting (WAP) for all the plots in the experiment. After each weeding, the soil adhering onto the weeds was carefully removed and the weed material weighed with a weighing balance. In each case, the fresh weed weight was recorded and the weeds then dried at 60^0C in a GenLab Oven (Genlab limited, Cheshire, UK) for 72 hours and then weighed with an electronic balance (Sartorious Mechatronics, Boutersem, Belgium) to obtain the dry weight.

Parameters measured on legumes

Number of seeds per pod and 100 seed weight (g)

Ten pods were shelled individually and the mean number of seeds per pod and mean 100 seed weight determined.

Grain yield was determined by shelling and weighing the grains per plot and then expressed in tha^{-1}. Moisture content of the samples was taken using a seed moisture meter (Seedburo Equipment Company, Illinois, USA).

Parameters measured on Cassava

Root length (cm)

Root length was measured from the base of the root to the tip. The measurement was made on five marketable roots from the harvestable plot and the average taken as the mean root length.

Fresh root weight (kg)

Root weight was determined by weighing the roots. Roots from five plants were bulked and placed in a sack and weighed on a hanging scale and the weight recorded. The weight was divided by five to obtain the fresh root weight per stand. Based on the mean root weight per stand and at a spacing of 1m x 1m the yield per hectare was estimated for all the treatments.

RESULTS AND DISCUSSIONS

Growth form and degree of occurrence of predominant weeds

A total of 14 weed species from 10 families were observed at the study area (Table-2) with the Poaceae, Fabaceae and Asteraceae families being the dominant ones. The weed species that were dominant on the field were *Centrosemapubescens* Benth, *Chromolaenaodorata* (L), *Talinumtriangulare* and *Panicum maximum* whilst the least abundant weed species recorded were *Boerhaviadiffusa, Euphorbia heterophylla* L., *Digitarialongiflora (*Retz.) Pers, *Imperatacylindrica, Pennisetumpedicellatum*Trin, *Cyperusrotundus* and *Amarantusspinosus* (Table-2).

The prominent weeds identified on the experimental plots comprised of all categories of weeds including broad leaves, grasses and sedges. The different weed species found were in line with the findings of Sattin and Berti (2006) who reported that weed flora usually includes several species that contemporarily infest the same field. The Asteraceae and Poaceae were dominant in the area despite the variations with Nyctaginaceae, Commelinaceae, Fabaceae and Portulacaceae species. This is expected since Asteraceae and Poaceae are the largest families of the dicotyledons and monocotyledons, respectively.

Table-2. Predominant weeds identified indicating their degree of occurrence growth form and family.

Weed species	Degree of occurrence	Growth form	Family
Boerhaviadiffusa	+	AF	Nyctaginaceae
*Centrosemapubescens*Benth	+++	AF	Fabaceae
Chromolaenaodorata(L)	+++	PF	Asteraceae
Commelinadiffusa(L)	++	AF	Commelinaceae
*Euphorbia heterophylla*L.	+	AF	Euphorbiaceae
Portulaca maximum Jacq	++	AF	Portulacaceae
*Tridaxprocumbens*L.	++	AF	Asteraceae
Talinumtriangulare	++	AF	Portulacaceae
Digitarialongiflora(Retz.)Pers	+	AG	Poaceae
Imperata cylindrical	+	PG	Poaceae
Panicum maximum	+++	PG	Poaceae
*Pennisetumpedicellatum*Trin	+	AG	Poaceae
Cyperusrotundus	+	PS	Cyperaceae
Amarantusspinosus	++	AF	Amaranthaceae

+ Low, ++ Medium, +++ High. AF: annual forb/broad weed; AG: annual grass; PF: perennial forb/broad weed; PG: perennial grass; PS: perennial sedge.

The predominant weeds in the area have been reported by Mangara *et al.* (2008) as problem weeds in various parts of the world. Among the predominant weeds, *Panicum maximum* has been described as a highly successful invader in the tropics. It is very competitive, highly resistant to fire and quickly invades gaps left in natural vegetation after fire. Also, Duke (1983) stated that *Panicum maximum* grows well on a wide variety of well drained soils and is suited to areas of 870 mm to 1000 mm of rainfall which falls within the range of annual rain received in Asuansi and thereby supporting its growth.

