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Effects of Landrace Legumes-Velvet Bean, Lima Bean and African Yam Bean-On the Performance of Yam, Cassava Based Crop Mixtures

I.I. Ibeawuchi, M.C. Ofoh, M.I. Nwufo and J.C. Obiefuna
Department of Crop Science and Technology,
Federal University of Technology,
P.M.B. 1526, Owerri, Nigeria

Abstract: This study appraised the effects of landrace legumes, velvet bean (*Mucuna pruriens* Var. utilis) Lima bean (*Phaseolus lunatus* L.) and African yam bean (*Stenostylis sternocarpa*) on the performance of yam, cassava based crop mixtures. The three-landrace legumes were intercropped with tuber based cropping system. The 18 treatments comprising yam/maize/mucuna, yam/maize/lima, yam/maize/African yam bean, yam/maize cassava/maize/mucuna, cassava/maize/lima, cassava/maize/African yam bean, cassava/maize, yam/maize/cassava/mucuna, yam/maize/cassava/mucuna, yam/maize/cassava/ African yam bean, yam/maize/cassava, yam, cassava, maize, Mucuna, Lima bean and African yam beans were laid out in a randomized complete block design replicated three times. The research was carried out at the training and research farm of the Federal University of Technology, Owerri, located at latitude 5° 20′N and 5° 29′N, longitude 7°E and 7°02′E in the humid rainforest zone of southeastern Nigeria. Growth and yield data were collected and statistically analysed. The heavy canopy cover of mucuna in all crop combination associated with it coupled with high number of component crops per plot reduced maize and cassava plant heights as well as maize grain yield, fresh cassava roots and fresh yam tubers. However, crop mixtures with lima bean and or African yam bean did not significantly $p \geq 0.05$ affect maize and cassava plant heights nor depressed fresh cassava roots, maize grain and fresh yam tuber yields. All the legume crops performed well in sole cropping system than in mixture of more than three component crops as a result of competition for the necessary growth resources.

Key words: Landrace legumes, yam, cassava based crop mixtures

INTRODUCTION

Many of the research attempts made to revitalize agriculture especially our cropping systems in Nigeria and to create a sustainable rural livelihood have not given adequate emphasis to our traditional cropping systems and the land race legumes in particular. By means of diversification new in-roads have been made in the area of genetics and breeding and more recently in biotechnology of crop species especially the DNA marker-assisted crop improvement. However, not much effort has been made in improving the traditional farming systems using the landrace legumes, which exist in the cultivated and wild forms.

The advances made in agriculture in the past few decades have witnessed the colonial research efforts on adapting some well known and highly researched pulse species such as groundnut

Corresponding Author: I.I. Ibeawuchi, Department of Crop Science and Technology, Federal University of Technology, P.M.B. 1526, Owerri, Nigeria

(*Arachis hypogaea*), soybean (*Glycine max* (L.) Merr) and cowpea (*Vigna unguiculata* (L.) Walp) to high production in the lowland humid belts with limited resources without any attempt on the advancement of the landrace legumes. Our indigenous smallholder farmers who produce majority of our food have not wholly adopted some of these exotic legumes introduced into our farming environment. This poses serious challenge to researchers in the humid tropics of Southeastern Nigeria because there are some landrace legumes that could be upgraded through appropriate agronomic research. This research tends to address this problem by intercropping these landraces with yam; cassava based cropping systems to evaluate their performance. It is believed that, these land races might even perform better than the exotic pulses. The landraces are often preferred by our smallholder farmers due to considered fewer production problems as they grow and yield well in the traditional age long complex mixed cropping systems. These landraces include; the Lima bean (*P. lunatus* L.) which locally is called *Akidi-nwangwu*, African yam bean (*Sphenostylis sternocarpa*), locally called *Okpa odudu*, the velvet bean (*Mucuna pruriens* var utilis) known locally as *Agbiri* and are known to perform well in the highly leached infertile soils (Ultisols) of Southeastern Nigeria. There has been limited research to identify their production systems, potentials in nitrogen fixation, soil conservation and fertility and documentation about their forage potentials. Also, there have been few trials to improve these species as crop plants and more especially to explain the agronomy required for their large-scale production either in sole or intercropping systems.

The lima bean is sporadically sown in mixed cropping systems after maize has been harvested. The dry seeds are boiled and used for food in Nigeria. However, it is a lesser-known legume crop in the low land tropics. Its intercropping with vegetable crops in the tropics had been reported (Van der Measeen and Sadikin, 1989). It is cultivated for its immature and dry seeds like in Asia where the immature sprouts, leaves and pods are consumed and because of its astringent qualities, is used as a diet for fever in traditional Asian medicine and the dry bean is used to produce flour rich in protein in the Philippines and also to enrich bread (Van der Measeen and Sadikin, 1989).

