CONTRIBUTIONS OF *MORINGA OLEIFERA* IN INTERCROPPING SYSTEMS TO FOOD SECURITY IN THE DERIVED SAVANNA ZONE OF SOUTHEASTERN NIGERIA

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ABSTRACT

The experiment was conducted at the Teaching and Research farm of the Akanu Ibaim Federal Polytechnic, Unwana, Ebonyi State during 2014 cropping season to assess the contribution of Moringa oleifera intercrop on the performance of crops in the derived savanna zone of Southeastern Nigeria. The experiment was laid out in a randomized complete block design (RCBD) with six treatments replicated three times. The treatments consist of sole maize, sole sweet potato, sole moringa, moringa + maize, moringa + sweet potato and moringa + maize + sweet potato. Data on crop growth and yield parameters were collected and subjected to analysis of variance and mean separation was done using least significant differences at 5% level of probability. Results indicated a reduction in soil acidity from 1.86 to 1.60 in the cropping system. There was significant difference ($P \leq 0.05$) on crop growth and crop components, except on leaf area of maize and moringa oleifera. Maize yields were not significantly influenced by the treatment as compared to sweet potato and moringa leaf yield. However, among the treatments used, moringa + maize and moringa + sweet potato crop combinations produced the highest crop growth and yield of maize, sweet potato and moringa oleifera while sole crops produced the lowest. This work the proves the significance of moringa oleifera on crop performance.

Keywords: Intercropping, Moringa oleifera, Maize, Sweet potato and Food security

INTRODUCTION

Land in the Southeastern Nigeria is predominantly used for farming, which is faced with challenges of low soil fertility due to intensified cropping, soil degradation, soil and environmental pollution due to inappropriate use and management of agro-chemicals introduced during farming. This poor management of land and farming resulted to hunger, poverty due to low and/ or poor yield of crops in the area. Soil fertility constraints were to be overcome using inputs such as improved crop varieties, fertilizer, chemical control of pest and disease and weeds. Although these approaches were successful, they encountered problems and challenges such as high cost of fertilizers, un- availability of appropriate brand of fertilizer and continued high rate of use and indiscriminate use of these fertilizers, leading to environmental pollution. Yield of crop responses to fertilizer have declined due to soil degradation, leaching and micronutrient deficiencies. Larger numbers of poor farmers cannot afford high levels of fertilizers and other high external input technology, nor do they have the capital or the skill to apply the technology. The need to improve soil fertility to support the hungry population has led to the renewed interest in the use of Moringa oleifera in intercropping system in the soil nutrient management and sustainable environment.

Moringa oleifera popularly known as 'Okwe oyibo' in Igbo, 'Zogallaganah' in Hausa, 'Ewe-Igbale' in Yoruba (Keay, 1989) and Eto Uwem in Etik/Ibibio is considered one of the world's most useful trees as almost every part of the plant is used for food, feed, medicine, or some other beneficial properties (Papillo, 2007) , and moringa has been considered to have the potential for the increase in the production as well as improve the nutrition of the people (Essien *et al*, 2014). Moringa oleifera is a valuable multipurpose crop to reduce hunger, poverty and increase nutritive intakes of the people (Agbogidi *et al*, 2010), as it is known traditionally as vegetable because of its potential to improve nutrition, boost food security, foster rural development and food sustainability (CTA,2001). Against this background, this study was designed to evaluate the contribution of *Moringa oleifera* in intercrop farming systems in the derived savanna of Southeastern Nigeria.

MATERIALS AND METHODS

Location: The study was carried out at the Teaching and Research Farm of Akanu Ibiam Federal Polytechnic, Unwana, Afikpo, Ebonyi State, Nigeria .Unwana is located on the latitude 06^1 N and longitude 08^0E. It lies within the humid region of the derived savanna zone of Southeastern Nigeria. The region and characterized by dry season from November to March with mean annual temperature of 29^0c to 32^0c and wet season from April to October with mean annual rainfall of 1500mm to 2000mm (NIMET, 2003). The underlying and geological material is shale with sand intrusions, locally, classified as the ‘Asu’ River group. The soil is a hydromorphic ultisol and has been classified as Typic - Haplustult (FDALR, 1985). The soil type ranges from sandy loam to loamy clay with moderate organic matter on the soil. The vegetation of the experimental site is typical of derived savannah of degraded humid forest of the South East agro-ecological zone of Nigeria, characterized by tall grasses, shrubs and trees. The site was previously planted with cassava and maize, and left to fallow for one year.

