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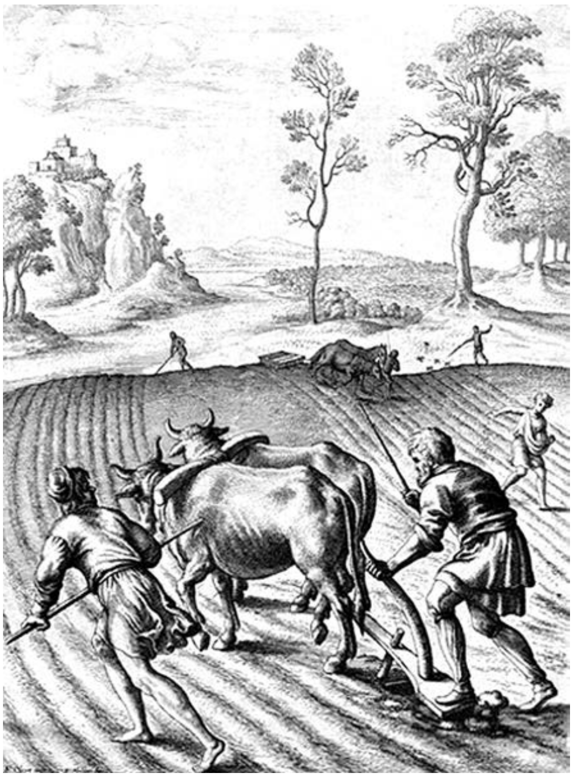

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Economic Yield and Sustainability of Maize Crop (*Zea mays* (L.) in Association with Cowpea (*Vigna unguiculata* (L.) Walp) and Egusi-melon (*Citrullus lunatus* (Thumb) mansf) in South Western Nigeria

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Abstract: Field experiments were conducted during the April 2004 and December 2005 cropping seasons at Kwale, Ndokwa West local Government Council farm annex, in south western Nigeria, to determine the compatibility of maize, cowpea and egusi-melon as well as their economic yield and the stability of these mixtures. The growth parameters considered were plant height and leaf number of maize, cowpea height and number of branches, egusi-melon vine coverage, weed biomass as well as economic yield while land equivalent ratios were calculated from the economic yield. The result of the experiment showed that sole egusi-melon and in association with maize and cowpea significantly suppressed weeds compared to other cropping systems. The economic yields of sole crops were significantly higher than in their respective crop associations. Associations of three crops had higher combined yields than two crops or sole crops. The LER, was highest in three crop association of 1.91. It was concluded that a system, with the highest combined economic yield, highest LER, in addition to ensuring better crop diversity in the humid tropical environment, a mixture of maize/cowpea/egusi-melon is recommended than sole crops or one or two crop associations.

Key words: Inter cropping, economic yield, LER, sustainability

INTRODUCTION

Intensification of cropping in time and space by growing crops simultaneously or in relay on the same piece of land is a popular practice in the humid tropics (Gomez and Gomez, 1983; Chinaka and Obiefuna, 2000). Growing of diverse crops in mixtures offers a dependable return than sole cropping (Ogunfowora and Norman, 1973) controls erosion, suppresses weeds, reduces the effects of pests and diseases, provides a good soil management condition (Lal, 1995; Tian *et al*., 1999; Makinde *et al*., 2001; Unamma *et al*., 2004) and increases efficiency in utilization of the soil growth resources.

With intensive cropping with little or no fallow period, soil infertility occurs and yield declines. This can be circumvented by adopting cropping systems that have some capability to recycle nutrients and at the same time controls erosion and weeds. The use of leguminous crop that fix atmospheric nitrogen, of which the associated crop benefits, (Agboola and Fayemi, 1972; Igboarugo and Badejo, 1998; Sharma *et al*., 1996) and also, cover crops to control erosion and weeds can be a sustenance strategy. Egusi-melon, cowpea (Ife brown) are some of farmers popular crops in south western Nigeria. They can be grown in association with other crops in order to maximize land use and higher productivity per unit land area. However, their compatibility with a major food crop such as maize needs to be properly assessed, as to fully appreciate their effects on production. The objective was therefore, to determine the compatibility of maize with cowpea and egusi-melon as well as the economic yield and stability of these mixtures.

