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EFFECTS OF DIFFERENT INTERPLANTED LEGUMES WITH CASSAVA ON MAJOR SOIL NUTRIENTS, WEED BIOMASS, AND PERFORMANCE OF CASSAVA (*MANIHOT ESCULENTA* CRANTZ) IN THE SOUTHWESTERN NIGERIA

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ABSTRACT

A two - year field experiment was carried out at the Teaching and Research Farm of the University of Ibadan, Nigeria, during 2003 / 2004 and 2004 / 2005 to appraise the influence of interplanted legumes with cassava on major soil nutrients, weed biomass, and performance of cassava. The experiment was laid out in a randomized complete block design, with three replications. The different crop associations included: sole cropped cassava (control), cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean. The results obtained indicated that there were significant differences ($P \le 0.05$) among the various crop associations in yield and yield components of cassava, as well as weed biomass. Organic carbon decreased by 24% in sole cassava, contrasting increases of 42, 39, 35 and 33% for cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively. Similarly, sole cassava decreased total nitrogen by 33%, compared to increases of 52, 49, 46 and 43% for cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively. The percentage decreases in exchangeable potassium were 13, 27, 30, 30 and 33% for sole cassava, cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively. The two – year average values indicated that crop association increased cassava tuber yield from 6.95 t ha^{-1} for sole cassava (control) to 8.70, 8.62, 8.66 and 8.62 t ha^{-1} for cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively. The values of weed population density, adduced to different crop associations were 132, 94, 96, 97, and 96 weeds/m^2 for sole cassava, cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively.

Keywords: Cassava, legumes, soil nutrients, weed biomass.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is hardly grown as a sole crop. It is usually grown in association of other arables, such as maize, sweet potato, cocoyam, vegetables and legumes. In the recent time, cassava/legume mixture has gained prominence in view of the nutritional and cash benefits of legumes. Crop scientists have recommended the inclusion of legumes in crop production systems to combat the problem of declining soil fertility, as well as increasing incidence of weed infestation.

Previous research studies have unfolded the advantages of cassava/legume mixture, especially in improving the N content of the soil through fixation of atmospheric nitrogen (Kim, 2005; Aigh, 2007). Udeata (2005) and Kurtz (2006) reported significantly higher values of yield and yield components of cassava interplanted with legumes than those of the yield components of sole cropped cassava. Although, legumes are known to fix nitrogen into the soil, research has it that the amount of N fixed depends on legume species. People *et al.* (1990) reported (73 – 354), (168 – 208), (72 – 124), (55 – 168) and (40 – 65) kg N ha^{-1} fixed into the soil by cowpea, pigeon pea, groundnut, soybean and bambara, respectively.

Studies by Bianteau (2004); Leaph (2005) and Sasiba (2007) indicated increases in N content of the soil under crop rotation involving certain legumes, and under intercropping with legumes. Carel (2006) reported increases in soil available phosphorus under intercropping involving legumes after cropping, and adduced this to the mineralisation of organic phosphorus, which in turn, results in the release of more P for crop use. Atilola *et al.* (2004) recommended the inclusion of tropical legumes in intercropping systems as a way of reducing loss of available P. These authors attributed the reduction in loss of available P to certain changes in micro – environment, which therefore, promoted greater mineralisation of organic P.

The weed suppression – ability of cassava is low, and this is due perhaps, to its slow – growing nature. However, intercropping cassava with certain legumes has been reported to alleviate the problem of weed infestation in cassava fields (Ait, 2006). Zoufa *et al.* (1992) found 13% reduction in weediness in cassava intercropped with maize, and a further reduction of between 16 and 40% by intercropping with slow – growing smother crops such as groundnut, cowpea or melon. Mutsaers *et al.* (1993) ascribed the significant increase in yield of cassava in cassava / legume intercrop relative to sole cassava to less incidence of weed infestation by the legume.

In view of the increasing wave of the problem of unavailability and / or high cost of chemical fertilizers and herbicides, as well as the detrimental effects of the application of these chemicals on environmental quality, to avert this, and to improve soil fertility, hence, raising the present level of cassava yield on farmers' farms, the recommendation of appropriate natural techniques of soil fertility improvement and weed management is imperative. To this end, this paper reports a two – year trial, aimed at evaluating the effects of interplanted legumes with cassava on major soil nutrients, weed biomass, and performance of cassava.