Field Methods: The field was cleared, marked and prepared into blocks and plots with each plot measuring 3m X 3m in size. Six treatments were replicated three times and were built into a randomized complete block design (RCBD). The treatment used included, sole maize, sole sweet potato, sole moringa, moringa + maize, moringa + sweet potato, and moringa + maize + sweet potato. Each test crop was planted 1m X 1m plant spacing.

Data Collection on Plant Parameters: Measurements were taken from the following plant parameters:

1. Plant Height of maize and moringa at 2, 4, 6, 8, 10 and 12 weeks after planting (WAP). This was measured by using measuring tape/meter rule to measure from the base to the apex region of the last mature open leaf.
2. Vine length of potato at 2, 4, 6, 8, 10 and 12 WAP was measured by using measuring tape/meter rule to measure from the base to the apex region or apical meristem of the plant.
3. Leaves number at 2, 4, 6, 8, 10 and 12 WAP were counted on each of the selected and tagged plants in each plot.
4. Stem girth/vine girth at 2, 4, 6, 8, 10 and 12 WAP of the selected and tagged plants were measured by using venier caliper and mean recorded.
5. Yield parameters measured included; fresh cob weight, dry cob weight, number of tubers, weight of tubers, fresh and dry biomass weight.

Collection of Soil Sample and Laboratory Analysis: A composite soil sample from different representative field location was collected from the experimental site with soil auger at a depth of 0-20cm for initial soil sample were collected from each of the plots to determine the changed that occurred due to treatments used. The soil sample collected were processed and analyzed in the laboratory.

Data Analysis: All data collected were subjected to analysis of variance (ANOVA) while the mean were separated using the least significant difference (LSD) at 5% probability level, according to the procedure for randomized complete block design as outlined by Akindele (2004).

RESULTS AND DISCUSSION

Effect of Treatments on Soil Physical and Chemical properties of the studied area (0-20cm) before and after harvest

Results on soil physico-chemical properties of the study site (Table 1) showed that the soil was sandy loam to loamy soil with 74.89 to 82.15 sand, 11.50 to 9.00 silt and 18.51 to 11.00 clay before and after harvest, respectively. Soil organic carbon concentration ranges from 1.377% to 0.959% in the before and after harvesting, respectively; and the soil total nitrogen was 0.110% to 0.060%, respectively. The status of the soil before and after harvest shows that the soil is slightly acidic with nutrient elements and organic carbon less than initial levels. The soil was low in exchangeable cation ranged from 0.010cmolkg^{-1} to 3.80cmolkg^{-1} for Ca. the results showed that, the low in organic carbon and nutrients elements in the soil before and after harvest might have been attributed to poor ground cover and high uptake of nutrients by the plants in the intercropped systems. The intercrop plants must have fed extensively on the available nutrients especially the exchangeable bases thus depleting them in the soil since no additional fertilizer containing them was added. Michael *et al* (2013) had earlier observed that, these nutrients are very vital for the normal functioning of plants and plants can feed even luxuriously on them except Na which can easily cause problem to the plant.

Table 1: Physical and Chemical Properties of the Studied Soil (0-20cm) depth before and after harvest

Soil properties	Before planting	After harvest
Sand (%)	74.89	82.15
Silt(%)	11.50	9.00
Clay (%)	18.51	11.50
pH (H_2O)	6.40	5.37
pH (Hcl)	5.60	4.91
Textural class	Sandy loam	Loamy soil
Organic carbon (%)	1.377	0.958
Organic matter (%)	2.373	1.601
Total Nitrogen (%)	0.110	0.060
Exchangeable bases (cmolkg^{-1})		
Potassium (K^+)	0.014	0.017
Calcium (Ca^{2+})	3.80	1.00
Magnesium (Mg^{2+})	0.938	0.501
Sodium (Na^+)	0.010	0.011
Cation Exchange Capacity (CEC) cmolkg^{-1})	7.268	11.70
Exchangeable acidity (EA) cmolkg^{-1}	1.86	1.60
Available phosphorus (mg/kg)	6.58	6.02

Effects of Treatments on Crop Growth Parameters

The results (Table 2) indicated a significant difference ($P \leq 0.05$) improvement on the growth performance of maize due to treatments application. It was observed that sole maize (Sma) produced the tallest plant height while moringa + Maize + sweet potato crop combination (mo + ma + sp) produced the shortest maize plant. Leaf number was also observed to be significant. However, moringa + maize intercrop produced the highest leaf number while moringa + maize + sweet potato crop mixtures produced the least leaf number. Similarly, stem girth was bigger in moringa + maize crop mixture than insole maize and moringa + maize + sweet potato combinations.