Effect of cassava-legume based cropping system on weed dry matter

The effect of cassava-legume based cropping system on weed dry weight (kgha^{-1}) at 4 and 8 weeks after planting (WAP) is presented in Table-3. The results indicated a significant (P<0.05) reduction in weed dry weight among the treatments at 4 and 8 weeks after planting.

The results indicated that at 4 WAP, the sole crop of cassava was not able to suppress weeds resulting in a significantly high weed dry weight of 1.0 tha^{-1}. However, the sole cropping of the three legumes and cassava-legume

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based cropping systems were able to suppress weeds and hence a significant reduction in weed dry weight ranging from 0.2 - 0.70 tha^{-1}. There was a further reduction in weed dry weight at 8 WAP (Table-3) for the same treatments.

In the sole cassava, significantly higher weed dry matter was recorded for the 4^{th} and 8^{th} WAP. The weed dry matter yield at 4^{th} and 8^{th} WAP recorded in most plots is an indication that weed constitutes a major problem to crop production especially to the resource poor farmers because of the absence of efficient and adequate techniques for their control (Ibeawuchi and Ofoh, 2003).

In general, weeds grow better under sole cassava than under sole legumes and the cassava-legume based cropping system treatments. This was expected since sole cassava gave the highest weed dry matter for the 4^{th} and 8^{th} WAP. This implies that the surface area covered by the cassava was lower, this is because cassava has a slow early growth (Njoku and Muoneke, 2008) resulting in slow canopy formation thus permitting much weed growth.

Table-3. Mean dry weight of weeds (t/ha) at 4 and 8 weeks after planting.

Cropping systems	**4 WAP**	**8 WAP**
Sole crop		
Cowpea	0.30	0.15
Groundnut	0.30	0.20
Soybean	0.30	0.15
Cassava	1.00	0.54
Cassava- Cowpea based cropping systems		
C_1C_{o1} (1 row of cassava alternating with 1 row cowpea)	0.40	0.20
C_1C_{o2} (1 row of cassava alternating with 2 rows cowpea)	0.24	0.15
C_1C_{o3} (1 row of cassava alternating with 3 rows cowpea)	0.22	0.11
C_2C_{o2} (2 rows of cassava alternating with 2 rows cowpea)	0.65	0.22
C_2C_{o3} (2 rows of cassava alternating with 3 rows cowpea)	0.60	0.23
Cassava- Groundnut based cropping systems		
C_1G_1 (1 row of cassava alternating with 1 row groundnut)	0.33	0.20
C_1G_2 (1 row of cassava alternating with 2 rows groundnut)	0.28	0.20
C_1G_3 (1 row of cassava alternating with 3 rows groundnut)	0.41	0.14
C_2G_2 (2 rows of cassava alternating with 2 rows groundnut)	0.57	0.16
C_2G_3 (2 rows of cassava alternating with 3 rows groundnut)	0.58	0.25
Cassava- Soybean based cropping systems		
C_1S_1 (1 row of cassava alternating with 1 row soybean)	0.40	0.23
C_1S_2 (1 row of cassava alternating with 2 rows soybean)	0.32	0.22
C_1S_3 (1 row of cassava alternating with 3 rows soybean)	0.20	0.17
C_2S_2 (2 rows of cassava alternating with 2 rows soybean)	0.70	0.22
C_2S_3 (2 rows of cassava alternating with 3 rows soybean)	0.48	0.20
CV (%)	19.5	17.8
Lsd (0.05)	0.14	0.06

C - cassava, C_o- cowpea, G - groundnut, S - soybean

The lowest weed dry matter recorded by the sole legume crops was also evident because the legumes were able to grow faster to form a canopy that suppressed the growth and development of weeds and significantly reduced weed biomass, thus, resulting in better weed control. Early canopy closure by closely spaced groundnut crop has been shown to smother weeds efficiently hence reducing weed/crop competition, especially for soil nutrients and water (Coolman and Hoyt, 1993).

The results obtained for the mean dry weed for the 4^{th} and 8^{th} weeks after planting are similar to those of Musambisi *et al*, (2002) who reported that intercropping field beans *(Phaseolus vulgaris)*, groundnuts and cowpea reduced the number of weed seeds, especially *Striga*and suppressed germination and growth of other weeds. Also,

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intercropping helps in the suppression of at least the secondary growth of weeds that occur after the intercrops have fully covered the ground.

