

Full Length Research Paper

Yield effects of intercropping white guinea yam (*Dioscoreae rotundata* P.) minisetts and maize (*Zea mays* L.) in the southern Guinea savanna of Nigeria

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Field experiments were conducted from May to October during 2003 and 2004 cropping seasons at the Research Farm, University of Agriculture, Makurdi, Benue State, Nigeria, to evaluate the yield effects of intercropping white Guinea yam (minisetts) and maize and to assess the advantages of the intercropping system. Maize yield was not significantly affected by intercropping with yam-minisetts. However, tuber yield of yam-minisetts intercropped with maize was significantly ($P \leq 0.05$) depressed by 15.0 and 16.3% respectively, in 2003 and 2004 compared to monocultured yam-minisetts. However, total yield was greater than the component crop yield, either planted as sole or in mixture. Intercropping yam-minisetts and maize gave land equivalent ratio (LER) values of 1.98 and 1.95 respectively, for years 2003 and 2004, thus, indicating that higher productivity per unit area was achieved by growing the two crops together than by growing them separately. With these LER values, 49.5 and 48.7% of land was saved respectively, in 2003 and 2004, which could be used for other agricultural purposes. In addition, maize was about three-quarters as competitive as yam-minisetts, indicating that both crops are complimentary and suitable in mixture.

Key words: White guinea yam, minisetts, maize, intercropping, Nigeria.

INTRODUCTION

Yam and maize are the most important food crops in Nigeria both in land under cultivation and in their immense contribution to rural and regional economies (Agboola, 2000). Nigeria produces more than 70% of the total world production of yam and about 50% of maize (Madu and Nwosu, 2001).

The southern Guinea savanna zone of Nigeria is a major yam and maize producing area. In this zone, several races of *Dioscoreae rotundata* P. and *Zea mays* L. are grown. A popular local variety of *D. rotundata* in north central Nigeria is 'Dan onicha' while that of improved variety of *Z. mays* is the 'Downy mildew early streak resistance-white' (DMESR-W).

Recent studies in the zone have shown a high potential and suitability of the use of *D. rotundata* as minisetts in rapid seed yam multiplication (Kalu and Ortese, 1993; Ijoyah and Kalu, 2003b). Over 50% of the yams and 75% of the maize grown in Nigeria are produced under intercropping systems (Okigbo and Greenland, 1996). Intercropping has been associated with such advantages

as better utilization of environmental factors, greater yield of food supply, increasing the return per unit area and insurance against crop failure (Beets, 1982). Unamma (1999) in his studies on yields obtained from crops under intercropping reported that maize depressed the yield of yam by about 28% in a yam-maize mixture even though the maize population used was only 50% of the optimum for sole maize. Similarly, Madu and Nwosu (2001) reported that maize yield in a yam and maize intercrop was 26 % more than in sole maize at equivalent population density. Although, the minisetts technique has been developed for the rapid production of seed yam, farmers preferred its use for the simultaneous production of 'seed' and 'ware' yams (Kalu, 1989). Ijoyah (2010) reported that a larger proportion of ware yams (801 to 1000 g) could be produced from cut minisetts (25 to 30 g). Maize has been intercropped with 'ware' yams and other similar tuber crops, however, there is dearth of information on its intercropping with seed yams using the minisetts technique. The purpose of this study, therefore,

Table 1. Meteorological information for Makurdi (May – October) 2003, 2004.

Months	Average monthly rainfall (mm)	Average monthly temperature (°C)		Mean daily radiation (Cal cm ⁻² day ⁻¹)	Average relative humidity (%)
		Max.	Min.		
2003					
May	135.2(8) ⁺	28.8	24.1	175.0	72.4
June	241.0(11)	29.5	23.4	170.2	73.6
July	204.8(11)	30.3	22.6	176.1	73.2
August	243.0(16)	30.0	23.0	160.5	73.8
September	287.3(18)	29.8	22.8	166.0	71.3
October	98.7(9)	30.4	22.4	164.0	73.6
2004					
May	98.0(11) ⁺	30.0	23.6	172.1	74.8
June	161.5(11)	30.3	23.0	174.4	74.0
July	204.8(11)	30.2	22.7	168.2	74.8
August	243.0(16)	30.3	23.1	165.0	74.4
September	287.3(18)	30.4	21.2	169.0	73.8
October	98.7(9)	30.4	23.3	164.1	72.4

⁺Values in parenthesis indicate number of rainy days. Source: Air force base, Makurdi meteorological station.

was to determine the yield effects of intercropping white Guinea yam used as minisett in the production of seed yams in mixture with maize and to assess the advantages and suitability of the intercropping system.

