EFFECTS OF VARIOUS PLANTING RATIOS ON THE PERFORMANCE OF MAIZE AND COWPEA IN MIXTURES

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Abstract
The experiment was conducted at the Teaching and Research Farm of Ambrose Alli University, Ekpoma to evaluate the performance of maize and cowpea planted at various replacement ratios. Weight of grains per plant and grain yield were higher in cowpea in maize-cowpea intercrop planted in ratio 2:1. Based on the total yield and land equivalent ratio (LER) values, the optimum yield ratio was in maize+cowpea planted in ratio 2:1. The planting ratio 1:1 of maize-cowpea intercrop was found to increase the number of root nodules of cowpea at 6 WAP; this also brought corresponding increase in weight of root nodules per plant at 6 WAP. Potassium was higher in the ear leaf of sole maize than in the mixtures and phosphorus was higher in mixture of maize and cowpea planted in ratio 1:1. Maize grain from maize-cowpea intercrop at 1:2 had the highest concentration of N and P. Maize grains from maize-cowpea ratio 1:1 had the highest concentration of Mg, while the highest maize yield was recorded in maize+cowpea intercrop planted in ratio 1:2.

Keywords: Evaluation, ratio, yield, maize and cowpea

Introduction

Mixed intercropping is a very common feature in the cropping system among peasant farmers in the less developed countries of the world. Kurt (1982) explained that intercropping is an agro-based cropping system where two or more crops are planted simultaneously on the same piece of land. It is thought to have evolved to meet local situations and conditions (Egharevba, 1982) and is mostly practised among various small farm holders (Famaye, 2003). Okigbo and Greenland (1976) estimated that 99% of cowpea and 75% maize grown in Nigeria are intercropped. Intercropping may involve growing of the component crops in random mixed stands as widely practised by some farmers (Andrews, 1975; Usenbo, 1977) or in patches as in traditional farming systems (Okigbo and Greenland, 1976) or in different adjacent stands which are arranged in rows (Kumar and Yusuf 1991). In some cases, the crops are just intermingled with no distinct row arrangement (Abalu, 1984). Therefore, the way and manner in which the farmer organizes the growing of various crops and how he arranges them in the field becomes very important. Traditional cropping systems are very flexible and well adapted to the local environment, physically as well as socially. As a consequence, intercrops vary under the influence of climate, soils, topography, land tenure, access to markets, food preference, etc. This is mainly related to the choice of component crops as well as varieties, planting time, spatial arrangement and planting density (Kurt, 1982).

Intercrops are said to be better than monocrops because of the higher yield, protection against risks of drought and pests, even distribution of labour requirements and the provision of a more balanced human diet (Vandermeer, 1990). It provides food and income at different periods of the year for the family (Emede and Adegoke, 2011). Yield advantages resulting from intercropping may be due to component crops having different durations or growth patterns, hence, make major demands on resources at different times, thereby resulting in better temporal use of growth resources (Ile *et a*l., 1996; Mbah and Muoneke, 2007). Essien, *et al.* (2015) explained that increase in yield and yield

components of crops in crop mixtures than in sole crop could be as a result of different level of nutrients uptake of the crops. Olufajo and Singh (2002) suggested that cowpea could be included in farming systems of the humid areas because of its potential to provide green manure in addition to producing primary products of grain and fodder. When nitrogen fertilizer is not applied, intercropped legumes will fix most of their nitrogen from the atmosphere and not compete with maize for nitrogen resources (Adu-Gyamfi *et al*., 2007).

Moreover, crops differ in the way they use environmental resources, thus they can complement each other when grown together, making better use of resources than monocrops (Willey, 1979). The current trend in global agriculture is to search for highly productive, sustainable and environmentally friendly cropping systems (*Crew and Peoples, 2004).* When two crops are planted together, inter specific competition or facilitation between plants may occur (Zhang and Li, 2003).

The ratio at which the intercropping of maize and cowpea should be carried out is not well established in most experiments or in the literature. There is need to find out the appropriate ratio in which maize and cowpea as component crops are intercropped in order to get maximum benefit in terms of nutrient uptake by maize and yield of both crops in the forest savanna transition zone.

Materials and Methods

The experiments were carried out in the Teaching and Research Farm of the Faculty of Agriculture, Ambrose Alli University, Ekpoma in 2004-2005. Ekpoma is located between latitude $6^{0}41^{1}$ and $6^{0}48^{1}$ North of the equator and longitude $6^{0}02^{1}$ and $6^{0}11^{1}$ East in a forest-savanna transition zone of South-South Nigeria. Before planting, soil samples were collected at depths of 0-15cm from various parts of the experimental site. The composite soil samples were analysed for their physico-chemical properties as presented in Table 1. The soil sample from experimental site was found to be deficient in nitrogen (0.70g/kg) and phosphorus (13.63g/kg) being that the critical level of nitrogen is 1.5g/kg according to Sobulo and Osiname (1981) and the critical level of phosphorus is 15g/kg according to Adepetu *et al.* (1979).

