Tropical Agricultural Research & Extension 9, 2006

Potential of intercropping soybeans (*Glycine max* (L.) Merrill) and cowpea (*Vigna unguiculata* L. Walp) with sunflower (*Helianthus annuus* L.) in the transition zone of south west Nigeria

*V.I.O Olowe[1,], J.A. Ajayi[2] and A.S. Ogunbayo[2]
[1] Research and Development Centre (RESDEC), University of Agriculture, P.M.B 2240, Abeokuta, Ogun State, Nigeria
[2] Department of Plant Physiology and Production, University of Agriculture, P.M.B 2240, Abeokuta, Ogun State, Nigeria

Accepted 20th April, 2006

ABSTRACT

Field trials were conducted at the Teaching and Research Farm of University of Agriculture, Abeokuta (7° 15´ N, 3° 25´ E, altitude 144 m above sea level) located in the forest – savanna transition zone of south west Nigeria, to assess the agronomic and economic potentials of intercropping soybeans and cowpea with sunflower at three growth stages (simultaneously (SS) at planting, tenth true leaf stage, V10 and eighteenth true leaf stage, V18) in 2002 and 2003. Land use advantage in terms of land equivalent ratio (LER>1.00) ranged between 1.04 – 1.40 in 2002 and 1.05 – 1.24 in 2003 for the intercropping systems, whilst marginal intercrop compatibility in terms of land equivalent coefficient (LEC>0.25) ranged between 0.29 – 0.48 for sunflower/soybeans SS, at V10 and V18 in 2002 and sunflower/cowpea SS in 2003. These identified agronomic advantages did not guarantee substantial economic efficiency in terms of monetary equivalent ratio (MER>1.00) for some of the intercropping systems with LER>1.00 and LEC>0.25. Sunflower/cowpea SS in 2002 and sunflower/soybean V10 in 2003 recorded small monetary advantage over the most productive sole crop with MER=1.12 and 1.04 and sunflower yield equivalent (1349.2 and 1421.6 kg ha^{-1}), respectively.

Keywords: intercropping, land equivalent ratio, land equivalent coefficient, monetary equivalent ratio, potential.

INTRODUCTION

Intercropping has been a common practice in the tropics and it is often the general assumption that intercropping combinations should result in increased total production per unit area relative to the sole crop. However, Fukai and Trenbath (1993) in a review concluded that results from intercropping studies vary from one season to another even within specific locations. Hence there is a need to develop productive and sustainable intercropping systems with compatible component crops for specific locations. Sunflower (*Helianthus annuus* L.) has been recog-

* Corresponding author

nized as one of the potential substitutes for the traditional vegetable oil sources (oil palm and groundnut) in the tropics (Ogunremi, 2000). The crop is second only to soybeans as a source of vegetable oil in the world. The agro-climatic potential of the forest and derived savanna ecologies for sunflower cultivation under sole and intercropping have been confirmed (Ogunremi, 1984 and 1986; Adetunji and Amanze, 2001; Agele *et al.* 2002, Olowe *et al.* 2003). Information on the agronomy of sunflower in the forest – savanna transition zone is very limited, despite the suitability of this region for other savanna crops like sorghum, soybeans, sesame and cowpea (Bello, 1999; Okeleye and Ariyo, 2000 and Olowe *et al*., 2003). Sunflower, soybeans, cowpea and most edible grain legumes are usually recommended for planting during the late cropping season because they require dry weather for harvesting and post-harvest handling in order to obtain good quality seeds.

At present sunflower is predominantly planted as a sole crop and rarely as an intercrop in tropical Africa, despite some of its favourable morphological characteristics (erect growth habit, easily harvestable head, comparable resistance to lodging and limited ground cover) which qualify it as an excellent intercrop (Robinson, 1984). Cowpea is predominantly planted as an intercrop in the West African region and its actual farm yields are lower (25 – 100 kg ha^{-1}) than yields (300 – 500 kg ha^{-1}) reported by International Institute of Tropical Agriculture (IITA) research station in Kano state, Nigeria (with no insecticide protection) leading to severe insect attack (Rachie, 1985). Soybean has been successfully intercropped with corn in the forest savanna transition zone (Olowe *et al*., 2003). Studies have been reported on intercropping sunflower with different types of legumes (Zekeng, 1980; Robinson, 1984, Shivaramu and Shivashankar, 1992 and Kandel *et al*., 1997) and more recently in Nigeria with cassava and maize (Fagbayide, 2000; Adetunji and Amanze, 2001 and Olanite *et al*., 2002). There have been no reports on the intercropping of sunflower with edible grain legumes in tropical Africa. Therefore, there is a need to generate information on the potentials of intercropping sunflower with crops of economic importance in order to be able to advice prospective farmers who might want to adopt the cropping systems in the forest – savanna transition ecology.