MATERIALS AND METHODS

Site description

This study was carried out at the Research Farm, University of Agriculture, Makurdi, Nigeria during the planting seasons of 2003 and 2004 to determine the suitability of white Guinea yam (minisett) for intercropping with maize. The study location (7°44'N, 8°35'E) and at an altitude of 228 m above sea level, falls within the southern Guinea savanna agroecological zone of Nigeria. The meteorological information of the area over the trial period is provided in Table 1. The average monthly temperature over the years ranged from 21.2 to 30.4°C, while the average relative humidity ranged from 71.3 to 74.8%. Mean daily radiation was low throughout the growth period while the month of September recorded the highest amount of rainfall and highest number of rainy days.

Treatments and experimental design

The field was ploughed, harrowed, ridged and divided into twelve treatment plots, each measuring 10 x 10 m. Each plot consisted of 10 ridges spaced 1 m apart. The three cropping systems (sole yam-minisett, sole maize and the intercrop of yam-minisett and maize) constituted the treatments. The treatments were arranged in a randomized complete block design (RCBD) with four replications.

In the sole maize plot, seeds were planted in mid-May in each year, on top of ridges, at a depth of about 2 cm using 25 cm intra-row spacing. Two maize seeds were sown per hole and later thinned to one plant per stand at 3 weeks after planting (WAP)

giving a plant population density of 400 maize stands per plot (40,000 plants per hectare equivalent). In the sole yam-minisett plot, minisett were planted at a depth of about 6 cm, on top of ridges, using 25 cm intra-row spacing, giving a plant population density of 400 yam-minisett stands per plot (40,000 plants per hectare equivalent). The third treatment consisted of the intercrop of yam-minisett and maize at equal population densities. Maize was planted in between the stands of yam-minisett, on top of the ridges. Both yam-minisett and maize were planted at same time in mid-May as soles and in intercrop.

The local variety of white yam used as minisett was 'Dan onicha', while the improved variety of maize used was 'Downy mildew early streak resistant-white' (DMESR-W). Both varieties of crops are popularly grown by farmers and showed good adaptation to the local environment (Kalu and Erhabor, 1992; Ijoyah and Kalu, 2003a).

Intact tubers weighing about 400 g, free from bruises and rotting were selected. Minisett weighing about 25 g each were cut from the tubers according to the procedure described by Okoli et al. (1982). Yam-minisett and maize were treated with 'Apron plus' (a.i. carboxin/furathiocarb) powder to prevent fungal infection after planting according to the method described by Ijoyah and Kalu (2003a). The cut surfaces of treated minisett were air dried to allow for curing three days before planting (Unamma, 1999).

Cultural practices

The plots were manually weeded four times using the native hoe at 4 week intervals, starting from the date of planting. The recommended rates of compound fertilizer (NPK) for sole maize: 100, 40 and 60 KgK/ha; for sole yam-minisett: 50, 20 and 40 KgK/ha and for the intercrop of yam-minisett and maize: 120, 120 and 120 KgK/ha were applied as described by Ekpete (2000), using the row method of application. The fertilizer was applied twice to each plot at 3 and 9 WAP.

Harvesting of maize was done in late August while that of the yam-minisett tubers was done in mid-November in each year, when

Table 2. Effect of intercropping yam-miniset and maize on establishment count, days to 50% establishment, leaf area (120 DAP), frequency of tuber twining, number of tubers per plot and tuber yield of yam-miniset in 2003 and 2004 planting seasons.