Table 2: Effect of Treatment on maize Growth and Growth components:

Treatment	Plant height (cm)	Leaf number	Stem girth (cm)	Leaf area
Sma	116.73	9.82	4.57	29.60
Smo	-	-	-	-
Ssp	-	-	-	-
Mo+ma	102.28	9.92	5.93	48.93
Mo+sp	-	-	-	-
Mo+ma+sp	92.12	8.92	5.13	70.06
LSD($p \leq 0.05$)	5.77	0.07	1.27	Ns

Sma = Sole maize, Smo = Sole Moringa, Ssp = Sole sweet potato, Mo = Moringa, Ma = Maize, sp = Sweet potato

On the contrary, there was no significant difference among the treatment used on leaf area of maize (Table 2). However, among the treatments, moringa + maize + sweet potato (mo + ma+ sp) crop combinations had the widest leaf area of maize while sole maize had the narrowest leaf area.

The results of the growth parameters of *moringa oleifera* (Table 3) showed that, the treatments significantly ($p \leq 0.05$) improved the growth parameters of Moringa oleifera except on leaf area. The mean plant height obtained indicated that moringa + maize + sweet potato (mo+ma+sp) produced the tallest plant (212.58cm) while sole moringa produced the shortest plant (67.17cm). the results on leaf number showed that crop mixture of moringa + maize gave the highest leaf number followed by moringa + maize + sweet potato while moringa + sweet potato gave the least leaf number. Stem girh was observed to be significantly ($p \leq 0.05$) improved due to treatments used. Moringa intercrop with maize produced the biggest stem followed by moringa + maize + sweet potato crop combinations while sole moringa produced the smallest stem girth. Alyhough leaf area was not significant (Table 2), the results obtained indicated that moringa+maize+sweet potato crop combinations had the highest leaf area followed by moringa+maize while moringa + sweet potato crop mixture had the least leaf area.

Table 3: Effect of Treatment on moringa Growth and Growth components:

Treatment	Plant height (cm)	Leaf number	Stem girth (cm)	Leaf area
Sma	-	-	-	-
Smo	67.17	7.66	2.92	11.45
Spp	-	-	-	-
Mo+ma	71.38	16.44	4.21	31.88
Mo+sp	72.17	6.99	3.39	8.36
Mo+ma+sp	212.58	14.55	3.61	35.10
LSD($p \leq 0.05$)	35.5	11.4	1.24	Ns

Results (Table 4) also showed the effects of treatments on the growth parameters of Sweet potato. There were significant differences among the treatments on vine length, leaf number, and vine girth and leaf area. The results (Table4) indicates that sole sweet potato produced the longest vine length (52.96cm) followed by moringa + sweet potato (44.92cm) while moringa + maize + sweet potato produced the shortest vine length (32.71cm). Leaf number was high on sole sweet potato followed by moringa + sweet potato mixture while moringa + maize + sweet potato crop mixtures produced the least leaf number. Vine girth and leaf area were observed to be high in sole sweet potato followed by moringa + sweet potato crop mixture while moringa + maize + sweet potato crop mixtures had the smallest and least vine girth and leaf area, respectively.

Table 4: Effect of Treatment on Sweet potato Growth and Growth components:

Treatment	Vine length (cm)	Leaf number	Vine girth (cm)	Leaf area
Sma	-	-	-	-
Smo	-	-	-	-
Ssp	52.96	16.23	2.39	50.63
Mo+ma	-	-	-	-
Mo+sp	44.92	14.44	1.93	39.02
Mo+ma+sp	32.71	12.19	1.49	35.70
LSD(p≤0.05)	5.38	1.20	0.29	4.12

Effects of Treatments on Crop Yield (t/ha)

The effects of treatments on maize yield are presented in Table 4. The results showed no significant difference (p≤0.05) among the treatment used. However, sole maize produced the highest weight of fresh cob while moringa + maize produced the least fresh cob weight. Results also indicated that sole maize produced the highest weight of dry cob and shelled grain yield while moringa + maize + sweet potato produced the least shelled grain yield at harvest.