The weed dry matter for the intercrop recorded for the 4th week after planting reduced in the 8th week after planting. This trend had earlier been reported by Ayeni *et al*, (1984) that smother crops may not be effective shortly after planting but are more effective in controlling weeds after they are well established. This was confirmed by Zuofa *et al*., (1992) who recorded a reduction in weed dry weight in cassava intercropped with smother crops from 20% at 3 WAP to 9% at 6 WAP. Also, Finlay (1974), reported that soybeans require early weeding because of their relatively slow early development and after 6 to 8 weeks, act as smother crop with a closed canopy. He also suggested that crop competition is the cheapest and most useful method the resource poor farmer has to control weeds.

In the cassava-cowpea based cropping systems, one row of cassava alternating with three rows of cowpea and one row of cassava alternating with two rows of cowpea were able to suppress weeds more efficiently because of increased plant population of the cowpea which led to better area cover thereby suppressing the weed growth. Similar results were obtained for cassava-soybean based cropping systems where one row of cassava alternating with one row of soybean and one row of cassava alternating with two rows of soybean reduced weed dry matter by 0.20 tha^{-1} and 0.32 tha^{-1}, respectively, compared to two rows of cassava alternating with two rows of soybean which recorded a significantly high weed weight by 0.76 tha^{-1}.

Generally, it is expected that an increase in plant population and closer spacing will reduce weed growth. However, Moody (1978) pointed out that, increasing the population of the main crop by a ratio of 2:1 can reduce the weed-suppressing ability of the smother crop. It seems that, at a higher smother crop population, the magnitude of competition may reduce the effectiveness of the smother crops and the main crop in controlling weeds (Ayeni *et al*., 1984). This explains the reason for high weed dry weight recorded for treatments that were made up of high plant population of the legumes.

In comparing the three legumes abilities to suppress weeds, groundnut was able to suppress weeds more effectively than cowpea and soybean. This could be due to groundnut ability to grow fast to form a closed canopy and reduction in nutrient drain by weeds. The result obtained is also in line with Zuofa *et al*. (1992) who reported that among the three legumes, groundnut gave best weed control, followed by cowpea and melon although the differences observed in the weed dry weight were not significant.

Effects of cassava-legume based cropping system on seed weight and yield of legumes

The yield of cowpea was significantly (P<0.05) lower in the cassava-cowpea based cropping system (Figure-1). However, there was no significant difference (P>0.05) of cassava-cowpea based cropping system on the 100 seed weight of the cowpea (Figure-1).