Several researchers have developed different concepts/indices while trying to evaluate the productivity and efficiency of different intercropping systems. Such indices include relative crowding effect, RCE (De Wit, 1960), crop equivalent factor, CEF (Donald, 1963), coefficient of agressivity, CA (Mc Gilchrist and Trenbath, 1971), land equivalent ratio, LER (Willey, 1979), competitive ratio, CR (Willey and Rao, 1980), land equivalent coefficient, LEC (Adetiloye *et al*., 1983), staple land equivalent ratio, SLER (Reddy and Chetty, 1984), area time equivalent ratio, ATER (Hiebsch and Mc Collum, 1987) and monetary equivalent ratio, MER (Adetiloye and Adekunle, 1989). These indices measure the productivity of the systems by comparing yields or monetary returns in intercropping with that of sole crop. However, each of the indices has its limitations. Hence, Hidlebrand (1976) advised that whichever concept is going to be adopted must be well understood by the farmer such that it can guide him in allocating his limited resources between competing demands. This study was therefore, carried out to evaluate the agronomic advantages using the LER and LEC and economic advantages using the MER when interseeding soybeans and cowpea into sunflower at different growth stages in the forest-savanna transition zone of Nigeria.

MATERIALS AND METHODS

Site description

The study was conducted on sandy loam soil (oxic Pauleudult) at the Teaching and Research Farm of University of Agriculture, Abeokuta (7^{o}15´ N, 3^o 25´ E, altitude 144 m above sea level) during the late rainy season (July – November) of 2002 and 2003. The farm is located in the forest – savanna transition zone of south west Nigeria. This zone has a bi-modal rainfall pattern, with peaks in July and September and a short dry spell in August often referred to as '*august break*'. Weather data during the period of experimentation are presented on Table 1. The experimental site was planted to maize prior to the study. The soil had a pH (water:soil; 1:1) of 6.4, 6.0% clay, 10% silt, 84% sand, 1.25% organic matter, 0.20% total N, 0.9 cmol (+) kg^{-1} soil exchangeable K and 4.8 mgkg^{-1} available P.

Varieties of sunflower, soybeans and cowpea

A local adapted, open pollinated and late maturing (120 days) sunflower variety called 'Funtua' was used in the study. The soybean and cowpea varieties were TGx 1448-2E and IT 90K-76, respectively. TGx 1448-2E is a late maturing (115-120 days) variety that is resistant to lodging, pod shattering and *cercospora* leaf spot disease, and good at stimulating suicidal germination of striga (*Striga hermonthica*). ITK90-76 is a brown seeded and medium maturing (100-105 days) variety that requires reduced insecticidal application.

Experimental design and treatments

The experiment was laid out in a randomized complete block design with three replications. The treatment combinations included sole crops of sunflower, soybeans and cowpea, and six intercrop combinations of sunflower/soybeans and sunflower/cowpea. The six intercrop combinations were sunflower/soybean and sunflower/cowpea sown simultaneously at planting (SS), three weeks after planting, WAP (V10 – tenth true leaf stage) and 6WAP (V18 – eighteenth true leaf stage). V10 and V18 stages were determined by counting the number of true leaves at least 4 cm in length beginning from the leaf above the cotyledons as described by Schneiter and Miller (1981).

Crop husbandry

After proper land preparation, planting of sunflower, soybeans and cowpea was done at 60 x 30 cm, 60 x 5 cm and 60 x 25 cm spacings, respectively. The seeds of the crops were planted on 5th July, 2002 and 8th August, 2003 along 5m long rows and the seedlings thinned to one plant per stand at 2WAP. No herbicides were used because the typical resource poor farmers do not often use herbicides. Weeding was done manually at 3 and 6WAP. These periods coincided with the two growth stages

(V10 and V18) at which the legumes were interseeded into sunflower. Foliar insects on the legumes , especially cowpea were controlled with three sprays of karate 2.5EC (containing 25g lambda-cyhalothin per litre) at 10 day intervals starting from 5WAP. Sunflower heads and soybeans plants were harvested manually at physiological maturity (R9 – when bracts had become yellow and brown) and harvest maturity (R9 – when about 95% of pods on a plant had turned brown) as described by Schneiter and Miller (1981) and Fehr and Caviness (1977), respectively. Picking of mature cowpea pods was done twice. Harvested pods were sun-dried and later threshed to determine grain yield.