MATERIALS AND METHODS

The experiment was conducted at the Ndokwa west local government council farm annex in Kwale, Delta State, Nigeria from April 2004 to December 2005. Kwale is located on latitude 05° 46N and longitude 06° 26E. The soil type is known as tropical Alfisol and is a well drained sandy soil-loam with a pH of 6.1. The pre-planting soil analysis is presented in Table 1. The experiment was laid out in a randomized complete block design with 4 replicates. The plot size was 4×4 m (16 m^2) with one 1 m inter-plot and inter-block spaces. There were seven treatments as follows:

- T_1 maize
- T_2 egusi-melon
- T_3 cowpea
- T_4 maize/cowpea
- T_5 maize/egusi-melon
- T_6 cowpea/egusi-melon
- T_7 maize/egusi-melon

Table 1: Pre-planting soil analysis of experimental site

Soil property	Values
Soil texture	Sandy-loam
pH 1:1 water	6.10
% Organic carbon	0.50
% Total N	0.25
Available P (ppm)	15.00
Exchangeable Ca^{++} C mol kg^{-1}	5.82
Mg mg kg^{-1}	1.20
K cmol kg^{-1}	0.31
Na cmol kg^{-1}	0.14
CEC mg kg^{-1}	10.10

Table 2: Crop population per hectare in sole and in the mixed system

	Maize	Cowpea	Egusi-melon
Sole crops	30,000	30,000	30,000
Maize/cowpea	30,000	22,500	
Maize/egusi-melon	30,000		22,500
Cowpea/egusi-melon		30,000	22,500
Maize/cowpea/egusi/melon	30,000	22,500	22,500

The crop varieties were TZSR maize, Ife brown cowpea and local egusi-melon. Maize was obtained from the office of the Ministry of Agriculture, Kwale, cowpea from Agip, Nigeria Green River Project and egusi-melon was sourced locally. They were sown during the 2004 and 2005 cropping seasons. All the seeds were planted at the rate of 3 seeds per hole, each at a spacing of 100×100 cm. Plant population stood at 30,000 per hectare for sole crops of maize, cowpea and egusi-melon (Table 2).

Maize height (second internode from soil level) was measured, Leaf number counted from the second week after planting (2 WAP) to the 8 WAP. Similar observations were carried out for cowpea height and number of branches. Percentage vine cover was assessed using quadrants randomly located within each plot. Other parameters measured were weed biomass and economic yield of maize, cowpea and egusi-melon. All the data were subjected to analysis of variance and the means showing significant differences were separated using Duncan Multiple Ranges Test.

RESULTS AND DISCUSSION

At the second and third weeks of planting, maize was significantly taller in association with cowpea (Table 3), than maize associated with any other crop, while at 6, 7 and 8 weeks after planting, sole maize crop was significantly taller than maize associated with any other crop.

Leaf production was better enhanced in sole crop production ($p<0.05$) from 6 WAP till the final measurement (Table 4). This parameter was most depressed in maize/cowpea/egusi-melon mixtures for the period of study.

The better performance of sole maize crop compared to maize in the mixtures Supports Lizarranga's (1980) findings of better growth performances of sole crops than in their mixtures with other crops. Similarly, Olasantan (1988), observed better growth performances in sole crops than in their intercrops.

Cowpea height did not show any consistent trend (Table 5). However, cowpea was significantly taller as a sole crop and cowpea/maize mixture than with egusi-melon and with maize and egusi-melon by the 7th week after planting.

Branch production was consistently superior in sole cowpea crop (Table 6) from the 5th week after planting till final observation at 8 WAP. At final measurement, cowpea in association with maize and melon were most significantly depressed in terms of branch production.

The better the performance of sole crops in growth parameters when compared with their intercrops is in line with the findings of Lizarranga (1980), who reported that sole crops exhibited better growth parameters than in mixtures with other crops.

Vine coverage in egusi-melon did not show any consistent trend (Table 7). It remained significantly higher when combined with cowpea and maize than as a sole crop or mixed with cowpea or maize alone in the 4th and 5th week after planting. By the 7th WAP, the differences in vine coverage had disappeared, an indication of the aggression of egusi-melon, both as a sole crop and in its mixtures.

Among the treatments applied, egusi-melon as a sole crop significantly reduced weed growth and weed dry matter when compared with the sole crops of maize and cowpea (Table 8). The highest weed count and dry matter was recorded in sole crops of maize, cowpea and maize/cowpea mixture. This development may be connected with the growth habit of egusi-melon and perhaps the crop mixture in the system. Egusi-melon is a food crop, live mulch and a low growing cover crop, reduces solar radiation reaching the soil and so reduces weed emergence and growth. Also, higher storey crops like maize and erect cowpea, with limited canopy would permit more sunlight (although not measured) to reach the soil. Egusi-melon as a life mulch in the system would reduce incidental light rays and suppress the emergence and growth of weeds. This supports Bridgemohan and Braithwaite (1989) who reported that maintenance of ground cover or crop residues reduces the germination of weeds in cultivated soil. Similarly, Hammerton (1984) reported that, intercropping contributes to weed control while Bashir *et al.* (1988) reported that, weed types and biomass decreased with increase in planting density.