Results (Table 5) also revealed that there were significant differences (p≤0.05) among the treatments used on the yield of sweet potato except on the number of tubers and circumference of tubers. From the results, sole sweet potato gave the highest tuber number while moringa + maize + sweet potato gave the least number of tubers. Moringa + sweet potato crop mixture produced the highest length of tubers, circumference of tubers, weight of tubers and tuber dry matter content while sole sweet potato produced the least on all the yield components measured.

Table 5: Effect of Treatment on Yield and Yield Component of crops (t/ha)

	Maize Yield				Sweet Potato				
Treatment	**WFC (kg)**	**WDC (kg)**	**Wt. of100seeds (g)**	**SGY (kg)**	**NOT**	**LOT (cm)**	**COT (cm)**	**WOT (kg)**	**TDM (g)**
Sma	7.07	4.10	2.87	18.4	-	-	-	-	-
Smo	-	-	-	-	-	-	-	-	-
Ssp	-	-	-	-	11.0	2.30	15.25	16.3	2.7
Mo+ma	7.95	4.70	3.89	18.9	-	-	-	-	-
Mo+sp	-	-	-	-	7.06	3.01	19.10	18.3	4.7
Mo+ma+sp	7.24	4.20	2.80	18.3	3.66	2.74	18.55	17.0	3.10
LSD(p≤0.05)	Ns	Ns	Ns	Ns	Ns	1.14	Ns	0.69	0.2

Effects of Treatments on the Fresh and Dry Weight of Moringa Leaf Yield

The results (Table 6) showed the effects of treatment on the fresh and dry weight of Moringa leaf yield. The results showed a significant variation on the fresh leaf weight at different months studied. It was observed that moringa + maize + sweet potato crop combination at 3 months after planting (MAP) significantly (P≤0.05) gave the highest fresh leaf weight of moringa oleifera in the studied area followed by moringa + sweet potato crop mixtures while moringa + maize produced the lowest fresh leaf weight. At 6, 9 and 12 MAP, moringa + maize produced the highest fresh leaf weight of moringa followed by moringa + sweet potato while sole moringa produced the lowest fresh leaf weight of *Moringa oleifera*.

Table 6: Effect of Treatment on the Fresh and Dry weight of Moringa Leaf Yield (t/ha)

	Fresh Leaf Yield				Dry Leaf Yield			
Treatment	3	6	9	12	3	6	9	12
Sma	-	-	-	-	-	-	-	-
Smo	14.0	16.6	18.3	15.3	2.94	3.25	3.28	2.05
Ssp	-	-	-	-	-	-	-	-
Mo+ma	13.7	18.8	20.7	16.6	3.68	3.89	3.40	2.73
Mo+sp	17.3	18.5	20.5	15.9	3.60	3.79	3.40	2.50
Mo+ma+sp	17.5	18.0	20.2	15.6	3.52	3.13	3.38	2.10
LSD ($p \leq 0.05$)	0.12	1.11	1.13	0.10	1.2	0.1	1.03	0.33

The result (Table 6) also showed the effects of treatments on dry leaf weight of moringa oleifera. At 3, 6, 9 and 12 MAP, moringa + maize produced the heighest dry leaf yield of moringa followed by moringa + sweet potato while sole moringa produced the lowest dry leaf yield. Generally, the result revealed that, the leaf yield of moringa oleifera trend in the treatments increased progressively and reached its peak on the 12MAP, after which it there was a reduction.