MATERIALS AND METHODS

Study site

The two – year experiment was carried out at the Teaching and Research Farm of the University of Ibadan, Nigeria, during 2003 / 2004 and 2004 / 2005 cropping seasons. The soil of the study site belongs to the broad group alfisols (USDA, 1975) of the basement complex, although, locally classified as Ibadan series (Smyth and Montgomery, 1962). The soil was highly leached, with low to medium organic matter content, deep red clay profile, with top sandy loam texture, slightly acidic to neutral. The study site had earlier been cultivated to arable crops before it was left fallow for three years before the commencement of this study. The fallow vegetation was manually slashed, the land was deeply ploughed and harrowed.

Collection and analysis of soil samples

Prior to planting, ten core soil samples, randomly collected from 0 – 15 cm top – soil were mixed to form a composite, which was analysed for physical and chemical properties. At the end of the investigation (soon after harvest), another set of composite samples was collected per plot and analysed. The composite samples were air dried, ground, and passed through a 2 mm sieve. The sieved samples were then analysed. The pH was determined by glass electrode pH meter. Bray P – 1 extractant was used to extract available P, organic C and total N were determined by the Walkey – Black oxidation and Kjeldahl digestion techniques, respectively. Exchangeable bases – K, Ca, Mg and Na were extracted by neutral normal ammonium acetate. K, Ca and Na were determined by flame photometry, while Mg was by Atomic Absorption Spectrophotometry. Effective Cation Exchange Capacity (ECEC) was obtained by summation method (i.e. sum of K, Ca, Mg, Na and exchangeable acidity). The determination of exchangeable acidity was by extraction – titration method described by Mclean (1965). Particle size distribution was done by the hydrometer method of soil mechanical analysis, as outlined by Bouyoucous (1951).

Experimental design and treatments

The experiment was laid out in a randomized complete block, with three replications. The different crop associations included: sole cropped cassava (control), cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean.

Planting

In 2003 / 2004 and 2004 / 2005, planting was done on March 20 and March 16, respectively. Stem – cuttings (20 cm long each) of cassava variety TMS (Tropical Manihot Series) 30572 were planted at 1 m x 1 m (10,000 plants ha^{-1}). Cowpea seeds were planted at 50 cm x 100 cm (20,000 plants ha^{-1}). Groundnut seeds were planted at 30 cm x 50 cm (66,666 plants ha^{-1}). Soybean seeds were planted at 40 cm x 80 cm (31,250 plants ha^{-1}). Pigeon pea seeds were planted at 50 cm x 100 cm (20,000 plants ha^{-1}).

Collection and analysis of data

At 6, 12 and 18 weeks after planting (WAP), and before weeding, data on weed population density and weed dry weight were collected, and determined by counting and harvesting all the weeds within 50 cm x 50 cm quadrants, randomly placed in four locations within each plot. The collected weed species were weighed fresh, and later oven – dried, until a constant weight was obtained. At harvest (one year after planting), data were collected on the yield and yield indices of cassava. Analysis of variance was done, and treatment means were compared, using the Least Significant Difference (LSD) at 0.05 level of probability.

RESULTS

Table 1 shows the physical and chemical properties of soil of the study site before cropping. The soil was sandy loam in texture, with a pH of 5.5. The soil organic carbon and total nitrogen were 2.88 and 1.30 gkg^{-1}, respectively. The available phosphorus was 1.90 mgkg^{-1}. The exchangeable bases – K, Ca, Mg and Na were 0.30, 2.00, 1.64 and 0.24 cmolkg^{-1}, respectively. The exchangeable acidity and effective cation exchange capacity (ECEC) were 0.30 and 4.48 cmolkg^{-1}, respectively.

Changes in soil nutrient status after cropping

Table 2 shows the effects of interplanted legumes with cassava on organic carbon, total nitrogen, available phosphorus and exchangeable potassium. Sole cassava decreased organic carbon by 24%, contrasting increases of 42, 39, 35 and 33% for cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively. Similarly, sole cassava decreased total nitrogen by 33%, as against increases of 52, 49, 46 and 43% for cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively. Sole cassava decreased available phosphorus by 8%, compared to increases of 38, 37, 35 and 34% for cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively. The percentage decreases in exchangeable potassium were 13, 27, 30, 30, and 33% for sole cassava, cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively.