The experiment involved maize, and cowpea intercrop. The cultivar of maize (*Zea mays* L.) used was ACR 89-DMR-ESR-W, with white kernel; a downy mildew streak resistant and early maturing variety, developed by the International Institute of Tropical Agriculture (IITA), Ibadan. The cultivar of cowpea (*Vigna* unguiculata L. (Walp), used was IT 90k-277-2, with medium sized white seeds and matures in 2-3 months after planting. The vines climb up to a height of 100-250cm and it is semi-erect. The three crops were obtained from IITA, Ibadan. The insecticide used was 'karate' produced by Zeneca limited. It is a highly effective broad-spectrum insecticide with active ingredient, Lamdacyhalotrin; it kills insect pests by contact and ingestion. The equivalent of 800ml of 'karate' 2.5EC in 1000 litres of water per hectare was used.

The crops were grown in ratios with the following treatment combinations: Sole maize; Sole cowpea; Maize + Cowpea in ratio 1:1, Maize + Cowpea in ratio 1:2 and Maize + Cowpea in ratio 2:1. The treatments were replicated four times to give a total of 20 experimental units. The treatments were arranged into a randomized complete block design in a piece of land measuring 24.75 x 23m, that is, area of 569.25m^2 (0.057 ha.). This area was divided into 4 blocks, each block was further sub-divided into 5 smaller experimental units measuring 3.75 x 4.50m with an area of 16.88m^2. A walking path of 1m was also created between the blocks and experimental units. A basal application of fertilizer NPK 15-15-15 at 100kg/ha was made to make up for the deficiency of nitrogen and phosphorus (Table 1). The maize and cowpea were planted at three seeds per hole on the flat. They were later thinned at 2

WAP to one plant per stand in both crops. The planting of both sole and mixture of maize and cowpea were done at the same distance of 75cm inter-rows and 25cm intra-rows and the intercrop was a replacement series as indicated in Table 2. The plant populations for sole maize and sole cowpea were 53,318 and 53,318 plants/ha respectively. For the intercrops, maize plus cowpea in ratio 1:1, 1:2 and 2:1 had the plant populations of 26,659:26,659; 17,773:35,545 and 35,545:17,773/ha respectively. The percentage of intercrop ratio treatments for planting maize and cowpea is shown in Table 3.

The parameters measured in maize where ear height, plant height at harvest, stem girth, number of leaves at tasselling, ear leaf area, days to 50% tasselling, number of ears or cobs per plot and grain yield. The parameters measured in cowpea were number of leaves per plant at 6 WAP, length of the central stem at 6 WAP, number of root nodules per plant at 6 and 8 WAP, leaf area, days to 50% flowering of cowpea, number of pods per plant at 50% podding, number of pods per net plot, weight of pods per net plot, weight per pods, shelling percentage and yield.

The vegetative data of maize and cowpea were collected from three stands at the middle of each plot of every replicate and the means computed. But in case of yield of maize and cowpea, net stands were considered in the plant population. For all the data collected, the mean were computed and subjected to analysis of variance (ANOVA) and the means were separated by least significant different (LSD) at 5% level of probability. Land equivalent ratios (LER) for the whole intercrops involving maize, and cowpea were calculated as defined by Willey (1979), Mead and Willey (1980), Remison (1991) and Cheema *et al.* (2006) with the formula:

$$\text{LER} = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where Yab - Yield of component 'a' as intercrop grown in combination with component 'b'; Yaa - Yield of component 'a' as sole crop. Yba - Yield of component 'b' as intercrop grown in combination with component 'a'. Ybb - Yield of component 'b' as sole crop. A ratio > 1, signals yield advantage, a ratio < 1, signals yield disadvantage and a ratio = 1, no differences in yield.