The velvet bean (*Mucuna pruriens*) is a vigorously growing annual plant that has a number of species and hybrids (Oudhia and Tripathi, 2001). It has trailing vine grown mostly for green manuring or temporary pasture. The velvet bean is a perennial herbaceous climber mostly found in the wild. It requires high temperatures and a humid climate but will grow on poor sandy loams (Oudhia and Tripathi, 2001).

The African yam bean grown in several West African countries for their seeds and tubers are not common and their cultivation is fast declining. In Nigeria, the crop is known as Okpa *Odudu* or *Girigiri*. It belongs to the family leguminoseae and sub-family papilliinoideae and can be seen in a variety of ecological zones ranging from fertile highland areas to sandy leached areas in the lowlands and also in swampy areas (Schippers, 2000). The plant is a vigorous herbaceous vine that climb and twines to heights over three meters with trifoliate leaves and leaflets being up to 14 cm in length and 5 cm broad.

Yam production is an age long practice in West Africa and Nigeria in particular. Yams rank second to cassava as the most important crop in Africa, In turn, Africa accounts for nearly 98% of World yam production. A total of about 26 million tones of yams are produced on the continent annually (Onwueme, 1989). This figure has almost doubled presently. According to a popular Igbo saying, Yam was given to man by god and so believed to be closely linked to the origin of mankind. Yam is part of the religious, social and cultural heritage of many Nigerian tribes where yam still plays a key role in religious ceremonies. In fact, it has been shown that most yam species originated from West Africa (Onwueme and Sinha, 1991) hence yam is truly an indigenous crop in the cultural and biological sense.

Maize has been involved in intercropping with many tuber and vegetable crops. Maize/cassava intercropping system is popular with farmers in Nigeria (Ibeawuchi and Ofoh, 2000). Maize

(*Zea mays* L.) belongs to the family gramineae. It is an annual monoecious plant and it is one of the most important agricultural plants in the world. In many African countries, maize is the basic staple food for subsistence farmers, miners and city dwellers.

Cassava is one of the principal plants of use to man because of the important role it plays as food. It belongs to the Euphorbiaceae family the *Manihot* gender and a dicotyledonous plant. It has numerous species but *Manihot esculanta* has become of wide spread culture (Pierre, 1989). In Nigeria, cassava is prepared as cassava fufu and served with vegetable soups. Boiled cassava and cassava chips are eaten with coconut, groundnuts, fish or meat. Salads made with cassava are usually well balanced and nutritious (Pierre, 1989).

It is believed that this study will fit well into the farmer oriented research programme currently adopted to benefit smallholder farmers that are predominant in the humid tropical zone of Southeastern Nigeria. These farmers are numerous and make a higher percentage of the farming population of Nigeria.

MATERIALS AND METHODS

The experiment was conducted at the teaching and research farm of the School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri (FUTO), Nigeria; located between latitudes 5°23' 8.7 N and longitudes 6°59' 39.4 E at a height above sea level of 55 m (Hand held Global positioning system). Owerri is in the tropical rainforest zone of southeastern Nigeria which ecologicaly is characterized with more than 2500 mm annual rainfall, 27-29° annual temperatures and 89-93% relative humidity. The soils formed from acid sands are classified as Ultisols (Eshett and Anyahucha, 1992). The Ultisols, (Acrisols in the FAO/UNESCO world soil map) are seriously acidic, coarse textured, highly leached upland soils occurring further south of the southeastern Nigeria. The soils have low mineral reserve and are, therefore, low in fertility (Eshett, 1993).

Planting Materials

Three landrace legumes endemic in the humid rainforest zone of southeastern Nigeria were used namely: African yam bean-*Sphenostylis sternocarpa*; *Lima* bean-*Phaseolus lunatus* and the velvet bean-*Mucuna pruriens* var. utilis. Mucuna grows in the wild but the black seeds were collected from the SAAT gene bank while lima bean and African yam bean were bought from the rural markets in Owerri agricultural zone.

Other planting materials included: Cassava (TMS 30555); Yam (white) obiaeturugo-local cultivar; Maize-TZSR yellow. Cassava cuttings and maize were bought from the Imo ADP Headquarters along Okigwe road, Owerri.

For the repeat of the experiment in 2002, seed yams and cassava cuttings were got from the 2001 plantings while the saved 2001 maize were used.

Land Preparation

Land preparation was done manually with machetes, spades and rakes since minimum tillage was used. In each case, the site after clearing was left to dry. The dry matter were later picked and removed from the site and thereafter the field was marked out for planting.