Effects of treatments on Crop Growth, Development and Growth Components

The increase in height of sole maize than in crop mixtures could be attributed to the ability of maize to utilize the available growth resources, probably due to none competition with other crops. This observation showed that, within the first four weeks of crop establishment, nutrients were depleted faster in intercrop mixtures of moringa + maize, moringa + sweet potato and moringa + maize + sweet potato than in sole cropping. Although it is not possible to attribute all the reductions in soil nutrients to uptake in sole maize, sweet potato and moringa or crop grown in mixtures, the uptake of nutrients however suggests that, an appreciable amount of soil nutrients were taken up by sweet potato and moringa since maize was harvested three months after planting. This confirm the work of Kapinga *et al* (1995), who stated that reduction in soil nutrients is as a result of uptake of nutrient by the plant for vegetative growth and bulking. Kapinga *et al* (1995) also observed that in root crop + cereal intercrop, more nutrients are taken up from 8-24 weeks after planting because it covers the anthesis period of maize and vegetative root initiatives and bulking periods in sweet potato.

The lower values of leaf number stem girth and leaf area in intercrop compared to sole crop could have resulted due to inter-specific competition among component crops. This is consistent with the report by Adipala *et al*, (2002) in his studies on crop mixtures. The more production of leaves which were obtained in moringa than maize and sweet potato could be as a result of differences in the type of plant and environmental adaptations. Competition effect between crop mixtures in intercropping which would have resulted due to intra-specific competition as stipulated by Mbah (2005) and Fageria (1999) brought about reduction in yield and yield components of crops.

Effects of treatments on Yield and Yield Components of Crops

The increase in yield and yield components of crops in crop mixtures than in sole crop could be as a result of different levels of nutrients uptake of the crops. Maize yield and yield components in the system could be attributed to the effect that maize might have utilized available resources efficiently than other crop in the intercrop systems. Similar observation was made by Ibeawuchi and Ofoh (2000) in maize/cassava intercropping systems on food security for low resource farmers under drought. The increase in sweet potato yield could be attributed to utilization of growth resources in the cropping systems, possibly due to decomposition of organic matter from intercrop plants. Essien *et al*, (2010) stated that during growth and development of crop, crops must intercept and observed growth factors and use them in the processes and produce biomass resulting in high yields. The increase in yield component could also be as a result of good growth rate of the crop utilizing better growth resources, and this suggested that through the early foliation and higher net assimilation rate (NAR) of the leaves during the early phase of plant growth tuber was enhanced. However, plants can be grown in competition without major effects in their growth if they have different individual adaptations; probably the performance of sweet potato in the cropping systems was due to inter-specific competition between the sweet potato stands and individual fallow species while those in sole plots were able to utilize the available resources on the environment.

Effects of Treatment on the Fresh and Dry weight of Moringa Leaf Yield (t/ha)

The increase in the fresh and dry leaf yield of moringa in moringa + maize and moringa + maize + sweet potato than in sole crop could be due to low evaporation potentials during the growth period and subsequently yield. Sweet potato has provided better soil cover compared to sole moringa, so water evaporation at soil surface was low. This agrees with the work of Ogindo and Walker (2005), who reported that maize-bean intercrop has been known to hold water, largely due to early high leaf area index and high leaf area. Also, the increase in leaf yield could be as a result of high soil pH preferred by moringa (Fuglie and Sreenja, 2001). The decrease in fresh and dry leaf yield of moringa at 12 months after planting, could be as a result of low moisture content and probably senescence, and browse productivity (per unit area) has been found to be linked to the habitat and soil physico-chemical properties (Dicko and Sikena, 1992). The highest annual dry matter yield obtained in this study (3.99t/ha) at 6MAP, could be as a result of moisture and nutrient availability to the plant and the significant reduction in yield during dry season could be as a result of moisture stress resulting in increase in the number of fallen leaves and the fact that this period coincides with flowering of the moringa plant with subsequent reduction in vegetative growth. Fadiyimu et al (2012) had earlier reported that season had significant effect on the yield of moringa.

CONCLUSION

Soils of the study area are highly degraded due to intensification of crops, bush burning, and erosion as well as soil acidity and thus require remediation. Moringa oleifera is a multipurpose tree plant that suit into cropping systems due to its potentials to improving soil fertility and thus improving productivity. Moringa oleifera in intercropping systems with food crops improves crop growth and yield performances by providing conducive crop growth environment as well improving the welfare of the farmers by increasing crop yield and balanced food nutrition when consumed. The result of the study indicated an improvement on crop growth and yield performances with Moringa intercrop. This means that moringa/maize, moringa/sweet potato and moringa/maize/sweet potato could be recommended to farmers for better and efficient productivity.

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