Results and Discussion

Most of the vegetative traits of maize grown in ratios differed significantly when compared to sole maize. However, ear leaf area and days to 50% tasselling did not significantly differe (Table 4). The mean height of maize was increased in pure stand although not significantly when compared to maize height in maize-cowpea planted in ratio 1:2. There was no competition for light in the mixture of maize and cowpea in any of the planting ratios. The possible reason could be that cowpea as component crop had more leaf area (Table 8) than maize that covered all the available space of the plots to receive more light. Generally, planting ratio had no effect on number of ears per plant and grain yield but the highest yield was recorded in maize intercropped with cowpea at the ratio of 1:2. Grain yield of maize was highest in maize-cowpea mixture sown in ratio 1:2, about 7.14% higher than the monoculture yield and also higher (14.41%) than the plot where maize-cowpea was sown in ratio 1:1. Having more cowpea stands than the maize stands, the maize stands may have benefited from the nitrogen fixed by cowpea. This is why Dahmardeh *et al*; (2009) stated that the inclusion of cowpea in intercrop systems might make extra soil N,P and K available to the following cereal crops such as maize because annual legumes contribute N through biological nitrogen fixation.

Planting ratios did not affect number of leaves per plant, stem height, stem girth and leaf area of cowpea (Table 28). It only delayed flowering and podding of cowpea planted in ratio 1:2. The delay of both flowering and podding was significantly different from days to flowering and podding of sole

cowpea and maize-cowpea planted in ratio 1:1. More delay would have been expected in ratio of 2:1 for maize and cowpea because of population of maize planted in respect to cowpea. Maize did not suppress cowpea growth because of the large surface leaf area of the cowpea plant (Table 8).

The number of pods at 50% podding per plant was significantly affected by planting ratio. Hence sole cowpea had the highest number of pods at 50% podding significantly differed from number of pods from maize and cowpea planted in ratio except maize and cowpea planted in ratio 1:2. But at the end of harvest, more pods per plant were obtained in ratio 2:1 for maize and cowpea intercrop. In this ratio (2:1), maize had no depressive effect on the performance of cowpea since number of pods, weight of pods, weight of grains per plant and grain yield (kg/ha.) were significantly higher than other ratios including the monoculture. The possible reason for this could be the large leaf area of the cowpea (Table 8) which had more access to sunlight, hence photosynthetic rate was greater than the other ratios and the monoculture, resulting in increase in yield.

The yield of maize was higher in the mixture in which maize-cowpea were planted in the ratio of 1:2 (33/67) when compared to yield from sole maize (100%), although not significantly different from other treatments. With regards to cowpea, higher yield was recorded in maize-cowpea in ratio 2:1 (67/33) when compared to monoculture cowpea (100%), which was significantly different from other treatments. In the plot where maize and cowpea were intercropped at the ratio of 2:1, there was positive complementation between maize and cowpea mixture. This is not in agreement with the findings of Remison (1980) where he found positive complementation in all mixtures except where maize formed 33% of the stand. But in this experiment, positive complementation was only found in the plot where 67% of maize and 33% of cowpea were planted. The disagreement could be as a result of differences in the varieties of cowpea and maize used including the environment in which the experiment was carried out.

The complementarity of maize and cowpea in ratio 2:1 resulted in high total stand yield (Table 10) in all the intercrop ratios. No wonder Mongi *et al.* (1976) and Baker (1978) reported that most farmers in the tropics do not invest much money on fertilizers, because cereal-legume mixtures give higher yield per unit area than sole cropping. They prefer to intercrop maize with a legume, because legumes serve as green manure and invaluable source of plant protein. Their capacity for working in association with certain bacteria to fix nitrogen in the soil for plant growth makes them unique among plants.

The total stand yield was largely determined by the yield of the highest yielding component, i.e maize. The highest total stand yield were found in mixtures containing the higher proportion of maize (Table 10). The highest total stand yield of the mixture was found in ratio of 67/33 (2:1) (Table 10). This is consistent with earlier finding reported by Remison (1980) that the highest total grain yield in mixture was at the ratio of 67/33 of maize-Ife brown, but not consistent with 50/50 ratio of maize-New Era mixture, where the maximum advantage of the intercrop occurred when maize and cowpea were grown at 50:50 ratio.

The land equivalent ratios of maize-cowpea intercrop in the three ratios were all above 1.0, showing that a higher productivity per unit area was obtained by intercropping maize-cowpea intercrop planted at ratio 2:1 had significant ($P < 0.05$) effect on total productivity per unit area with the LER being higher when compared with the other ratios. Planting ratio of maize and cowpea affected the phosphorus and potassium content of ear leaf of maize. Phosphorus was high in ear leaf from maize-cowpea intercrop planted in ratio 1:1 when compared to ear-leaf from sole maize and other treatments. On the other hand, potassium content was more in the ear-leaf from sole maize compared to other

planting ratios. Mg was higher in ear-leaf from the plot where maize-cowpea was planted in a ratio of 2:1 compared to sole maize (Table 6). The concentration of minerals in the ear-leaf of maize did not follow a particular pattern probably due to the poor nutrient status of the soil (Table 1).