The experiment was laid out in a randomized complete block design with 18 treatments replicated 3 times. This gave a total of 54 plots. Each plot measured 3×4 m with a space of 1m between each plot and 2 m between each block. There was a 1 m guard area round the experimental area, this gave a total of 1209 m^2 or 0.121 ha. The treatments included sole crops of the individual crops and their combinations as follows:

Yam-Based:	**Yam/cassava-based**
1. yam/maize/mucuna (y/m/mp)	9. yam/maize/cassava/mucuna (y/m/mp).
2. yam/maize/lima (y/m/l).	10. yam/maize/cassava/lima (y/m/c/l)
3. yam/maize/African yam bean (y/m/Ayb)	11.Yam/maize/cassava/African yam bean
(y/m/c/Ayb)	
4. yam/maize, (y/m).	12. Yam/maize/cassava (y/m/c)
Cassava-Based	**Sole Cropping**
5. cassava/maize/mucuna (c/m/l)	13. Yam (y)
6. cassava/maize/lima (c/m/l)	14. Cassava ©
7. cassava/maize/African yam bean (c/m/Ayb)	15. Maize (m)
8. cassava/maize (c/m).	16. Mucuna (Mp)
	17. Lima bean (L)
	18. African yam beans (Ayb)

Planting and Spacing

Planting was done in the first week of April 2001 as was also repeated in 2002. Seeds of the land race legumes were planted in holes at a depth of 2-5 cm at 50×50 cm spacing each. These were later thinned down to 1 per hole after germination giving a plant population of 20,000 plants per hectare for sole and intercropped plots of each of the three legumes.

Maize (TZSR-yellow), seeds were planted 2 per hole at a depth of 2-5 cm at 1×1 m spacing. This was thinned down after germination to 1 plant per stand giving a plant population of 10,000 plants per hectare.

Yam; *Dioscorea rotundata* (white) obiaeturugo local variety seed yams weighing 200-300 g were planted in holes measuring 30×30×30 cm at a spacing of 1×1 m on the flat. This gave a plant population of 10,000 plants per hectare.

Cassava (TMS 30555) cuttings measuring 20 cm long were planted on the flat at 1×1 m spacing giving a plant population of 10,000 plants ha^{-1}.

Agronomic Practices

No fertilizer or agrochemical was applied since the study involved legumes for soil fertility enhancement.

Staking

The yams were staked as and when due. The land race legumes shared the same stake with yam. In cassava-based system, the legumes utilized the cassava stems as stake support.

Weeding

Weeding was done 3 times with hoe at 4, 8 and 12 WAP for all the plots in the experiment. In each case, the weed fresh weight was recorded.

Training

Training of the yam and legume vines started immediately after staking and continued up to 12 WAP.

Stand counts were taken from each plot before harvest was done.

Harvesting was done at the maturity of each test crop.

Maize

Dried maize cobs in the field were harvested at 15 Weeks after Planting (WAP) when 99% of all the maize stands had dried. The cobs were sun dried and dehusked, shelled and the grain weight was obtained.

African Yam Bean

The long pods of the beans ripened and dried at different intervals. Harvesting of the dried pods were spread over a period of two weeks from 20-22 WAP. The pods were further sun-dried and split open and the seeds collected. The seeds were weighed with a Salter scale.

Lima Bean

The dry pods of the bean ripened at different times. Harvesting was spread over three weeks from 19-22 WAP. The pods were split, the seeds collected and their weight obtained.

Velvet Bean (*Mucuna pruriens*)

The pods matured 17 WAP and drying started two weeks later. Harvesting of the pods, which matured and dried at different intervals began from the 18 WAP and lasted till 23 WAP. The pods were split open by applying some pressure with a small stick. The black seeds were gathered and weight obtained.

Yam

The yams were harvest at 35 WAP with spade. The tubers were gathered and weighed and the weight recorded.

Cassava

The cassava stands were harvested at 60 WAP. The cassava cuttings were gathered plot by plot at 20 cuttings/bundle. Cassava tubers per plot were weighed and recorded.

Data Analysis

The data collected were collated and statistically analyzed using the Microsoft Excel Packafe (2000) and SPSS (2004) packages. Wahua 1999 was used to help in data analysis and interpretation.

RESULTS

Maize Plant Heights (cm)

Results of Fig. 1 shows the maize plant heights (cm) as affected by yam-based cropping systems. Results show that sole maize, yam/maize/lima and yam/maize/African yam bean, had the highest maize plant heights that were significantly different ($p \geq 0.05$) at 10 WAP from maize plant heights in Yam/Maize and yam/maize/mucuna pruriens cropping systems. The maize heights at 3 and 7 weeks after planting were not significantly affected by the cropping systems.

Results indicated that there was uniformity in maize heights at 3 WAP (Fig. 2). However, at 7 and 10 WAP, the maize plant heights (cm) in all the other crop combinations were significantly higher ($p \geq 0.05$) than that in cassava/maize/mucuna crop combination.