Weed population density

The influence of interplanted legumes with cassava on weed population density is shown in Table 3. On the two – year average, values of weed population density were 132, 94, 96, 97 and 96 weeds/m^2 for sole cassava, cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively.

Weed dry weight

Table 4 shows weed dry weight as affected by interplanted legumes with cassava. Values of weed dry weight were 75.6, 65.0, 64.2, 63.8 and 63.7 gm^{-2} for sole cassava, cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively.

Tuber yield and length of cassava tuber at harvest

Tuber yield and length of cassava tuber as affected by interplanted legumes with cassava are shown in Table 5. The mean values of cassava tuber yield were 6.95, 8.70, 8.62, 8.66 and 8.62 t ha^{-1} for sole cassava, cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively. The mean values of cassava tuber length were 14.11, 17.97, 17.90, 17.99 and 17.96 cm for sole cassava, cassava + cowpea, cassava + groundnut, cassava + pigeon pea and cassava + soybean, respectively.

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Table 1: The physical and chemical composition of soil of the study site before cropping

Parameters	Values
pH	5.5
Organic carbon (gkg-1)	2.88
Total nitrogen (gkg-1)	1.30
Available phosphorus (mgkg-1)	1.90
Exchangeable K (cmolkg-1)	0.30
Exchangeable Ca (cmolkg-1)	2.00
Exchangeable Mg (cmolkg-1)	1.64
Exchangeable Na (cmolkg-1)	0.24
Exchangeable acidity (cmolkg-1)	0.30
ECEC (cmolkg-1)	4.48
Texture (gkg-1)	
Sand	600
Silt	216
Clay	184

DISCUSSION

The decrease in soil organic carbon (SOC), total nitrogen (N), available phosphorus (P) and exchangeable potassium (K) associated with sole cassava agrees with the reports of Kurtz (2004) and Crick (2007), who noted a significant reduction in these four nutrient elements, following cassava cultivation. Following the production of a lot of leaf litter fall (biomass) by cassava during the growing season, one would have expected a commensurable increase in SOC after cropping. However, the decrease in SOC after cropping, is due perhaps, to the fact that the cultivation of cassava may have resulted in the provision of conducive conditions for the action of soil microbial biomass with resultant accelerated organic matter decomposition, hence, SOC depletion (Kurtz, 2004; Crick, 2007). This implies that continuous cultivation of cassava will consequently result in a marked reduction in soil fertility and attendant declined crop yields. Thus, to minimize the reduction of SOC accompanying cassava cultivation, the recommendation of appropriate soil organic matter (SOM) management techniques, such as incessant and copious manure additions, adequate fertilization, crop rotation, and return of plant residues to soil cultivated to cassava is imperative. The decrease in total N, available P, and exchangeable K that attended sole cropped cassava can be ascribed to the decrease in SOC, as N, P and K, like other nutrient elements, are integrally tied to the SOM or SOC, hence, the maintenance of SOM is paramount in sustaining other soil quality factors (Gerh *et al.,* 2006). The very slight decrease in available P, compared to N and K after cropping, suggests that cassava did not

Table 2: Effects of different interplanted legumes with cassava on major soil nutrients after cropping

Treatments (Crop association)	OrganicC (gkg^{-1})				Total N (gkg^{-1})				Available P ($mgkg^{-1}$)				Exchangeable K ($mgkg^{-1}$)			
	Initial	Final	* Change	% Change	Initial	Final	* Change	% Change	Initial	Final	* Change	% Change	Initial	Final	* Change	% Change
Sole cassava (control)	2.88	2.20	-0.68	24	1.30	0.87	0.43	33	1.90	1.75	-0.15	8	0.30	0.26	-0.04	13
Cassava + cowpea	2.88	4.09	1.21	42	1.30	1.98	0.68	52	1.90	2.63	0.73	38	0.30	0.22	-0.08	27
Cassava + groundnut	2.88	3.99	1.11	39	1.30	1.94	0.64	49	1.90	2.60	0.70	37	0.30	0.21	-0.09	30
Cassava + pigeon pea	2.88	3.89	1.01	35	1.30	1.90	0.60	46	1.90	2.57	0.67	35	0.30	0.21	-0.09	30
Cassava + soybean	2.88	3.84	0.96	33	1.30	1.86	0.56	43	1.90	2.55	0.65	34	0.30	0.20	-0.10	33

