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Performance of pigeon pea genotypes intercropped with maize under humid tropical ultisol conditions

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Key words
Genotypes, intercropping, performance, pigeonpea, maize.

1 SUMMARY

Five improved pigeonpea genotypes from ICRISAT (ICPL 87, ICPL 85063, ICP 7120, ICPL 161, ICPL 87119) and one Nsukka Local genotype fiofio" were assessed in a mixture with two maize genotypes (hybrid and open pollinated maize genotype) at Nsukka, Nigeria, over two years. The experiment was a factorial, laid out in a Randomized Complete Block Design (RCBD) with three replications. The result showed that intercropping significantly ($P<0.01$) reduced the dry matter fractions of the leaf, stem and root (g/plant) of pigeonpea and the grain yield (kg/ha) significantly ($p<0.05$) compared with the sole crop system. Hybrid maize depressed pigeonpea yield more compared to the open pollinated maize. The ICRISAT pigeonpea genotypes generally gave significantly ($P<0.05$) higher grain yield than the local genotype whether in the intercrop or sole crop system. Intercropping had less yield depressing effect on maize than on pigeonpea in respect of their dry matter fractions and grain yields. Intercrop grain yields (kg/ha) for maize were close to their sole crop yields. Land equivalent ratio values greater than one (≥1.0) was obtained in all intercrop combinations implying greater land productivity of the intercropping system. Pigeonpea/maize mixtures gave significantly ($p<0.01$) higher total income per unit land area compared to sole pigeonpea systems The improved ICRISAT pigeonpea genotypes gave greater income in both mixtures and sole systems compared to the local pigeonpea genotype and are recommended for adoption by farmers in maize additive series intercropping system at 1:1 pigeonpea to maize plant population ratio.

2 INTRODUCTION

The advantage of intercropping over sole cropping has been reported by several authors (Jodha, 1979; Fukai, 1993; Iken &Amusa, 2004; Ullah *et al.,* 2007). According to

Mutsears *et al.,* (1983), intercropping is a time-honoured practice in the humid tropics with three potential advantages of better use of physical resources (solar radiation, mineral nutrients and water), higher labour productivity and reduced risk as compared with sole cropping. According to Ullah *et al.*, (2007) intercropping is one of the preferred ways to increase productivity and intensify land use, and also reduce the amount of herbicides and fertilizers applied.

Pigeonpea (*Cajanus cajan* (L) Millsp) is an important multipurpose pulse legume in the tropics and subtropics. It is grown for its wide range of products. The seed, pod, and the leaf are used for human and livestock nutrition and the crop generally enhances soil fertility through leaf litter and biological nitrogen fixation (Snapp *et al.,* 2003). It is cultivated in more than 25 tropical and sub-tropical countries either as sole crop or intermixed with some cereals and other legumes (Reddy *et al.,* 1993). Rainfall is a limitation to pigeonpea production in semi-arid regions where it is mostly produced (Guy *et al.,* 2001). Insect pests such as pod borer- *Heliothis zea*, pod fly- *Melanagromyza obtuse*, bugs *Clarigralla* spp. and Bruchids are also a major constraint on yield in most areas. The Bruchids (*Callosobruchus* spp.) attack the crop in the fields and then build up in stored pods or seeds.

Whiteman *et al.,* (1985) reported that pigeonpea has a long history of production in intercropping systems practiced by traditional farmers and that it is characterized by low yields due to the use of low yielding long-duration cultivars. In Nigeria, Tabo *et al.,* (1995) reported that sorghum, maize, cassava, bambara nuts, melons and castor serve as pigeonpea intercrops. They reported low yields in farmers fields due to use of low yielding long-duration local varieties which has made farmers to desire and seek for improved varieties.

Maize (*Zea mays* (L.) is an important cereal crop grown in most tropical African countries for human consumption, for livestock feed and for industrial purposes. Farmers mostly grow the open pollinated maize but hybrid maize genotypes are also becoming popular. In many tropical countries like Nigeria, maize is often planted in intercropping systems (Alabi & Esobhawan, 2006).