Figure 3 showed that at 3 and 7 weeks after planting, there were uniform maize plant heights. However, at 10 WAP, sole maize, yam/maize/cassava/lima and yam/maize/cassava/African yam bean had the highest heights, which were significantly taller than the other maize plants in the crop mixture.

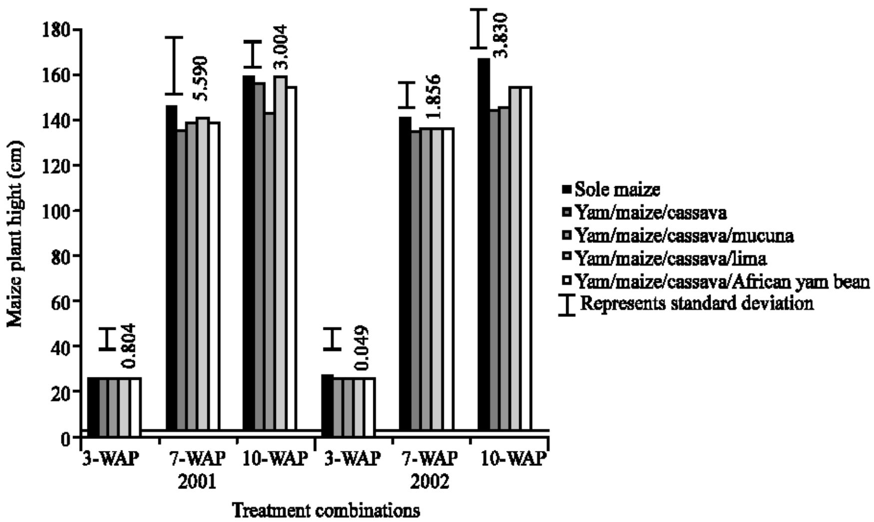

Fig. 1: Maize plant heights (cm); at 3, 7 and 10 weeks after planting as affected by yam-based cropping system, 2001 and 2002. LSD (0.05) = 2.75

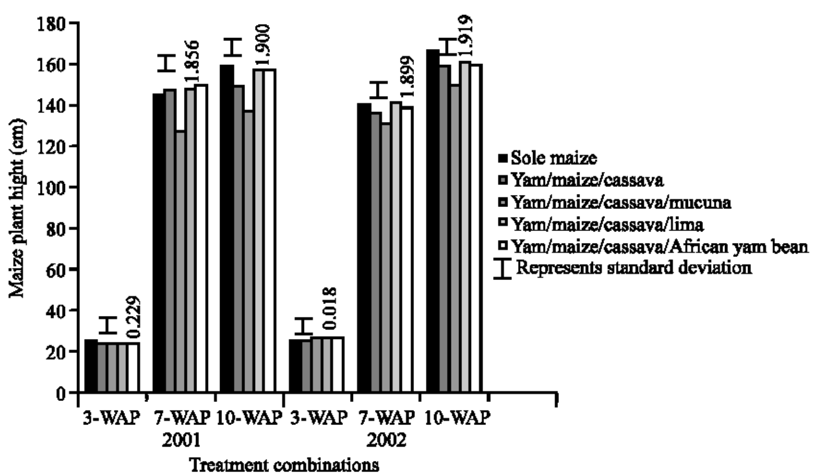

Fig. 2: Maize plant heights (cm), at 3, 7 and 10 weeks after planting (WAP), As affected by cassava-based cropping system LSD (0.05) = 2.40

Cassava Plant Heights (cm)

Figure 4a shows the cassava plant heights (cm) as affected by cassava-based cropping system. The data after analysis showed no significant differences. Figure 4b shows the cassava plant heights (cm) as affected by yam/cassava based cropping system. Also, there were no significant differences in heights. However, from the Fig. 4a and b presented, there are some noticeable differences in height 12 WAP, but statistically not significant.

Effect of the Landrace Legumes on the Performance of Yam, Cassava-Based Cropping Systems

Table 1 shows maize dry grain yields t ha^{-1} and stand count as affected by yam-based cropping system. The result shows that in 2001, sole maize, yam/maize/lima, yam/Maize/African yam bean and