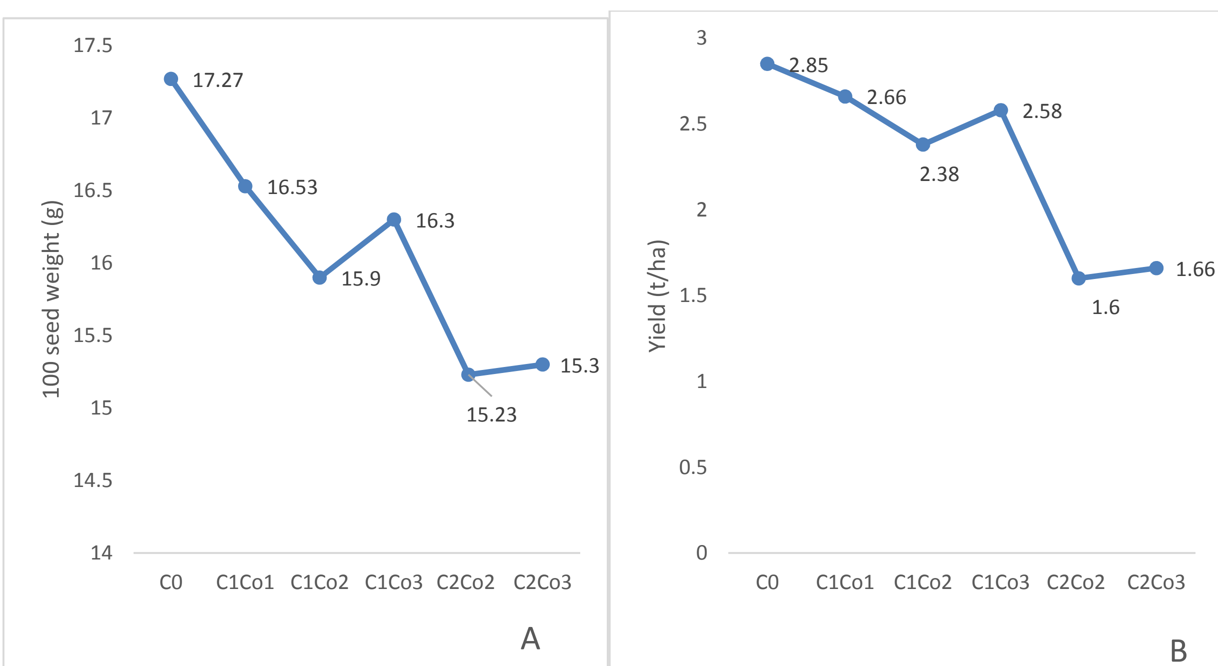

Figure-1. Effect of spatial arrangement on cowpea 100 seed weight (g). $Lsd_{0.05} = 2.24$ (A) Yield (t/ha). $Lsd_{0.05} = 0.58$ (B).

Groundnut yield was significantly (P<0.05) reduced in the cassava-groundnut based cropping systems but there was no significant (P>0.05) effect of the cropping systems on 100 seed weight (Figure-2).

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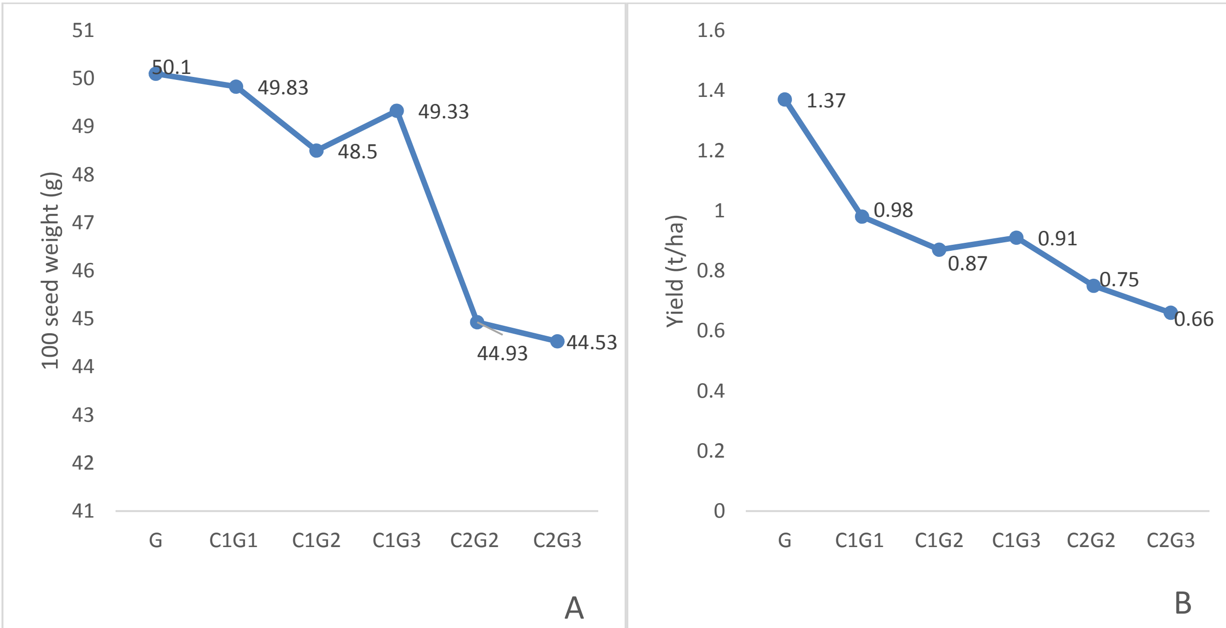

Figure-2. Effect of spatial arrangement on groundnut 100 seed weight (g). $Lsd_{0.05} = 5.68$ (A) Yield (tha^{-1}). $Lsd_{0.05} = 0.12$ (B).