Rao and Willey (1980) indicated that pigeonpea combined well with early maturing cereals and legumes to give yield advantages as measured by the Land Equivalent Ratio (LER) under Indian conditions. Release of improved pigeonpea genotypes by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) offers an opportunity for the crop under the traditional mixed cropping system. This study was carried out to assess the intercrop productivity of five ICRISAT short- and medium-duration pigeonpea genotypes and one long-duration local pigeonpea grown in mixtures with two maize genotypes (hybrid and open pollinated). The result would provide data that form the basis for the initiative to introduce the new shorter duration ICRISAT genotypes into the mixed cropping system of many tropical African countries where the long duration genotypes are commonly grown.

3 MATERIALS AND METHODS

3.1 Study site: The experiment was conducted at the Teaching and Research Farm of the Department of Crop Science, University of Nigeria Nsukka, during the 2005 and 2006 cropping seasons. Nsukka is located in a humid tropical area at latitude 6°52/N and longitude 7°24/E, and altitude of 447m above sea level in the derived savannah belt of Nigeria. The soil has been classified as an ultisol (Asiegbu, 1989).

3.2 Experiment layout: Treatments comprised five short- and medium-duration pigeonpea genotypes from ICRISAT and one local (Nsukka) long-duration genotype. The ICRISAT genotypes were: ICPL 87 and ICPL 161 (short-duration), ICPL 85063, ICP 7120, and ICPL 87119 (medium- duration). The maize genotypes were Oba Super II (hybrid maize) and 'New Kaduna' (open pollinated maize). The six pigeonpea genotypes were combined with the two maize genotypes in intercrop arrangements, and with the sole crop of each genotype. The treatments were laid out in a factorial experiment in Randomized Complete Block Design (RCBD), and there were three replications.

During each year, soil samples at 0 - 30cm depth were taken with an auger at random from representative locations of the field and bulked together and subsampled for physical and chemical characterization of the site. The experimental site was ploughed, harrowed and ridged at 1.0m apart in each of the two cropping seasons of 2005 and 2006. Each of the three blocks had 20 plots each measuring 5.0m x 3.0m. The treatments were randomly assigned to the treatment plots in each block.

Pigeonpea was planted on either side of the 1-metre ridge at a spacing of 0.5m x 0.5m or 60 plants/plot to obtain a calculated population of 40, 000 plants per hectare. Maize was planted at the crest of the ridge at a spacing of 1m x 0.25m giving 12 plants/ridge or 60 plants/plot representing 40,000 plants/ha. The same plant population was used under both intercrop and sole crop treatments in additive series of intercropping.

Both pigeonpea and maize were planted at the same time in the third week of July in each of the two cropping seasons. Two seeds were planted per stand and later thinned to one plant/stand three weeks after planting. Weeding was done twice at 21 and 45 days after planting (DAP) by hoeing. Fertilizer was applied by band method at the rate of 120kg N, 60 kg P and 80 kg K per hectare. Insect pests of pigeonpea were controlled by spraying with "BEST ACTION" (Cypermethrin plus Dimathoate) at the rate of 1.5Litres/ha at 50% flowering and at podding.

3.3 Sampling and data recording: Two pigeonpea plants were sampled from the inner ridges in each plot at the flowering stage and carefully cleaned and separated into stem, leaf and root fractions. The fractions were oven dried at 70°C to constant weight and the dry matter yield recorded. Dry pods were harvested from five sampled plants of the central ridges of each plot for yield assessments. Two maize plants from the inner ridges in each plot were destructively harvested at tasselling stage and separated into leaf, stem and inflorescence fractions, and oven dried at 70°C to constant weight. Maize cobs were hand harvested at maturity from five plants in the inner ridges for yield assessment.

3.4 Data analysis: The data were analysed using GENSTAT (3) Discovery edition package as appropriate for a factorial experiment in randomized complete block design (RCBD). Detection of differences among treatment means for significant effect was done by use of the standard error of the difference between two means. The intercropping efficiency was assessed using the Land Equivalent Ratio (LER) according to Mead and Willey (1980) using the formula:

$$\text{LER} = \frac{YA}{SA} + \frac{YB}{SB}$$

Where;

YA and YB = individual crop yields in intercropping and

SA and SB = the crop yields as sole crops.