Cropping system	Establishment count		Days to 50 % establishment		Leaf area index (120 DAP)		Frequency of tuber twining		Number of tubers per plot		Yield (t/ha)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Sole	371.2	380.4	45.1	47.3	4.27	4.13	1.44	1.50	415.2	420.4	1.47	1.35
Intercrop	363.6	371.2	43.2	45.2	3.10	3.02	1.17	1.06	390.4	398.4	1.25	1.13
Means	367.4	375.8	44.2	46.3	3.69	3.58	1.31	1.28	402.8	409.4	1.36	1.24
LSD (P = 0.05)	ns	ns	ns	ns	0.5	0.7	ns	ns	3.2	4.6	0.1	0.1
Cv(%)	12.0	10.6	18.1	12.3	7.6	9.8	10.0	18.0	6.3	10.4	8.5	6.2

DAP: Days after planting.

large portion of the leaves were observed dried and falling off which are signs of senescence. Weight of cobs were taken in kg/ha and converted to t/ha. The yam-miniset plots were harvested manually. Each harvested tuber was cleaned of soil and weighed immediately. Yield of maize and yam-miniset were taken from a net plot of 15 m².

Data collection

Data taken for yam-miniset included establishment count (the presence of two expanded leaves on a vine was used as an indication of stand establishment, (Kalu, 1989). Days to 50% establishment and leaf area index at 120 days after planting (DAP) were determined. The leaf area index was determined using the graphical method of squares as described by Wuhua (1985). Other data taken for yam-miniset include frequency of tuber twining, number of tubers per plot and tuber yield (t/ha). Data taken for maize include maize plant height (cm) at flowering. The plant height (measured as the distance from the soil surface to the collar of the top most leaf) was obtained from a sample of 10 plants per plot. Days to 50% silking and number of cobs per plot were also taken. Cob length (cm) and cob diameter (cm) were determined using a measuring tape. The diameters at the head centre and tail ends of the cobs were measured and averaged. The cobs were weighed using an electronic weighing balance to obtain cob weight (g). The cobs were later shelled manually, while the total grains for each plot weighed to obtain the yield (t/ha). Thereafter, 1000 grains were taken from the whole bulk of grains and weighed to obtain weight of 1000 grains (g).

Statistical analysis

The data were subjected to analysis of variance (ANOVA), while the Least Significant Difference (LSD) was used to separate treatment means where F values were significant (Steel and Torrie, 1980). The total intercrop yield and land equivalent ratio (LER) were determined as described by Trenbath (1984) using the formula:

$$LER = Y_{ij} + Y_{ji} / Y_{ii} + Y_{jj}$$

Where Y_{ij} and Y_{ji} are yields of crops i and j intercropped with j and i respectively. Y_{ii} and Y_{jj} are yields of the sole crops.

The competitive ratio (CR) as described by Willey and Rao (1980) is determined using the formula:

$$CR = L_y / L_m \cdot Z_y / Z_m$$

Where: L_y : Partial LER for yam-miniset, L_m : Partial LER for maize.

Z_y and Z_m are the sown proportion of yam-miniset and maize respectively. The percentage land saved as described by Willey (1985) was calculated using the formula:

$$\% \text{ Land saved} = 100 - 1/LER \times 100.$$

The intercropping data were used to determine the productivity of the intercropping system and to assess the suitability of the crops for intercropping.

RESULTS AND DISCUSSION

The temperature range of 21.2 to 30.4°C and the relative humidity range of 71.3 to 74.8% recorded from May to October for both years (Table 1) were considered optimal for the growth and development of the component crops. This view supports Okoli (2000) who reported that temperature range of 20 to 30°C with relative humidity of 70 to 75% are ideal for optimal growth and development of yam and maize.

Establishment count and days to 50% establishment of yam-minisets were not significantly affected by intercropping (Table 2). However, leaf area index of yam-minisets at 120 DAP was significantly ($P \leq 0.05$) greater when planted as sole than as intercrop with maize. This might be due to the competitive effect for growth resources such as light when both crops are in mixture. Maize could have exhibited a shading effect over yam-minisets, thus, promoting a reduction in the leaf area of yam-minisets.

Although the frequency of tuber twining was not significantly affected by the cropping system, however, number of tubers produced from the intercropped yam-minisets was lower than that obtained from yam-minisets planted sole. The competition for growth resources might have been responsible for the reduction in the number of tubers produced under intercropping. Madu and Nwosu (2001), reported that yams planted sole, generally have greater efficiency in utilizing the growth environment, thus, promoting a greater number of tubers compared to those in intercrop.

Table 3. Effect of intercropping yam-minisetts and maize on maize plant height at flowering, days to 50% silking, number of cobs per plot, cob length, cob diameter, cob weight, weight of 1000 grains and yield in 2003 and 2004 planting seasons.