* Change = Final – Initial

Table 3: Effects of different interplanted legumes with cassava on weed population density

Treatments (Crop associations)	Weed population density (weeds/m^2)						
	6 WAP		12 WAP		18 WAP		
	2003/2004	2004/2005	2003/2004	2004/2005	2003/2004	2004/2005	Mean
Sole cassava (control)	128a	133a	143a	146a	120a	124a	132
Cassava + cowpea	117b	121b	88b	89b	77b	74b	94
Cassava + groundnut	119b	123b	93b	95b	75b	73b	96
Cassava + pigeon pea	119b	120b	95b	96b	76b	74b	97
Cassava + soybean	117b	119b	98b	96b	74b	72b	96

Values followed by the same letter in the same column are not significantly different at P>0. 05. WAP = Weeks After Planting.

Table 4: Effects of different interplanted legumes with cassava on weed dry weight

Treatments (Crop associations)	Weed dry weight (g/m^2)						
	6 WAP		12 WAP		18 WAP		
	2003/2004	2004/2005	2003/2004	2004/2005	2003/2004	2004/2005	Mean
Sole cassava (control)	74.3a	76.1a	84.4a	85.0a	66.6a	67.2a	75.6
Cassava + cowpea	65.1b	65.9b	70.1b	70.8b	58.6b	9.1b	65.0
Cassava + groundnut	64.4b	65.1b	69.4b	69.8b	57.8b	58.9b	64.2
Cassava + pigeon pea	64.2b	64.0b	68.9b	69.0b	58.0b	58.6b	63.8
Cassava + soybean	64.4b	63.9b	68.2b	68.9b	58.1b	58.4b	63.7

Values followed by the same letter in the same column are not significantly different at P>0.05. WAP = Weeks After Planting.

Table 5: Effects of different interplanted legumes with cassava on tuber yield and length of cassava tuber at harvest

	Cassava tuber yield (t ha^{-1})			Length (cm) of cassava tuber		
Treatments (Crop associations)	2003/2004	2004/2005	Mean	2003/2004	2004/2005	Mean
Sole cassava (control)	6.81b	7.08b	6.95	14.20b	14.02b	4.11
Cassava + cowpea	8.51a	8.88a	8.70	18.00a	17.93a	17.97
Cassava + groundnut	8.43a	8.81a	8.62	17.89a	17.91a	17.90
Cassava + pigeon pea	8.48a	8.84a	8.66	17.98a	7.99a	17.99
Cassava + soybean	8.40a	8.83a	8.62	17.95a	17.97a	17.96

Values followed by the same letter in the same column are not significantly different at $P>0.05$.

remove much P from the soil, unlike N and K. The low correlation between soil P and plant – content and yield testifies to the low uptake of P by cassava (Ryi, 2007). One factor that can be implicated for the low P uptake by cassava is that of mycorrhizal association, which makes possible the addition of as much as 15 ppm P to the soil from fixed P by soil mycorrhiza (Ryi, 2007). The practical implication of the low P uptake by cassava is that, P perhaps, is not a limiting nutrient element in the nutrition of cassava, hence, a high root yield of cassava can still be achieved despite the low native P.

The decrease in exchangeable K associated with both sole cropped cassava and cassava/legumes mixture after cropping agree with the findings Ajeigbe (2003) and Farinu (2006), who reported a decrease in exchangeable K in cassava / legume mixture after cropping. This observation implies that a lot of K must have been removed from the soil system by these two crops (cassava and cowpea), especially cassava, as the indispensability of K in cassava nutrition had been demonstrated by many studies (Ajeigbe, 2003; Farinu, 2006). The tremendous quantity of K removed in cassava tubers at harvest, as well as low root yield of cassava due to K deficiency are a pointer to the indispensability of K in cassava nutrition (Ajeigbe, 2003; Farinu, 2006). Much as the decrease in exchangeable K can be adduced to removal by cassava and cowpea, another factor that can be implicated for the decrease in exchangeable K is the inability of legumes to fix appreciable quantities of K into the soil, unlike N, as legumes are generally known for N – fixation. The increase in SOC, total N and available P, following the inclusion of various legumes after cropping, agrees with the findings of Bianteau (2004); Leaph (2005); Sasiba (2007). The increase in SOC can be attributed to the decomposition of a lot of biomass return from cassava and cowpea during the growing season, as earlier reported by Ojeniyi and Adetoro (1993), who noted an appreciable increase in SOC, following the decomposition of leaves of *Gliricidia sepium* (a tree legume). The authors adduced the increase in SOC after cropping to the high rate of mineralisation, informed by the fast rate of decomposition of legume leaves due to their low C : N ratio. So, the increase in SOC resulted in the increase observed in total N and available P, as the concentration of these two nutrient elements, like that of other elements, depends on the amount of SOC or SOM (the major determinant of other soil quality factors) (Gerh *et al.,* 2006). Asides, the increase in total N can be explained in the light of the ability of legumes to fix large quantities of N into the soil, thus, improving the soil N status (Kim, 2005; Aigh, 2007). Also, Carel (2006) ascribed the increase in available P after cropping under intercropping involving legumes to the mineralisation of organic P, which in turn, resulted in the release of more P for crop use. As crops use the P, it declines, but replenished by desorption of adsorbed phosphate.