LER>1 indicates intercrop advantage.

Monetary Index (MI) was also used to assess the intercropping efficiency. It was obtained by multiplying the unit market price of a commodity with its yield per hectare. The total cash value per hectare from the mixtures were obtained by summing up the monetary values from the yields of the component crops. They were then compared with the cash value per hectare of the sole pigeonpea crop yields. The local market price of pigeonpea and maize per kg in 2007 were ₦55 and ₦45 (Nigerian naira) which are equivalent to 0.44 and 0.36 USD respectively. The Nigerian naira values were used to obtain the calculated cash values.

4 RESULTS

In both 2005 and 2006, rain fell fairly frequently between May and October with two modal peaks in June and October (Table 1). The average maximum air temperature was high with between 30°C and 34.5°C in the months of January to November with slight depression during the frequent raindays of June, July, August and September. Average minimum air temperature was fairly low in July, August, November and December, but were never lower than 18°C. Relative humidity was not less than 70% in the rainy months of May to November. The soil of the experimental site in both years was a sandy clay loam with acidic reaction. It was considered low in organic matter, nitrogen and exchangeable bases (Table 2).

Intercropping significantly (P<0.01) depressed pigeonpea leaf dry matter in both 2005 and 2006 cropping seasons (Table 3). Hybrid maize intercrop significantly depressed pigeonpea leaf dry matter yield compared to the open pollinated maize intercrop in both 2005 and 2006 cropping seasons. The pigeonpea genotypes differed randomly in leaf dry matter yield during the 2005 and 2006 seasons of production with no genotype exhibiting consistent superiority. There was no significant cropping system × pigeonpea genotype interaction in 2005 but there was a significant ($P<0.05$) effect in 2006.

Table 1: Metereological data for 2005 and 2006 at Nsukka, Nigeria.

2005 records	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec**
Rainfall (mm)	0	70.1	14.9	14.0	142.5	323.8	246.2	125.4	208.0	304.2	10.1	1.2
Rain days(No.)	0	2	2	10	11	18	20	17	19	16	1	1
Max. Air temp.(°C)	31.6	35.2	34.4	33.6	30.6	29.4	28.3	27.3	28.7	30.1	32.4	22.4
Min. Air temp.(°C)	25.2	22.8	23.3	23.1	22.2	21.8	20.9	20.3	21.5	21.1	21.3	20.7
RH (%)	57.5	64.3	67.1	69.2	73.9	74.8	76.9	76.9	76.9	73.8	66.2	63.1
2006 records												
Rainfall (mm)	36.3	4.0	103.1	51.0	243.8	259.6	213.8	195.5	190.5	313.9	1.5	0
Rain days	1	2	4	5	16	16	21	19	25	19	1	0
Max. Air temp.(°C)	33.1	33.6	33.1	35.5	30.5	29.9	28.6	27.8	28.7	29.9	31.7	32.6
Min. Air temp.(°C)	23.0	23.2	22.8	23.3	21.3	21.2	21.5	20.8	21.3	21.2	18.9	17.9
RH (%)	66.5	67.8	67.6	68.2	74.4	74.9	76.8	77.4	76.7	74.8	60.8	50.0

RH = relative humidity

Table 2: Physical and chemical characteristics of the soil at the experimental sites at Nsukka, Nigeria before planting.

Mechanical properties:	**2005**	**2006**
Clay (%)	19.76	21.04
Silt (%)	9.28	10.56
Fine sand (%)	46.56	50.04
Textural class	Sandy clay loam	Sandy clay loam
Chemical properties:		
pH in H20	5.2	5.1
pH in KCL	4.5	4.9
Organic matter:		
Carbon (%)	0.93	0.63
Nitrogen (%)	0.070	0.068

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Table 3: Intercropping effects of two maize genotypes on dry matter (g/plant) of leaves, stem and roots of six pigeonpea genotypes.