The effect of spatial arrangement on soybean yield and 100 seed weight in a cassava-soybean based cropping system is presented in Figure-3. There was no significant ($P<0.05$) effect of cassava-soybean intercrop on soybean yield and 100 seed weight of the soybean.

The sole soybean recorded the highest yield of 1.44 tha^{-1} but this was not significantly different from treatments C_1S_1, C_1S_3, C_1S_2 with yield of 1.42 tha^{-1}, 1.15 tha^{-1} and 1.11 tha^{-1} respectively. The lowest yield of 0.91 tha^{-1} recorded for C_2S_3 was not significantly different from the other treatments (Figure-3).

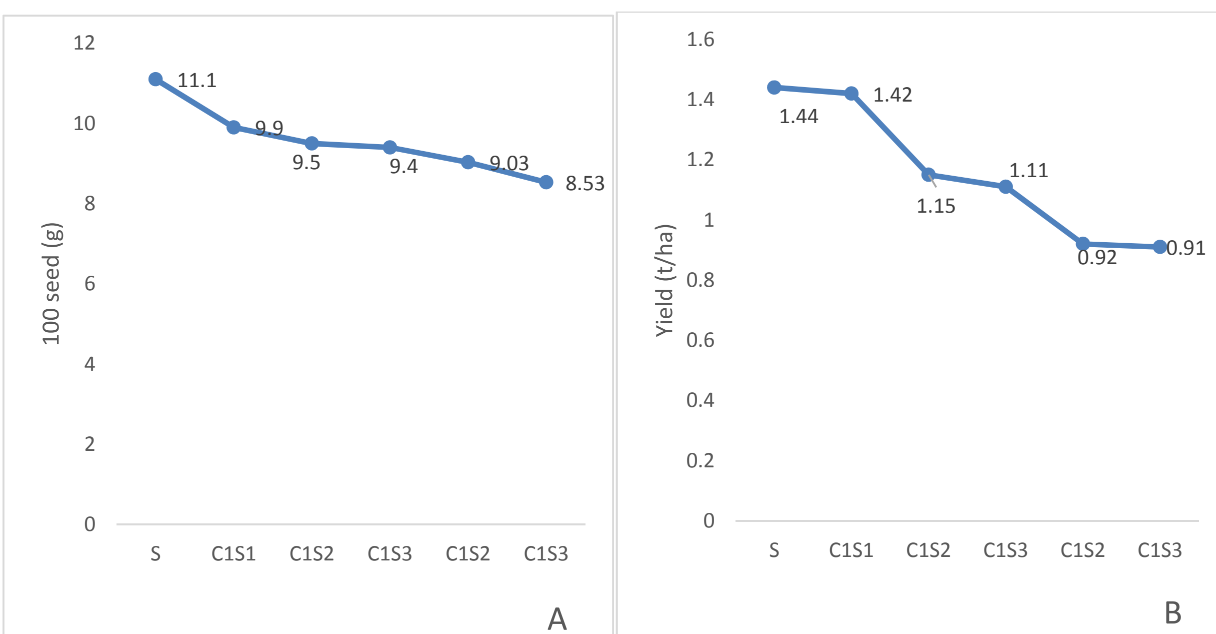

Figure-3. Effect of spatial arrangement on soybean 100 seed weight (g). $Lsd_{0.05} = 1.66$ (A) Yield ($t\ ha^{-1}$). $Lsd_{0.05} = 0.48$ (B).

Intercropping cassava with varying cowpea plant populations may influence the performance of the component crop. The main effect of cassava-cowpea intercrop on cowpea yield was significantly ($P<0.05$)

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lowered among the treatments. In this study, cowpea grain yield varied significantly ($P<0.05$) with the cropping system, however, similar work done by Njoku and Muoneke (2008) contrasted the result of this study. In their study, cowpea grain yield did not vary significantly ($P>0.05$) no matter the cropping system adopted. The sole cowpea (C_o) and the alternate row of cowpea with cassava (C_1C_{o1}) had the highest yield (2.85 tha^{-1} and 2.66 tha^{-1}). Increasing the number of rows of the cowpea in the intercrop significantly ($P<0.05$) reduced the yield of the cowpea. This result confirms work done by Ayoola and Makinde (2008) who observed a significant ($P<0.05$) reduction in cowpea yield when intercropped with cassava.