Table 3: Maize height (cm) as influenced by crop combinations

	Time (weeks after planting)						
Treatments	2	3	4	5	6	7	8
Maize	23.04AB	39.41B	67.39A	78.15A	130.55A	158.67A	196.41A
Maize/cowpea	23.10A	42.87A	63.48AB	77.42	121.32B	149.14B	181.59B
Maize/egusi-melon	22.80C	37.72C	60.21B	76.60	115.01C	130.92C	174.08C
Maize/cowpea/egusi-melon	22.89BC	36.71D	59.82B	72.24	113.19C	126.34D	169.33C

Within each column, means followed by similar alphabets are not significantly different at 5% level of probability

Table 4: Maize leaf number as influenced by crop combinations

	Time (weeks after planting)						
Treatments	2	3	4	5	6	7	8
Maize	6.08A	7.01A	7.47A	8.71A	10.30A	11.30A	14.93A
Maize/cowpea	6.03A	6.94AB	7.49A	8.23AB	10.29A	11.30A	14.29AB
Maize/egusi-melon	5.94A	7.11A	7.33B	8.21AB	9.80B	10.84AB	13.18B
Maize/cowpea/egusi-melon	6.05A	6.41B	7.33B	7.91B	9.40B	10.00B	13.10B

Within each column, means followed by similar alphabets are not significantly different at 5% level of probability

Table 5: Cowpea height (cm) as influenced by crop combination

	Time (weeks after planting)					
Treatments	2	3	4	5	6	7
Cowpea	10.30B	11.30B	16.61B	20.05B	24.06A	25.45A
Maize/cowpea	10.67B	11.11B	17.29A	20.24A	23.99A	24.50AB
Cowpea/egusi-melon	11.19AB	12.67AB	16.85B	19.21AB	23.83A	24.07B
Maize/cowpea/egusi-melon	11.79A	13.71A	18.07A	18.41B	23.75A	23.80B

Within each column, means followed by similar alphabets are not significantly different at 5% level of probability

Table 6: Cowpea branches as influenced by crop combination

	Time (weeks after planting)					
Treatments	2	3	4	5	6	7
Cowpea	1.00B	2.0A	3.0A	4.0A	5.0A	6.20A
Maize/cowpea	1.25AB	2.0A	3.0A	3.4AB	4.0B	4.40B
Cowpea/egusi-melon	1.50A	1.8A	3.0A	3.2AB	3.8B	4.20B
Maize/cowpea/egusi-melon	0.75C	1.8A	2.25B	3.0B	3.6B	4.00B

Within each column, means followed by similar alphabets are not significantly different at 5% level of probability

Table 7: Egusi-melon vine coverage as influenced by crop combination

	Time (weeks after planting)					
Treatments	2	3	4	5	6	7
Egusi-melon	1.30A	1.80B	2.90C	3.06B	4.80A	5.00A
Maize/egusi-melon	1.20A	1.60C	2.60D	3.20C	4.70AB	5.00A
Cowpea/egusi-melon	1.30A	2.00A	3.20B	3.40B	4.60B	5.00A
Maize/cowpea/egusi-melon	1.30A	2.40A	3.50A	4.30A	4.70B	5.00A

Within each column, means followed by similar alphabets are not significantly different at 5% level of probability

Table 8: Effects of weed suppression in intercropping using weed count and shoot dry matter (kg ha^{-1})

Treatments	Weed count at 6 weeks after planting	Weed dry matter at 6 weeks after planting	Weed dry matter at 14 weeks after planting
T_1 Maize	134.00A	48.40A	27.80B
T_2 Egusi-melon	5590.00D	20.10C	9.60C
T_3 Cowpea	115.10B	31.60B	29.10A
T_4 Maize/cowpea	100.90BC	31.10B	29.10A
T_5 Maize/egusi-melon	72.10C	20.80C	11.20C
T_6 Owpeaegui-melon	63.90C	18.30C	7.40C
T_7 Maize/cowpea/egusi-melon	60.70CD	18.20C	6.50C

Within each column, means followed by similar alphabets are not significantly different at 5% level of probability

The grain yield of maize was significantly higher in sole crops than in their mixtures (Table 9). Also, grain yield of maize in 2 or 3 crop mixtures were not significantly different (p>0.05) in the associations.