Pigeonpea Genotypes	Cropping System 2005: P/pea + HM	P/pea + OPM	Sole P/pea	Mean	Cropping System 2006: P/pea + HM	P/pea + OPM	Sole + P/pea	Mean
Leaf								
ICPL 87	28.5	29.3	40.6	32.8	20.3	23.1	27.2	26.9
ICPL85063	19.2	22.7	35.3	25.7	21.1	28.5	46.3	32.0
ICP 7120	27.2	30.3	44.4	33.9	21.5	25.2	25.2	24.0
ICPL 161	26.1	23.7	30.9	26.9	26.4	22.9	34.2	27.8
ICPL87119	18.8	21.6	29.5	23.3	18.5	21.4	33.8	24.6
Nsukkalocal	23.0	31.9	37.3	30.7	28.3	32.2	40.1	33.5
Mean	23.8	26.6	36.3	28.9	22.6	25.6	36.1	28.1
Stem								
ICPL 87	35.8	36.0	45.7	39.2	30.8	31.8	49.1	37.2
ICPL85063	27.0	29.8	41.8	32.8	23.8	32.9	65.6	40.8
ICP 7120	34.1	34.2	50.9	39.7	33.7	25.4	34.5	31.2
ICPL 161	32.9	30.1	40.0	34.3	38.0	24.7	39.7	34.1
ICPL87119	25.7	27.7	37.7	30.4	23.7	27.3	51.0	34.0
Nsukkalocal	27.2	37.8	47.8	36.3	34.0	49.9	49.0	44.3
Mean	30.4	32.6	43.3	35.5	30.7	32.0	48.0	36.9
Root								
ICPL 87	11.7	10.7	17.1	13.2	8.1	8.1	14.0	10.1
ICPL85063	9.8	10.1	11.5	10.5	6.3	8.2	16.8	10.4
ICP 7120	11.3	10.0	14.5	11.9	7.1	7.9	10.1	8.4
ICPL 161	11.7	10.9	13.7	12.9	8.6	10.8	12.9	10.8
ICPL87119	10.0	9.2	13.0	10.7	7.1	7.1	12.5	8.9
Nsukkalocal	10.9	12.0	14.5	12.7	8.2	11.1	13.1	10.8
Mean	10.9	10.5	14.0	11.8	7.6	8.9	13.2	9.9

	Leaf 2005	Leaf 2006	Stem 2005	Stem 2006	Root 2005	Root 2006
Sed between 2 cropping system means	2.110	1.540	1.891	2.77	0.757	0.966
Sed betwn.2 pigeonpea genotypes means	2.981	2.177	2.674	3.91	1.071	1.366
Sed for crop. Sys.× genotype interaction.	5.167	3.771	4.632	6.79	1.854	2.366

HM= Hybrid maize (Oba super 2)
OPM= Open pollinated maize (New kaduna)
P/pea= Pigeonpea

Intercropping also significantly ($p<0.01$) depressed pigeonpea stem dry matter yield compared to sole crop system in both 2005 and 2006 seasons. Pigeonpea genotypes intercropped with open pollinated maize had significantly ($P<0.01$) higher dry matter stem yield compared to those intercropped with hybrid maize. A similar trend was obtained in 2006 with the difference being not significant. The pigeonpea genotypes differed at random with no genotype exhibiting superiority during the 2005 and 2006 production seasons. For stem dry matter there was no significant ($P<0.05$) cropping system × pigeonpea genotype interaction in 2005 season but there was a significant ($P<0.01$) difference in 2006 season.

Intercropping significantly ($P<0.01$) reduced root dry matter yield of the pigeonpea genotypes compared to the sole crop system in both

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2005 and 2006 seasons. Hybrid maize intercrop reduced pigeonpea root dry matter yield more (but not significantly) than the open pollinated maize intercrop.

Maize genotypes did not differ significantly ($P<0.05$) in leaf dry matter yield (g/p) in 2005. However in 2006, the open pollinated maize genotype had significantly ($p<0.01$) higher leaf dry matter yield compared to the hybrid maize genotype (Table 4). Intercropping with the pigeonpea genotypes did not have significant effect on leaf dry matter in both 2005 and 2006 seasons. There was no significant maize genotype × cropping system interaction for this parameter.