In the cassava-cowpea intercrop, the single row of cowpea out yielded the double row and triple rows of cowpea. The reduction in the yield of cowpea with increasing cowpea population may be due to intense competition between the cowpea and the cassava. Similarly, Oseni and Aliyu (2010) reported of reduced cowpea yield in an intercrop when they investigated the effects of component crop density on the yield of cowpea intercropped with sorghum.

The highest grain yield of 1.37 tha^{-1} was recorded for the sole groundnut. There was a reduction in the yield of groundnut in the cassava-groundnut intercrop. The reduction in yield might be due to high population density which leads to competition for nutrient and water, hence, the reduction in the yield. This supports the assertion by Mason *et al*. (1986) who reported a reduction in groundnut yield from 2.1 t ha^{-1} in the sole groundnut to 1.3 tha^{-1} in the groundnut cassava intercrop.

Intercropping cassava with soybean reduced the 100 seed weight, and soybean yield. The highest soybean yield of 1.44 tha^{-1} was obtained in sole soybean because of reduced inter-specific competition for growth resources among the crops as well as higher aggregate population density per unit area.

The higher grain yield of the sole crop over the intercropped soybean has been reported (Olufajo, 1992). The yield was reduced to 1.42 tha^{-1} and 1.12 tha^{-1} for treatment C_1S_1 (one row of cassava alternating with one of soybean) and C_1S_2 (one row of cassava alternating with two rows of soybean). The yield reduction in the intercropped soybean could be due to shading by the taller cassava plants. Olufajo (1992) reported that shading by the taller plants in an intercrop could reduce the photosynthetic rate of the lower growing plants such as soybean which reduced their yields.

Also, doubling or tripling the rows of soybean in the intercrop decreased the yield of the soybean. The decreased yield with increased soybean plant density could be due to competition for growth resources between the component crops which reduced the rate of assimilated photosynthates in high density soybean plots. Similarly, Pal, *et al*., (1993) reported reduced intercrop yields when they investigated the effects of component crop density on the yield of sorghum intercropped with soybean in which an increase in soybean population reduced the yield of the soybean.

Effect of cassava-legume based cropping system on mean number of roots, root length and cassava yield

There were significant differences ($P<0.05$) in mean number of roots, root length and yield between the sole crop and the intercrop (Table-4).

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Table-4. Mean number of roots, mean root length (cm) and yield (t ha^{-1}) of cassava in cassava-legume based cropping system.

Cropping systems	Mean no. of roots	Mean root length (cm)	Fresh root yield (tha^{-1})
Sole crop			
Cassava	9.3	31	41.60
Cassava-cowpea based cropping systems			
1 row of cassava alternating with 1 row cowpea	8.7	28	27.20
1 row of cassava alternating with 2 rows cowpea	7.3	28	24.03
1 row of cassava alternating with 3 rows cowpea	7.0	25	21.87
2 rows of cassava alternating with 2 rows cowpea	5.4	23	19.40
2 rows of cassava alternating with 3 rows cowpea	3.0	17	17.53
Cassava-groundnut based cropping systems			
1 row of cassava alternating with 1 row groundnut	9.0	29	28.40
1 row of cassava alternating with 2 rows groundnut	8.7	28	24.13
1 row of cassava alternating with 3 rows groundnut	7.3	28	23.60
2 rows of cassava alternating with 2 rows groundnut	7.0	26.0	19.60
2 rows of cassava alternating with 3 rows groundnut	7.0	25	16.53
Cassava-soybean based cropping systems			
1 row of cassava alternating with 1 row soybean	7.0	26	29.07
1 row of cassava alternating with 2 rows soybean	6.6	25	24.00
1 row of cassava alternating with 3 rows soybean	6.4	25	23.33
2 rows of cassava alternating with 2 rows soybean	6.0	25	21.13
2 rows of cassava alternating with 3 rows soybean	5.7	24	16.03
CV (%)	5.5	11	23.2
Lsd (0.05)	3.1	4	9.20

There was significantly high root yield obtained for sole cassava because there was no competition for various resources except intra-specie competition. This might have paved the way for the increased growth and yield parameters which would have increased the yield.