The seed yield of melon was significantly higher in sole crop than in their mixtures (Table 9) and also the seed yield in 2 crop mixture were significantly higher than in 3 crop mixture.

Table 9: Economic yield of maize based cropping system

Treatments	Maize (t ha^{-1})	Cowpea (t ha^{-1})	Egusi-melon (kg ha^{-1})
Maize	3.90A		
Cowpea		0.84A	
Egusi-melon			64.40A
Maize/cowpea	3.20AB	0.61AB	
Maize/egusi-melon	3.10AB		58.30B
Cowpea/egusi/melon		0.57AB	50.70BC
Maize/cowpea/egusi-melon	2.90B	0.49B	40.60C

Within each column, means followed by similar alphabets are not significantly different at 5% level of probability

Table 10: Land equivalent ratio of maize based cropping system

Treatments	Maize	Cowpea	Egusi-melon	LER
Sole crops	1.00	1.00	1.00	1.00
Maize/cowpea	0.82	0.73		1.85
Maize/egusi-melon	0.79		0.85	1.64
Cowpea/egusi-melon		0.68	0.74	1.42
Maize/cowpea/egusi/melon	0.74	0.58	0.59	1.90

The grain yield of cowpea was significantly higher in sole crop than in their mixture (Table 9). Within the 2 or 3 crop mixture, the grain yield in 2 crop mixture were significantly higher than in 3 crop mixture. The better performance of sole crops than in their mixtures may be attributed to better utilization and less competition for growth resources than in mixtures. This is in agreement with the findings of Lizarranga (1980) who observed better performances and yield of sole crops than in their mixtures. Similarly, Ezumah *et al.* (1982) and Gondwe and Sauti (1994), observed higher yields in monocrops than in their mixtures.

The relative yield of the crops was highest in the sole crops and least in the 3 crop mixtures (Table 10). Thus, the 3 crop mixtures which had the least relative yields recorded the highest aggregate yield. The superior LERs obtained by intercropping made the mixtures more productive. This high LER obtained for the crop mixtures confirm the often expressed conclusion that intercropping is beneficial to the traditional farmer (Ugen and Wein, 1996).

The general trend in the study indicates some degree of interspecific competition in each crop mixture. Egusi-melon, which is a cover crop and a live-mulch utilized in this low external input system, reduced weed population and density. Live mulch minimizes the impact of raindrops, increases infiltration and reduces surface run-off and perhaps controls erosion (Akobundu, 1984). It also conserves moisture and provides a favourable micro-climatic conditions, which is greater than with monocropping or with out cover cropping. Ikerogu (1987) reported that intercropping water-melon with maize or cassava conserved moisture and increased land productivity per unit land area in Nigeria. The root system of the crops especially the cover crop must have bounded soil particles together, leading to better aggregation of the soil particles and improve soil structure (Lal, 1995). The indirect effects of this include enhanced microbial activities in the soil for better soil condition for the crop growth and productivity, which is an important factor for sustainable agricultural production in low external input system.

The inclusion of a legume in the system, which fixes atmospheric nitrogen to the associated crop in the mixture, was an advantage for sustainability of the system. Although, the nitrogen so fixed was not measured, the associated crops performed well. This supports Agboola and Fayemi (1972), Sharma *et al.* (1996) and Lulandala and Hall (1982), who observed that non-leguminous crops performed better with a leguminous crop than a non-leguminous crop. This also agrees with Igboanugo and Badego (1998), who stressed that intensive cultivation of N-fixing leguminous crops is a possible way of solving production problems and restoring degraded soil system. In most developing countries, where the cost of chemical fertilizer are expensive, the needed N in agro-ecosystems must therefore come from biological agents. The Biological Nitrogen Fixation (BNF), or atmospheric nitrogen fixed accounts for about 65% N which is currently utilized in Agriculture and this will be increasingly important in future crop productivity especially for sustainable systems, by peasants farmers and marginal lands utilization (Vance and Graham, 1995). The understanding of BNF will be useful in sustainable crop production.

A system with higher LER will hold a higher benefit to the resource poor farmers. In addition to enhancing crop diversity, it ensures reduced risk of total crop failure of monocrops, biological stability and higher economic returns. Although sole crops gave higher economic yields than in their mixtures, considering these mixture of maize/cowpea/egusi-melon appeared better suited to this conditions than the sole or two crop mixtures in the two cropping period employed in the study.

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