The maize genotypes did not differ in stem dry matter yield in both 2005 and 2006 seasons. Equally, intercropping did not significantly depress maize stem dry matter yield in 2005 but it had a significant ($P<.01$) effect in 2006 season where maize intercropped with ICP 7120 yielded significantly ($P<0.01$) higher than other pigeonpea/maize mixtures. There was no significant maize genotype × cropping system interactions in both 2005 and 2006 seasons.

In 2005 cropping season, neither maize genotype, cropping system nor maize genotype × cropping system interaction had any significant effect on maize grain yield (kg/ha)(Table 5). The intercropped maize genotypes mean grain yield was 85.5% of their sole crop mean grain yield. In 2006 however, hybrid maize yielded significantly ($P<0.05$) higher than the open pollinated maize and sole crop maize yielded significantly ($P<0.05$) higher compared to that in intercropped system. The intercropped maize genotypes mean grain yield was 72.8% of their sole crop mean grain yield.

Intercropping significantly ($P<0.01$) depressed pigeonpea grain yield (kg/ha) compared to the sole crop system (Table 6). In 2005, hybrid maize intercropping depressed pigeonpea grain by 34.2% while open pollinated maize intercropping depressed it by 27.7%. In 2006, hybrid maize intercropping depressed the grain yield in pigeonpea by 33.5% while open pollinated maize depressed it by 30.2%. The pigeonpea genotypes differed significantly ($P<0.01$) in grain yield (kg/ha) in both 2005 and 2006 cropping seasons with the Nsukka local genotype having significantly lower yield compared to the ICRISAT genotypes. ICPL 87 yielded significantly ($P<0.01$) higher than the other genotypes in 2005 while in 2006, ICPL 85063 yielded significantly ($P<0.01$) higher than the other genotypes. There was no significant cropping system × pigeonpea genotype interaction in both 2005 and 2006 seasons.

Land Equivalent Ratio (LER) values greater than 1.0 were obtained in all pigeonpea/maize mixtures under both open pollinated maize and hybrid maize mixtures in the two seasons of production (Table 7). ICPL 87 had above 1.50 LER values in mixtures with both hybrid and open pollinated maize in 2005 cropping season while ICP 7120 had above 1.60 LER values under open pollinated maize in both 2005 and 2006 cropping seasons.

Pigeonpea/maize mixtures gave significantly ($P<0.01$) higher monetary income compared to sole pigeonpea crops in both 2005 and 2006 seasons (Table 8). Although variation in total income among the pigeonpea genotype/maize mixtures was not significant ($P<0.05$) in 2005, it was significant ($P<0.01$) in 2006 with mixtures having ICPL 87 genotype giving significantly higher total income compared to those of the other genotypes. ICPL 87 mixtures had the highest mean total income in both 2005 and 2006 while Nsukka local genotype gave the least mean total income in both two years.

5 DISCUSSION

The rainfall distribution during the production period (Table 1) was adequate for both maize and pigeonpea crops. The air temperatures and relative humidity values were within the requirements of both maize and pigeonpea. The sandy textural class of the soil and its physicochemical properties (Table 2) indicated that the soil was adequate to support the crops' growth.

The significant ($P<0.01$) reduction in dry matter yields of leaves, stems and roots (g/plant) of intercropped pigeonpea compared to the sole pigeonpea was attributed to negative effect of the intercropped maize on the pigeonpea (Table 3). The maize crop was advantaged by its faster growth and compared to the slow growing and late maturing pigeonpea (Trenbath 1993). The sharing of growth resources among component crops under intercropping also limited growth and accumulation of dry matter compared to sole-cropping where such competition does not exist.

Under the intercropped system, the hybrid maize genotype (HM) significantly (P< 0.01) reduced the leaf and stem dry matter yield of pigeonpea compared to the open pollinated maize genotype (OM) in both 2005 and 2006 cropping seasons. This was attributed to the uniform growth of the hybrid maize and its upright leaf orientation which might have shaded the slow growing pigeonpea plants more at the early growth stage thereby limiting its growth. The hybrid would have also utilized the soil nutrients more efficiently as a higher nutrient feeder (Kogbe & Adediran 2003).