The maize grains from the planting ratio of 1:2 of maize-cowpea intercrop had high contents of N and P when compared to sole maize. The concentration of nitrogen and phosphorus were higher in maize grain when maize-cowpea was planted in ratio 1:2. Mg concentration was more in the maize grain from maize-cowpea intercrop when compared with maize grain from sole maize. The composition of all the minerals were at their highest in maize grain from the plot where maize and cowpea was intercropped in ratio 1:2 apart from Mg (Table 7). Planting of maize in association with cowpea in ratio 1:2 brought about increase in some mineral composition of the maize grains. The reason for this could be due to the high number of nodules formed which aided the availability of nitrogen for maize which later enhanced absorption of other minerals from the soil in the formation of maize grains.

The number of root nodules of cowpea decreased at 8 WAP in the plot where maize-cowpea was planted at ratio 1:1 whereas in other treatments, the root nodules increased. At 6 WAP; the weight of the root nodules at ratio 1:1 (Table 11) was higher than any other ratios. The planting ratio of 1:1 of maize-cowpea intercrop was found to increase the number of root nodules of cowpea at 6 WAP; this also brought corresponding increase in weight of root nodules per plant at 6 WAP. But at 8 WAP it was found to increase the number of root nodules of cowpea in maize-cowpea intercrop planted at ratio 2:1. Despite this, the highest yield of maize was obtained where maize-cowpea was planted in ratio 1:2.

Table I: The Physico-chemical properties of soils of the experimental sites before planting

Physico-chemical properties	Value
pH (1:2.5 in water)	6.20
Particle size (g/kg)	
Clay	46.00
Silt	9.00
Sand	945.00
Textural class	Sand
Carbon (g/kg)	8.70
Nitrogen (g/kg)	0.70
Phosphorus (g/kg)	13.63
Exchangeable cations (cmol/kg)	
Calcium	3.20
Magnesium	0.72
Sodium	0.32
Potassium	0.24
Hydrogen ion	0.20
Aluminum ion	0.00
ECEC	4.68
Micronutrient (mg/kg)	
Iron	37.30
Copper	0.65
Manganese	2.52
Zinc	0.16
Cadmium	0.02
Lead	0.07
Nickel	0.01
Chromium	0.01

Table 2: Sole planting and intercropping ratios of maize and cowpea

Treatment	Ratio	Spacing (cm)	Planting population per experimental unit	Stands/ha
Sole maize	----------	75x25	90	53,318
Sole cowpea	----------	75x25	90	53,318
Maize + cowpea	1:1	75x25	45:45	26,659: 26,659
Maize + cowpea	1:2	75x25	30:60	17,773:35,545
Maize + cowpea	2:1	75x25	60:30	35,545: 17,773

Table 3: Planting ratios of maize and cowpea

Crops	Planting ratio				
maize	0	33	50	67	100
cowpea	100	67	50	33	0

Table 4: Effects of replacement ratios of maize and cowpea on vegetative and flowering traits of maize

Treatment	Planting ratio	Plant height (cm) at 10 WAP	Ear height (cm)	Number of leaves at tasselling	Ear leaf area (cm^2)	Day to 50% tasselling
Sole maize	----------	156.25a	72.25a	11.38a	603.19a	54.00a
Sole cowpea	---------	----------	----------	----------	----------	----------
Maize+cowpea	1:1	135.81b	58.75b	10.19bc	536.14a	53.25a
Maize+cowpea	1:2	149.75ab	57.75b	11.19ab	550.40a	54.00a
Maize+cowpea	2:1	136.81b	63.95ab	9.69c	535.40a	53.50a

Means with the same letter on vertical row are not significantly different at 5% level

Table 5: Effect of planting ratios of maize and cowpea on yield and yield components

Treatment	Planting ratio	Number of ears/plant	Weight(g) of ears/plant	Weight(g) of grains/plant	Grain yield (t/ha)
Sole maize	----------	1.00a	56.67a	40.89b	3.78a
Sole cowpea	----------	----------	----------	----------	----------
Maize + cowpea	1:1	1.00a	48.44b	37.78c	3.54a
Maize + cowpea	1:2	1.00a	41.67c	32.67d	4.05a
Maize + cowpea	2:1	1.00a	58.33a	47.17a	3.93a

Means with the same letter on vertical row are not significantly different at 5% level

Table 6: Effect of planting ratios of maize and cowpea on mineral composition of ear leaf of maize