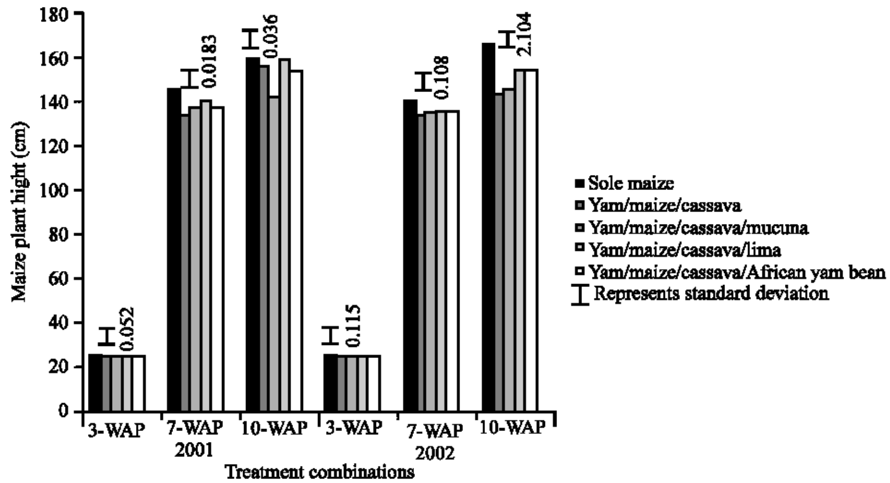

Fig. 3: Maize plant heights (cm); at 3, 7 and 10 weeks after planting as affected by cassava-based cropping system, 2001/2002. LSD (0.05) = 4.67

yam/maize gave high yields and were significantly higher ($p \geq 0.05$) than the yield from yam/maize/mucuna. Also, in 2002, the sole cropped maize and the other crop combinations had higher maize grain yield than yam/maize/mucuna cropping systems. Spearman coefficient of rank correlation was performed to understand the relationship between yields and stand count. In both 2001 and 2002 yield a high rank correlation with stand count of 0.925 and 0.950, respectively were recorded.

Table 2 shows the maize dry grain yield t ha^{-1} and stand count as affected by cassava-based cropping system. The results show that in both 2001 and 2002 maize grain yield under sole cropping and cassava/maize/African yam bean and Cassava/maize were higher ($p \geq 0.05$) than that for cassava/maize/mucuna. The Spearman coefficient of rank correlation was also high showing a close relationship between stand count and yield in both 2001 and 2002.

Table 3 shows the maize dry grain yield (t ha^{-1}) and stand count as affected by yam/cassava-based cropping system. The results show that the maize yield in 2001 was higher than that for 2002 in yam/cassava-based cropping systems. However in both years, the sole cropping of maize and maize intercropped with yam/cassava and either Lima or African yam bean had higher grain yield than maize intercropping with yam/cassava/mucuna and were significantly different ($p \geq 0.05$). The Spearman coefficient of rank correlation of 0.950 and 0.527 were obtained in 2001 and 2002, respectively indicating a close relationship between stand count and yield.

Table 4 shows the mean fresh tuber yield (t ha^{-1}) and stand count of yam (*Dioscorea rotundata*-local cultivar) as affected by the cropping system. The results revealed that the sole planted yam still had the full number of stand count per hectare. Also, there were no significant differences between the sole yam cropping, yam/maize/lima, yam/maize and yam/maize African yam bean in yam-based cropping system. But these were different significantly ($p \geq 0.05$) from yam/maize/mucuna and all yam based and in the yam/cassava-based cropping systems in both 2001 and 2002. The Spearman coefficient of rank correlation was not high especially in 2002 with 0.296.

Table 5 summarizes the data on fresh cassava tuber yield (t ha^{-1}) and stand count of cassava (TMS 30555) as affected by the cropping system. Yields were generally high in both 2001 and 2002. However, sole cassava cropping (18.25 and 16.61 t ha^{-1}) cassava/maize/lima (12.80 and 12.69 t ha^{-1}),

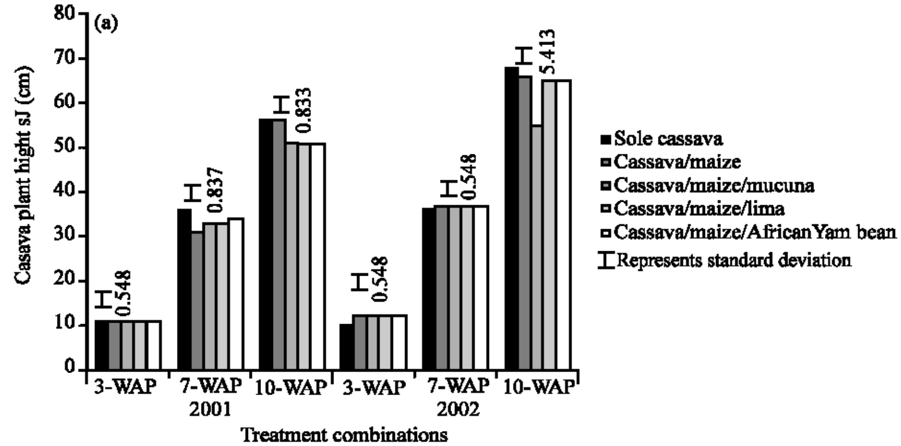

Fig. 4a: Cassava plant heights (cm), at 4, 8 and 12 weeks after planting (WAP), as affected by cassava-based cropping system