The insignificant effect of intercropping on maize genotypes leaf, stem and inflorescence dry matter and grain yields was attributed to the dominance of maize in the intercropping system; its early maturity thus avoiding serious competition for light, air and soil nutrients from the pigeonpea. Pigeonpea seedling growth is usually very slow for the first 30-50 days (Rachie & Silvestre, 1977).

The high mean grain yield of intercropped maize under both hybrid and open pollinated maize being 85.5% of its sole crop yield in 2005 and 72.8% of its sole crop yield in 2006, was in agreement with the findings of Egbe and Adeyemo (2006) and was attributed to the dominant nature of maize in the intercropping system (Enyi 1973). The significantly (P< 0.01) higher hybrid maize grain yield compared to that of open pollinated maize in 2006 was attributed to the hybrid vigour that is common in the hybrid maize genotypes.

The significant (P<0.0I) depressive effect of intercropping on pigeonpea grain yields was attributed to faster growth of maize leading to more shading and less nutrients being available for pigeonpea. The significant variation in grain yield among the pigeonpea genotypes in both 2005 and 2006 seasons are attributed more to genotypic effects than effects of intercropping..

In 2005, intercropped pigeonpea genotypes with hybrid maize yielded 65.8% of their sole crop counterpart while those intercropped with open pollinated maize yielded 72.3% of their sole crop counterpart. In 2006, the yield advantage again exhibited by pigeonpea intercropped with open pollinated maize (69.8% of sole crop yield) compared to those intercropped with hybrid maize with 66.5% further indicates its higher compartibility under a pigeonpea/maize intercropping system compared to hybrid maize. The significantly higher grain yields of the ICRISAT pigeonpea genotypes compared to the Nsukka local genotype was attributed to their improvement for high yields (Guy *et al.,* 2001).

The 27-34% yield reduction in intercropped pigeonpea yields in 2005 and between 30-33% in 2006 are similar to that reported by Smith *et. al.,* (2001) where 34% yield reduction was recorded in a maize/pigeonpea intercrop. This substantial performance of the intercropped pigeonpea despite the dominance by maize at the early growth stages could be attributed to the large time gap between the harvesting of maize and pigeonpea which according to Cenpukdee and Fukai (1992a) enables the late maturing pigeonpea crop to recover from any growth check from the earlier maize intercrop. It is implied too that pigeonpea nutrient demand peaks occurred much later compared to that of the maize crop thus suffering little or no competition from the maize crop at its later growth stages. This could be a reason for the high productivity of the pigeonpea/maize intercropping systems.

The land equivalent ratio (LER) values greater than 1.0 indicated intercropping advantage in all intercrop combinations (Table 7). Similar LER values greater than 1.0 in maize/pigeonpea intercropping have been reported (Patra *et. al.,* 1990, Tom, 1995, Mergaei *et. al.,* 2001 and Egbe & Adeyemo, 2006). The LER values above 1.50 for ICPL 87 mixtures with both hybrid and open pollinated maize in 2005 cropping season could be attributed to this genotype's good compatibility with maize. Similarly, the LER values above 1.60 LER for ICP 7120 with open pollinated maize in both 2005 and 2006 could also be indicative of its good compatibility with the open pollinated maize genotype.

The significantly (p<0.01) higher total income realized from pigeonpea/maize mixtures compared to sole pigeonpea (Table 8) further demonstrates the advantage of the intercropping system. The least total income in 2005 and 2006 seasons was realized from the Nsukka local genotype which demonstrates the need for its replacement in the African traditional mixed farming system. Among the ICRISAT genotypes, ICPL 87 gave the highest total income in both 2005 and 2006. This was in agreement with Egbe and Adeyemo (2006) who reported superior yield of maize associated with ICPL 87. Equally, ICPL 87 and ICP 7120

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maintained above average income values compared to the other genotypes in both 2005 and 2006 cropping seasons. The income earning superiority order for the pigeonpea genotypes was ICPL 87> ICP 7120 > ICPL 161> ICPL 86063 > ICPL 87119 > Nsukka local.