There is always the problem of rapid nutrient depletion under crop mixtures, due to the combined demands of the individual intercrops for nutrients (Diur, 2004; Yen, 2006). However, from the findings of this study, it is apparent that the extent of nutrient depletion, if any, depends on the kinds of crops constituting the mixture. The increase in major soil nutrients associated with the inclusion of legumes points to the indispensability of the contribution of legumes to improving and maintaining soil fertility, thus, making crop production enterprise more cost – effective, as little cost will be incurred in purchasing mineral fertilizers.

The significantly higher tuber yield of cassava interplanted with the various legumes than that of the sole cropped cassava, agrees with the findings of Udeata (2004) and Kurtz (2006). This observation suggests that the presence of the legumes in the cassava/legume mixtures was not detrimental, rather, may have been beneficial to cassava crops. The beneficial effects of legumes stem from their enriching soil by improving the soil N status, as legumes have the ability to fix N into the soil (Kim, 2005; Aigh, 2007). Much as the significant difference in the tuber yield of sole cropped cassava and that of cassava interplanted with legumes can be adduced to legumes improving the N economy of the soil, another factor that can be implicated for the significant yield difference is the increase in SOM in cassava/legume mixture, resulting from the decomposition of quite a lot of biomass produced by cassava and the legumes. This is because SOM has been reported to improve the physical, chemical and biological properties of the soil and attendant increased crop yields (Gerh *et al*., 2006).

The lower weed biomass in cassava/legume association than sole cassava agrees with the findings of Zoufa *et al.* (1992). This observation can be ascribed to the combined interference of both cassava and the legumes on weeds, due perhaps, to toxic chemicals (allelochemicals) secreted by cassava and legumes, as well as cassava and cowpea competing with weeds for growth resources (air, water, nutrients) (Zoufa *et al.,* 1992). Apart from the allelopathic effects of cassava and legumes on the weeds, the lower weed biomass associated with cassava/legume mixtures relative to sole cassava can be adduced to greater shading effects on weeds by cassava/legume mixture than sole cassava. This is because cassava/legume mixture provided better ground coverage due to higher canopy cover, and this placed cassava and legumes at an advantage of intercepting most of the solar radiation to the detriment of the under – storey weeds. The denial of solar radiation of weeds resulted in a marked reduction in their ability to synthesise carbohydrate with resultant low biomass production (Beiz, 2006; Benzor, 2007). This implies that, apart from the yield advantage associated with intercropping involving legumes, another attendant benefit of crop mixture is that of minimizing the incidence of weed infestation on the farm. While plant canopy under crop mixtures can play a complimentary role in reducing weed pressure, however, there is need for the provision of an initial weed – free environment for the proper establishment of crops before the first flush of weeds gets established. From the results of this study, biocontrol of weeds, using legumes, if well planned and executed, can serve as an alternative weed control method especially for the resource - poor farmers, who probably cannot afford chemical weed control method.

CONCLUSION

The results of this study have established that sole cropped cassava decreased SOC, total N, available P and exchangeable K. However, the inclusion of certain legumes resulted in an increase in the afore – mentioned soil nutrients after cropping. The tuber yield of cassava interplanted with legumes was significantly higher than that of the sole cropped cassava. Sole cropped cassava treatment gave a significantly higher value of weed biomass than the cassava / legume mixture counterpart.

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