Cropping system	Maize plant height at flowering (cm)		Days to 50% silking		Number of cobs per plot		Cob length (cm)		Cob diameter (cm)		Cob weight (g)		Weight of 1000 grains (g)		Maize yield (t/ha)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Sole	137.7	190.5	56.1	56.7	345.0	350.6	25.9	26.1	15.2	15.5	229.4	249.5	271.5	331.5	4.30	5.30
Intercrop	141.5	200.5	55.2	55.7	338.0	342.3	24.9	25.2	15.3	15.3	234.1	254.4	279.0	339.5	4.87	5.89
Means	139.6	195.5	55.7	56.2	341.5	346.5	25.4	25.7	15.3	15.4	231.8	252.0	275.3	335.5	4.59	5.60
LSD(P = 0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Cv (%)	14.3	5.6	7.8	6.3	13.2	18.3	8.5	10.3	14.3	11.0	6.5	7.8	9.5	10.2	7.4	5.2

Table 4. Yields of yam-minisetts and maize, total intercrop yield, land equivalent ratio, competitive ratio and percentage land saved from intercropping yam – minisetts and maize in 2003 and 2004 planting seasons.

Cropping system	Yam-minisetts yield (t/ha)		Maize yield (t/ha)		Total intercrop yield (t/ha)		LER		CR		% Land saved	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Sole yam-minisetts	1.47	1.35	-	-	-	-	-	-	-	-	-	-
Sole maize	-	-	4.30	5.30	-	-	-	-	-	-	-	-
Intercrop	1.25	1.13	4.87	5.89	6.12	7.02	1.98	1.95	0.75(3/4) ^a	0.76(3/4) ^a	49.5	48.7

Total intercrop yield: summation of intercrop yields of component crops in mixture; LER: land equivalent ratio = Intercrop yield of crop (A) / sole crop yield of crop (A) } Ly + Intercrop yield of crop (B) / sole crop yield of crop (B)}Lm; CR: competitive ratio = Ly / Lm (Division of the partial land equivalent ratios of the component crops in mixture); ^a: fraction of CR of yam-minisetts to maize; % land saved = 100 - 1 / LER x 100

Intercropping significantly ($P \leq 0.05$) depressed the tuber yield of yam-minisetts by 15.0 and 16.3% respectively, in 2003 and 2004 compared to when yam-minisetts were planted sole (Table 2). The competition for growth resources and shading by maize plant could be contributory factors. The larger leaf area obtained from yam-minisetts planted sole might have accounted for its proportional greater yield.

Maize plant height at flowering, days to 50% silking, number of cobs per plot, cob length, cob diameter, cob weight, weight of 1000 grains and maize yield were not significantly affected by

intercropping (Table 3) but maize yield in a yam-minisetts and maize intercrop was greater by 11.7 and 10.0% respectively, in 2003 and 2004 compared to the yield obtained from sole maize at equivalent population density. This view agreed with Okigbo (1980) who reported that maize yield in maize-cassava intercrop was 26% more than in sole maize at equivalent population density. The greater maize yield obtained under intercropping with yam-minisetts could be attributed to a reduction in soil water temperature, greater soil moisture conservation and reduction in nutrient loss.

The total intercrop yield was greater than the component crop yield, planted as sole or in mixture (Table 4). Intercropping yam-minisetts and maize gave LER values of 1.98 and 1.95, respectively, in the year 2003 and 2004, indicating that higher productivity per unit area was achieved by growing the two crops together than by growing them separately (Table 4). With these LER values, 49.5 and 48.7% of land was saved respectively, in 2003 and 2004 and which could be used for other agricultural purposes.

Maize was about three-quarters as competitive as yam-minisetts. The competitive pressure of the

component crops was low, thus, indicating that both crops are complementary and suitable in mixture.

Conclusion

From the results obtained, it can be concluded that it is advantageous to intercrop white Guinea yam as minisetts with maize. This is associated with a greater total intercrop yield, higher land equivalent ratio greater than 1.0, indicating a greater productivity per unit area. In addition, a greater percentage of land was saved that can be used for other agricultural purposes. The competitive pressure between the component crops was low, indicating that both crops are complementary and suitable in mixture. It is however, recommended that further investigation be evaluated across a wider combination of white Guinea yam and maize varieties and across different locations within the southern Guinea savanna ecological zone of Nigeria.

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