Table 4: Intercropping effect of six pigeonpea genotypes on leaves, stems and inflorescence dry matter weight (g/plant) of two maize genotypes.

Maize Genotypes	Maize + ICPL 87	Maize + ICPL 85063	Maize + ICP 7120	Maize + ICPL 161	Maize + ICPL 87119	Maize + Nsukka local	Sole Maize	Mean
				Leaf				
2005								
HM	23.6	20.8	18.9	23.9	26.5	24.6	26.7	23.6
OPM	25.0	19.1	17.6	17.5	17.0	25.1	21.0	20.3
Mean	24.3	20.0	18.2	20.7	21.8	24.8	23.8	21.9
2006								
HM	18.6	18.9	20.6	18.3	18.9	18.3	19.7	19.1
OPM	18.8	22.7	21.3	19.9	21.1	19.1	25.5	21.2
Mean	18.7	20.8	21.0	19.1	20.0	18.7	22.6	20.1
				Stem				
2005								
HM	80.7	66.5	62.1	80.0	97.6	78.4	74.5	77.0
OPM	79.6	62.9	59.5	54.7	52.7	70.6	80.3	65.0
Mean	80.2	64.7	60.8	67.2	75.2	74.2	77.2	71.4
2006								
HM	42.6	45.4	52.7	41.7	47.7	44.8	68.1	49.0
OPM	44.7	43.0	54.4	43.6	44.5	42.0	68.4	48.0
Mean	43.6	44.2	53.5	42.7	46.1	43.4	68.3	48.8
				Inflor.				
2005								
HM	2.6	2.4	2.2	2.5	2.2	2.7	2.9	2.5
OPM	2.1	2.4	2.3	2.1	2.2	3.5	2.5	2.6
Mean	2.8	2.4	2.2	2.3	2.2	3.1	2.7	2.5
2006								
HM	2.6	2.3	2.4	2.2	2.3	2.1	2.9	2.4
OPM	2.3	2.5	2.5	2.3	2.5	2.2	3.2	2.5
Mean	2.4	2.4	2.4	2.3	2.4	2.2	3.0	2.4

	Leaf		**Stem**		**Inflorescence**	
	2005	**2006**	**2005**	**2006**	**2005**	**2006**
Sed between 2 cropping system means	3.151	1.346	11.54	3.94	0.3139	0.1666
Sed between 2 maize genotypes means	1.684	0.720	6.17	2.10	0.1678	0.0891
Sed for crop system × genotype intern.	4.456	1.904	16.32	5.57	0.4439	0.2356

Table 5: Intercropping effect of two maize genotypes on the grain yield (kg/ha) of six pigeonpea genotypes.

Pigeonpea Genotypes	Pigeonpea + Hybrid maize	Pigeonpea + Open P-maize	Sole Pigeonpea	Mean
2005				
ICPL 87	1429	1459	1792	1560
ICPL 85063	749	1050	1680	1160
ICP 7120	1011	1142	1521	1225
ICPL 161	1219	1168	1617	1335
ICPL 87119	791	847	1334	990
Nsukka Local	701	809	1016	842
Mean	983	1079	1493	1185
2006				
ICPL 87	904	840	1416	1053
ICPL 85063	1035	1149	1694	1293
ICP 7120	895	1154	1405	1151
ICPL 161	850	871	1283	1001
ICPL 87119	974	847	1315	1045
Nsukka Local	714	754	957	828
Nsukka Local	895	936	1345	1059

	2005	**2006**
s.e.d between 2 crop. System means	66.4	83.6
s.e.d between 2 pigeonpea gen. means	94.0	118.2
s.e.d for crop.sys. x pigeonpea interaction	162.7	204.7

Table 6: Intercropping effects of six pigeonpea genotypes on the grain yield (kg/ha) of two maize genotypes.