Treatment	Planting ratio	%					
		N	P	K	Ca	Mg	Na
Sole maize	----------	2.60a	0.14b	1.73a	0.85a	0.26ab	0.16a
Sole cowpea	----------	----------	----------	----------	----------	----------	----------
Maize + cowpea	1:1	2.04a	0.20a	1.36bc	0.88a	0.19b	0.14a
Maize + cowpea	1:2	2.31a	0.08c	1.58ab	0.88a	0.24ab	0.17a
Maize + cowpea	2:1	1.97a	0.08c	1.31c	0.86a	0.29a	0.14a

Means with the same letter on vertical row are not significantly different at 5% level

Table 7: Effect of planting ratios of maize and cowpea on mineral composition of maize grains

Treatment	Planting ratio	%					
		N	P	K	Ca	Mg	Na
Sole maize	----------	0.70a	0.10b	0.47a	0.29a	0.05a	0.03a
Sole cowpea	----------	----------	----------	----------	----------	----------	----------
Maize + cowpea	1:1	0.62ab	0.09b	0.42a	0.27a	0.09a	0.03a
Maize + cowpea	1:2	0.73a	0,20a	0.49a	0.31a	0.07b	0.04a
Maize + cowpea	2:1	0.57b	0.10b	0.38a	0.29a	0.06bc	0.03a

Means with the same letter on vertical row are not significantly different at 5% level

Table 8: Effect of planting ratios of maize and cowpea on vegetative and flowering traits of cowpea

Treatment	Planting ratio	Number of cowpea leaves per plant	Stem height (cm)	Stem girth (cm)	Leaf area (cm^2)	Days to 50% flowering	Days to 50% podding
Sole maize	--------	----------	----------	--------	----------	----------	----------
Sole cowpea	---------	26.58a	20.90a	2.78a	4,778.60a	45.00b	51.00b
Maize + cowpea	1:1	25.58a	19.23a	2.91a	4,677.41a	44.75b	51.00b
Maize + cowpea	1:2	24.58a	21.70a	3.01a	4,503.67a	47.75a	53.75a
Maize + cowpea	2:1	28.33a	23.68a	3.21a	5,385.55a	46.00ab	52.25ab

Means with the same letter on vertical row are not significantly different at 5% level

Table 9: Effect of planting ratios of maize and cowpea on yield and yield components of cowpea

Treatment	Planting ratio	Number of pods at 50% podding per plant	Number of pods per plant at harvest	Weight(g) of pods per plant	Weight(g) per pod	Weight (g) of grains per plant	Grain yield (kg/ha)	Shelling percentage (%)
Sole maize	---------	---------	---------	---------	-------	--------	---------	--------
Sole cowpea	---------	8.00a	21.48b	63.46b	1.25a	46.15b	2,461.54b	67.74a
Maize+cowpea	1:1	4.70b	21.79b	69.23b	2.16b	41.54b	2,215.38b	60.05a
Maize + cowpea	1:2	7.25a	19.50b	60.27b	2.07b	38.46b	2,051.28b	59.49a
Maize + cowpea	2:1	5.51b	24.74a	92.31a	1.81a	60.00a	3,200.00a	65.39a

Means with the same letter on vertical row are not significantly different at 5% level

Table 10: Effect of planting ratios of maize and cowpea on total stand yield and land equivalent ratio

Treatment	Planting ratio	Maize yield (t/ha)	Cowpea yield (t/ha)	Total yield (t/ha)	Land equivalent ratio (LER)
Sole maize	----------	3.78a	----------	3.78b	----------
Sole cowpea	----------	----------	2.46b	2.46c	----------
Maize + cowpea	1:1	3.54a	2.22b	5.76a	1.84b
Maize + cowpea	1:2	4.05a	2.05b	6.10a	1.90b
Maize + cowpea	2:1	3.93a	3.20a	7.13a	2.34a

Means with the same letter on vertical row are not significantly different at 5% level

Table 11: Effect of planting ratios of maize and cowpea on number and weight of root nodules of cowpea at 6 and 8 WAP

Treatment	Planting ratio	Number of nodules/plant at 6 WAP	Weight(g) of nodules at 6 WAP	Number of nodules/plant at 8 WAP	Weight(g) of nodules at 8 WAP
Sole maize	----------	----------	----------	----------	----------
Sole cowpea	----------	20.67b	0.17b	27.33a	0.12a
Maize + cowpea	1:1	31.50a	0.36a	20.33a	0.17a
Maize + cowpea	1:2	25.25ab	0.16b	26.33a	0.12a
Maize + cowpea	2:1	21.34b	0.15b	28.33a	0.15a

Means with the same letter on vertical row are not significantly different at 5% level

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