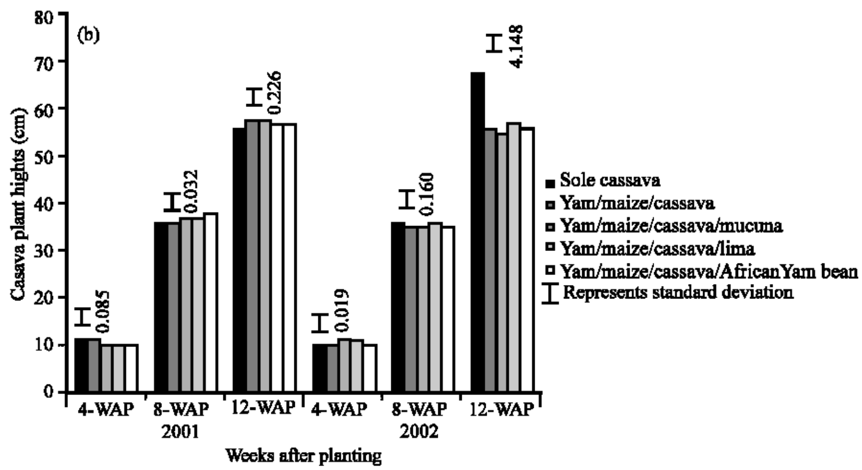

Fig. 4b: Cassava plant heights (cm), at 4, 8 and 12 weeks after planting (WAP), as affected by yam/cassava-based cropping system

Table 1: Maize grain yield (t ha^{-1}) and maize stand count as affected by yam-based cropping system

Cropping system yam-based	2001		2002		Annual average	
	Yield (t ha^{-1})	Stand count ha^{-1}	Yield (t ha^{-1})	Stand count ha^{-1}	Yield (t ha^{-1})	Stand count ha^{-1}
Sole maize	0.88	8333	0.76	7500	0.82	7917
y/m/mp	0.16	2500	0.21	3333	0.19	2917
y/m/l	0.86	8333	0.54	7500	0.70	7917
y/m/Ayb	0.86	8333	0.60	9167	0.73	8750
y/m	0.76	7500	0.51	9167	0.64	8344
LSD (0.05)	0.22		0.27		0.25	

Cassava/maize African yam bean (13.03 and 15.89 t ha^{-1}), yam/maize /cassava/lima (11.64 t ha^{-1}) and yam/maize/cassava/African yam bean 12.00 t ha^{-1}) gave statistically higher tuber yields than the other crop combinations. Also, the spearman coefficient of rank correlation 0.725 and 0.96 for 2001 and 2002, respectively between yield and stand count showed a close relationship.

Table 2: Maize dry grain yield (t ha^{-1}) and Maize stand count as affected by cassava-based cropping system

Cassava-based	2001 Yield (t ha^{-1})	2001 Stand count ha^{-1}	2002 Yield (t ha^{-1})	2002 Stand count ha^{-1}	Annual average Yield (t ha^{-1})	Annual average Stand count ha^{-1}
Sole maize	0.88	8333	0.76	7500	0.82	7917
c/m	0.78	8333	0.55	4167	0.67	6250
c/m/mp	0.33	4167	0.18	3333	0.26	3750
c/m/l	0.84	8333	0.54	5000	0.69	6667
c/m/Ayb	0.84	7500	0.53	4167	0.69	5834
LSD (0.05)	0.44		0.32		0.38	

Table 3: Maize dry grain yield: t ha^{-1} and stand count as affected by yam/cassava-based cropping system

Yam/cassava based	2001 Yield (t ha^{-1})	2001 Stand count ha^{-1}	2002 Yield (t ha^{-1})	2002 Stand count ha^{-1}	Annual average Yield (t ha^{-1})	Annual average Stand count ha^{-1}
Sole maize	0.88	8333	0.76	7500	0.82	7917
y/c/m	0.73	8333	0.53	5833	0.63	7083
y/c/m/Mp	0.27	3333	0.22	4167	0.23	3750
y/c/m/L	0.75	9167	0.53	5833	0.64	7500
y/c/m/Ayb	0.81	9167	0.51	5000	0.66	6584
LSD (0.5)	0.25		0.12		0.19	

Table 4: Mean fresh tuber yield (t ha^{-1}) ans stand count of yam (*D. rotundata*-local cultivar) as affected by the cropping system