Maize Genotype	Maize + ICPL 87	Maize + ICPL 85063	Maize + ICPL 7120	Maize + ICP 7120	Maize + ICPL 87119	Maize + Nsukka Local	Sole maize	Mean
2005								
Hybrid maize	2815	2784	3169	2595	3154	2807	3087	2917
Open P-maize	3141	2847	3004	2303	2713	2674	3546	2890
Mean	2978	2815	3086	2450	2938	2741	3316	2904
2006								
Hybrid maize	2890	3120	3621	2753	3156	3033	4281	3265
Open P-maize	2845	2707	3305	2753	2859	2699	3902	3010
Mean	2867	2913	3463	2752	3007	2866	4091	3137

	2005	**2006**
s.e.d between 2 cropping system means	336.6	193.6
s.e.d between 2 maize genotype means	181.0	103.5
s.e.d for crop.sys.x genotype interaction	478.8	273.8

CONCLUSION

The result of this study showed that there was more adverse effect of intercropping on the pigeonpea component than on the maize component in the pigeonpea/maize additive series intercropping system. However the greater than 1.0 land equivalent ratio (LER) values and total income exhibited the great benefit of the intercrop combinations. The ICRISAT ICPL 87 and ICP 7120 pigeonpea genotypes were considered most suitable for intercropping with maize and are therefore recommended for replacement of the local pigeonpea genotypes in use by traditional farmers.

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Table 7: Mean relative grain yield of maize and pigeonpea genotypes and land equivalent ratio (LER) values in the pigeonpea/maize intercropping system.

	2005			2006		
	Maize	Pigeonpea	LER	Maize	Pigeonpea	LER
Hybrid maize + Pigeonpea mixtures						
Sole maize	1.00	-	1.00	1.00	-	1.00
Sole pigeonpea	-	1.00	1.00	-	1.00	1.00
Hm+ICPL 87	0.75	0.79	1.54	0.67	0.66	1.33
Hm+ICPL85063	0.68	0.44	1.12	0.72	0.66	1.38
Hm+ICP 7120	0.77	0.68	1.45	0.86	0.63	1.49
Hm+ICPL 161	0.76	0.76	1.52	0.63	0.66	1.29
Hm+ICPL87119	0.80	0.59	1.39	0.73	0.74	1.47
Hm+Nsukkalocal	0.65	0.68	1.33	0.70	0.75	1.45
Open pollinated maize + Pigeonpea mixtures						
Sole maize	1.00	-	1.00	1.00	-	1.00
Sole pigeonpea	-	1.00	1.00	-	1.00	1.00
Om+ICPL 87	0.83	0.81	1.64	0.74	0.64	1.38
Om+ICPL 85063	0.82	0.61	1.43	0.69	0.72	1.41
Om+ICP 7120	0.85	0.76	1.64	0.83	0.82	1.66
Om+ICPL 161	0.75	0.74	1.49	0.71	0.68	1.39
Om+ICPL 87119	0.81	0.65	1.46	0.73	0.64	1.37
Om+Nsukkalocal	0.61	0.78	1.39	0.69	0.80	1.49

Table 8: Total income (□/ha) of pigeonpea/maize mixtures and pigeonpea sole crop systems.

Pigeonpea Genotypes	**Cropping System** Hybrid maize + Pigeonpea Income	Open P-maize + Pigeonpea Income	Sole Pigeonpea Income	Mean Income
2005				
ICPL 87	207951	208843	98582	172392
ICPL 85063	160589	185774	92376	146246
ICP 7120	189032	204665	83644	159114
ICPL 161	197397	197781	88917	155365
ICPL 87119	182223	177385	73385	144331
Nsukka local	153281	143205	55917	117468
Mean	182046	183276	82137	149153
2006				
ICPL 87	208649	206573	98582	171268
ICPL 85063	181591	179519	92376	151162
ICP 7120	220544	150840	83644	151162
ICPL 161	190941	165129	88917	148329
ICPL 87119	185492	175207	73385	144694
Nsukka local	175029	165917	55950	132299
Mean	193708	173864	82142	149905

	2005	**2006**
Sed between 2 pigeonpea genotype income means	11257.3	15022.0
Sed between 2 cropping systems income means	7960.1	7511.0
Sed for pigeonpea genotype x cropping sys. Interaction	19498.3	18398.1

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