Cassava intercropped with legumes generally decreased the cassava root yield by 30% to 60% as compared to cassava planted as a sole crop. Cassava-cowpea based cropping system caused 35% to 57% reduction in cassava yield. The reduction in cassava yield was due to the competition of the component crops (cowpea) for light, water and nutrients. This result is in line with the findings of Mason *et al*. (1986), who reported that intercropping cassava with cowpea reduced cassava yield by 14% to 24%. The percentage reduction in cassava yield obtained in this experiment is high and this might be due to the cassava variety (Capevarsbankye) used which is high yielding.

Increasing the plant population of the cowpea further reduced the yield of the cassava. The double row (C_1C_{o2}) and triple row (C_1C_{o3}) of cowpea reduced cassava yield to 57% and 52% respectively. This finding is in sharp contrast to a report by Eke-Okoro *et al*. (1999) who reported an increase in cassava root yield with increased cowpea population density. They further explained that the wide maturity gap between cowpea (about 90 days) and cassava (about 360 days) and the slow initial growth of cassava enhanced the compatibility of cassava and cowpea intercrop (Muleba *et al*., 1997) which may have resulted in the increased cassava yield.

There was a further decrease in cassava yield as the cowpea rows increased. The double row of cassava and double row of cowpea (C_2C_{o2}) and the double row of cassava with triple row of cowpea (C_2C_3) further reduced the cassava yield to between 53% and 58%, respectively. This could be attributed to intense competition among the main crop and the component crops for water, nutrient and sunlight. Similar result was reported by Olasantan*et al*. (1994).

For the cassava-groundnut based cropping systems, a reduction in cassava yield of 32%, 42%, 47%, 53% and 58% was recorded for all the treatments. The reduction in cassava yield might be due to competition between the groundnut and the cassava plants. Similarly, Prabhakar and Nair (1996) reported a reduction of cassava yields when intercropped with groundnut. From the results obtained, spatial arrangement and change in plant density reduced root yield and is in contrast with Prabhakar and Nair, (1996) who reported that neither spatial arrangement of cassava nor change in plant density of intercropped groundnut had any substantial effect on root yield of cassava. This could be due to the fact that groundnut a short-duration crop matured just after the maximum canopy development of cassava and harvested earlier before an increase rate of storage root bulking process in the cassava crop (Prabhakar and Nair, 1996).

With regards to cassava-soybean based cropping systems, one row of cassava with one row of soybean recorded 30% reduction in the cassava yield. The reduction in yields of cassava when intercropped with soybean at the same time had been attributed mainly to competition for basic growth resources like nutrients, light and space (Olufajo, 1992).

As the rows of soybean increased from one to two and three, the yield of cassava was further reduced by 42% and 44% for one row of cassava alternating with two rows of soybean and one row of cassava alternating with three rows of soybean, respectively. This shows that as soybean plant population increases, the yield of the main crop is reduced. The results confirmed the observations of Chinaka and Obiefuna (2000) in their study on sweet potato/maize mixed cropping. Also, spatial arrangement of double row of cassava with double row of soybean and double row of cassava and triple row of soybean further reduced the yield of cassava by 49% and 61% respectively. The results corroborated studies by Cenpukdee and Fukai (1992) in cassava/legume intercrop.
In general, the cassava-soybean based cropping system performed better with a higher cassava yield of 29.07 t/ha in comparison with cassava-groundnut intercrop (28.40 t/ha) and cassava-cowpea intercrop (27.20 t/ha) for the one row spatial arrangement. This is in sharp contrast to a report by Eke-Okoro *et al*. (1999) who observed highest cassava storage root yields when intercropped with groundnut, relative to other legume intercrops (soybean, and cowpea).

CONCLUSIONS

From the experiment it can be concluded that the weed flora composition in a small holder cassava cropping system at the southern fringes of the semi deciduous forest in Ghana consist of weeds belonging to the Poaceae, Asteraceae, Commelinaceae, Euphorbiaceae and Portulacaceae family with the *Panicum maximum, Talinumtraingulare, Chromolaenaodorata* (L) and *Centrosemapubescens* Benth being the predominant weeds in the area.

The results indicated that a spatial arrangement of one row of cassava alternating with one row of legume gave the best yields for the main and component crops.

It can also be concluded that intercropping is a better option for the resource poor farmers since it suppressed weed growth. The two rows and three rows of the legume gave the best weed control for the spatial arrangement.

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