Cropping system	2001 Yield (t ha^{-1})	2001 Stand count ha^{-1}	2002 Yield (t ha^{-1})	2002 Stand count ha^{-1}	Annual average Yield (t ha^{-1})	Annual average Stand count ha^{-1}
Sole yam	10.75	10000	10.54	10000	10.65	10000
Y/m/mp	3.00	3889	3.67	5000	3.34	4445
Y/m/l	10.02	9722	8.49	6945	9.49	8334
Y/m/Ayb	10.57	9444	10.21	8056	9.26	8750
Y/m	10.01	9444	8.97	9167	10.39	9306
Y/m/c/mp	1.92	3056	4.73	5833	3.33	4445
Y/m/c/l	7.64	7500	7.94	6667	7.29	7084
Y/m/c/Ayb	7.61	8611	8.46	6945	7.79	7078
Y/m/c	7.64	7778	6.93	8889	8.04	8334
LSD (0.05)	2.27		1.98		2.13	

Table 5: Mean fresh cassava root yield (t ha^{-1}) and stand count of cassava (TMS 30555), as affected by the cropping system

Cropping system	2001 Yield (t ha^{-1})	2001 Stand count ha^{-1}	2002 Yield (t ha^{-1})	2002 Stand count ha^{-1}	Annual average Yield (t ha^{-1})	Annual average Stand count ha^{-1}
Sole cassava	18.25	9722	16.61	7222	17.43	8472
c/m	9.28	7500	6.31	9444	9.80	8472
c/m/mp	9.11	8611	10.33	8333	9.97	8472
c/m/l	12.80	10000	12.69	9722	12.75	9861
c/m/Ayb	13.03	10000	15.89	9444	14.46	9722
y/m/c/mp	8.83	8611	3.89	5278	6.25	6945
y/m/c/l	11.64	9722	5.85	5000	6.36	7361
y/m/c/Ayb	12.00	9722	6.49	5278	8.75	7500
y/m/c	8.08	8611	4.42	5000	9.25	6806
LSD (0.05)	4.22		3.94		4.08	

Table 6 shows the mean dry grain yield of the landrace legumes (t ha^{-1}) as affected by the cropping system. Results show that, in both 2001 and 2002, yields of the sole legumes were higher than those in intercropping systems at $p \geq 0.05$. Yields of sole *Phaseolus lunatus* and *Sphenostylis sternocarpa* cropping and in intercropping with yam had higher yields and were higher than those intercropped with yam/cassava-based mixture. However the yields of Lima and African yam bean under cassava-based cropping system did not show any significant differences between them compared with those of yam-based and yam/cassava-based cropping systems.

Table 6: Dry grain yield of the landrace legumes (t ha^{-1}) as affected by the cropping system, 2001/2002 cropping seasons

Cropping systems	2001 Mucuna	2001 Lima bean	2001 African yam bean	2002 Mucuna	2002 Lima bean	2002 African yam bean	Annual average yield (t ha^{-1})
Sole mucuna	5.25	-	-	4.30	-	-	4.78
Sole lima	-	0.63	-	-	0.64	-	0.64
Sole Ayb	-	-	0.61	-	-	0.54	0.58
y/m/mp	3.12	-	-	1.92	-	-	2.52
y/m/l	-	0.53	-	-	0.46	-	0.50
y/m/Ayb	-	-	0.54	-	-	0.37	0.46
C/m/mp	2.97	-	-	1.07	-	-	2.02
C/m/l	-	0.44	-	-	0.55	-	0.49
C/m/Ayb	-	-	0.46	-	-	0.40	0.43
y/m/c/mp	1.10	-	-	1.28	-	-	1.18
y/m/c/l	-	0.37	-	-	0.26	-	0.32
y/m/c/Ayb	-	-	0.38	-	-	0.11	0.25
LSD (0.05)	1.11	0.14	0.22	0.63	0.19	0.25	

DISCUSSION

Maize Plant Heights (cm)

The non-significant effect of the maize heights at 3 and 7 WAP in yam-based and yam/cassava-based cropping system could be as a result of little or no competition for growth resources (light, water, nutrients) among the crops in the combinations. Possibly the growth factors were in sufficient amount and were shared by the different plant species (Ibeawuchi and Ofoh, 2000) in yam-based and yam/cassava based cropping systems.

The morphology (canopy cover) of the associated crop species yam/maize/land race legumes, cassava/maize/land race legume or yam/maize/cassava/landrace legumes may have covered up after 7 and 10 WAP to initiate shading of the maize plant within the new microenvironment. Since maize thrives well under high light intensity (Ustimenko-Bakumovsky, 1983) and has high demand for soil nutrients especially nitrogen (Onwueme and Sinha, 1991) the canopy cover affected light interception with time, thus reducing the rate of nutrient assimilation. Conover and Rex (1996) similarly reported that plants grow slower in less optimum light and use less fertilizer compared to when grown under optimum condition. It may therefore, be that as the canopy cover becomes heavy in most plots of the trial, maize plants grew slowly as a result of less nutrient uptake. This again depends on the extent of shading that must have occured, since plants respond to environmental factors such as periods of long or short day length, varying nutritional levels and genetic factors.

Cassava Plant Heights

Cassava plant heights were not affected by the cassava-based cropping systems at 4, 8 or 12 WAP. The cassava Cultivar TMS 30555 had uniform heights at up to 12 WAP. Such uniformity in height could be attributed to genetic make up of the plant (Gardner *et al*., 1981).

Maize Grain Yield (t ha^{-1})

Inter-cropping maize with yam/Lima or African yam bean, cassava/lima or African yam bean and yam/maize/cassava/lima or African yam bean did not significantly depress maize grain yield in any of the two trial years. This is an indication of the principles of complementarities of component crops as reported by Ibeawuchi *et al*. (2005).

Yam Fresh Tuber Yield (t ha^{-1})

Yam yield was low and this low performance of yam could be attributed to high number of component crops per plot coupled with heavy canopy cover of Mucuna which resulted in shading of sun light in plots associated with mucuna. This agreed with Onwueme and Sinha (1991) that the present commercial yields of yam fall far below the potential yields obtainable as a result of growing yams on poor soils.

Cassava Fresh Tuber Yield (t ha^{-1})

The significant differences obtained in cassava fresh root tuber yield among the intercropping systems being higher in 2002 than in 2001 could be attributed to changes in climatic and environmental conditions since uniform growth in height was observed for the cassava 30555 in the two trial years. This agreed with Ayoade (1993) who reported that any agricultural system is a man made ecosystem that depends on climate to function just like the natural ecosystem and that weather is the most important variable in agricultural productions affecting crop yields. However, cassava had higher fresh root yields in all the crop combinations with Lima and African yam bean than with Mucuna association.

Dry Grain Yield (t ha^{-1}) of the Landrace Legumes

The Velvet Bean (*Mucuna pruriens var. utilis*). The Velvet Bean had higher yields in sole cropping system (5.25 and 4.30 t ha^{-1}) in 2001 and 2002, respectively. This was higher than what was reported by Peace Corps (1990) of a yield average of 700 to 900 kg ha^{-1}. However, the report agreed with Singh *et al*. (1995) and Farooqi *et al*. (1999) that grain yield of 5000 kg ha^{-1} have been recorded from well managed irrigated crops having supports. This may be why farmers preferred to grow Mucuna as a sole crop instead of inter-cropping it (Mucuna News 2001, 1st Edn.).

Lima Bean

The grain yield of Lima in pure stands was 0.63 and 0.64 t ha^{-1} in 2001 and 2002, respectively. For the yam based, cassava based and yam/cassava based cropping systems the yields were 0.53, 0.44 and 0.37 t ha^{-1} in 2001 and 0.46, 0.55 and 0.26 t ha^{-1} 2002. This report agreed with Van der Measeen and Sadiku (1989) who reported a grain yield of 200-600 kg ha^{-1} throughout the tropics and observed that it may reach up to 2000-2500 t ha^{-1}. Also, the result agreed with Rice *et al*. (1990) that yields of up to 1500 kg ha^{-1} dried bean may be obtained. However, lima bean performs better in association with yam/maize, cassava/maize or sole cropping than with yam/maize/cassava, cropping systems.

African Yam Bean

The grain yield of African yam bean planted sole performed better than those intercropped. This could be as a result of its slow establishment in crop combinations involving more than three component crops as observed by Ibeawuchi and Ofoh (2003) that African yam bean could not compete effectively for growth resources in highly combined crop components. However, the average yield for sole cropping in 2001 and 2002 was 0.58 t ha^{-1} while 0.46, 0.43 and 0.25t ha^{-1} was recorded as average for yam based, cassava based and yam/cassava based cropping systems respectively in the two trial year. The range of the average yield of 0.43-0.58 t ha^{-1} agreed with the report of 0.6 t ha^{-1}by Ibeawuchi and Ofoh (2000).

CONCLUSIONS

There were high cassava root yield in the two cropping years for cassava-based crop mixtures and in yam based for 2001 cropping season. Yam and maize yields were depressed as a result of heavy canopy cover of mucuna due to shading effect and light interception, which helped in reduced photosynthesis and nutrient uptake, by the component crops. Farmers are encouraged to plant mucuna in plots and for proper use incorporate it into the soil for green manure to be followed by maize and yam cropping. This should be done year after year by planting mucuna at the harvest of maize when yam had already established. This will help improve the essential nutrient elements in the soil especially nitrogen since mucuna fixes large quantities of N in the soil. Researchers should gear efforts towards improving the three-landrace legumes genetically to make them candidate legumes for the lowland humid tropics. Finally, since the lima bean and African yam bean are already in use in our cropping systems by resource poor farmers, the farmers should be encouraged to cultivate mucuna for its numerous uses outside Nigeria.

Mucuna is a crop of the future therefore more effects should be placed on its research as human food and in health industries since it has found a place in the animal feed production industry as a replacement for energy and protein supplies.

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