Determination of LER, LEC and MER

LER, LEC and MER were used respectively to compare the agronomic advantage, yield stability and economic advantage, respectively. LER was determined by dividing yields for sunflower or soybeans or cowpea by their respective sole yields and the resulting ratios (relative yields) for the two crops were added to obtain the LER values (Willey, 1979). LEC was determined as a product of the relative yield for sunflower, soybeans and cowpea (Adetiloye *et al*., 1983). The MER was calculated as the sum of ratios of relative monetary returns from individual intercrop components to the highest monetary return from a sole crop from the entire land area occupied by both sunflower and legume per unit time (Adetiloye and Adekunle, 1989). MER describes the economic efficiency of a cropping system, whilst LER measures land use advantage by the intercrop over the sole. LEC, however, measures acceptable level competitive interaction confers sufficient degree of complementarity (i.e. it indicates the minimum level of reasonable contribution by the least productive intercrop component) if a yield advantage is indicated (Adetiloye *et al*., 1983).

Statistical analysis

Data were analyzed by ANOVA using the MSTATC package and means were separated by LSD at 0.05 (Steel and Torrie, 1980).

RESULTS

Weather conditions

Monthly rainfall and mean monthly temperatures for 2002, 2003 and twenty year mean (1982 – 2001) during the late cropping season are presented in Figure 1.

Sunflower

Under the wetter and cooler conditions of 2002, the grain yield of sunflower was not significantly affected by intercropping with either soybeans or cowpea (Table 1).

However, during the dry weather conditions of 2003, sunflower grain yield under sole was significantly ($P<0.05$) higher than grain yields of sunflower intercropped with soybeans SS, V18 or cowpea SS and V10. Interseeding cowpea into sunflower at V18, did not affect the grain yield of sunflower relative to the sole in both years (Tables 1 and 2). The overall yield performance of sunflower showed

Table 1. Grain yield, Land Equivalent Ratio (LER), Land Equivalent Coefficient (LEC), Monetary Equivalent Ratio (MER) and Sunflower yield equivalent of sunflower, soybeans and cowpea in sole and intercropping in 2002

Intercropping System	Mean Grain Yield (kg/ha)	LER Sunflower	LER legume	LER sole or total of intercrop	LEC	MER sunflower	MER legume	MER sole or total of intercrop	Sunflower yield equivalent (kg/ha)
Sole									
Sunflower	1212	1.00	-	1.00	-	1.00	-	1.00	1212.0
Soybeans	398	-	1.00	1.00	-	-	0.26	0.26	318.4
Cowpea	934	-	1.00	1.00	-	-	0.93	0.93	1120.8
Intercropping systems									
Sunflower + soybeans SS	753+312	0.62	0.78	1.40	0.48	0.62	0.21	0.83	1002.6
Sunflower + soybeans V10	922+227	0.76	0.57	1.33	0.43	0.76	0.15	0.91	1103.6
Sunflower + soybeans V18	1075+132	0.89	0.33	1.22	0.29	0.88	0.09	0.97	1180.6
Sunflower + cowpea SS	880+391	0.73	0.42	1.15	0.31	0.73	0.39	1.12	1349.2
Sunflower + cowpea V10	1116+111	0.92	0.12	1.04	0.11	0.92	0.11	1.03	1249.2
Sunflower + cowpea V18	1270+ 54	1.05	0.06	1.11	0.06	1.05	0.05	1.10	1334.8
SE±				0.05	0.07			0.09	104.0
LSD (0.05)				0.11	0.178			0.198	239.91

	Sunflower	Soybeans	Cowpea
Mean (kg/ha)	1032	262	373
SE-±	270.8	64.3	44.96
LSD (0.05)	624.55	204.65	143.06

Sunflower #100/kg, soybeans #80/kg, cowpea #120/kg (1US$=#134)
SS – sown simultaneously, V10 tenth true leaf stage, V18 eighteenth true leaf stage.

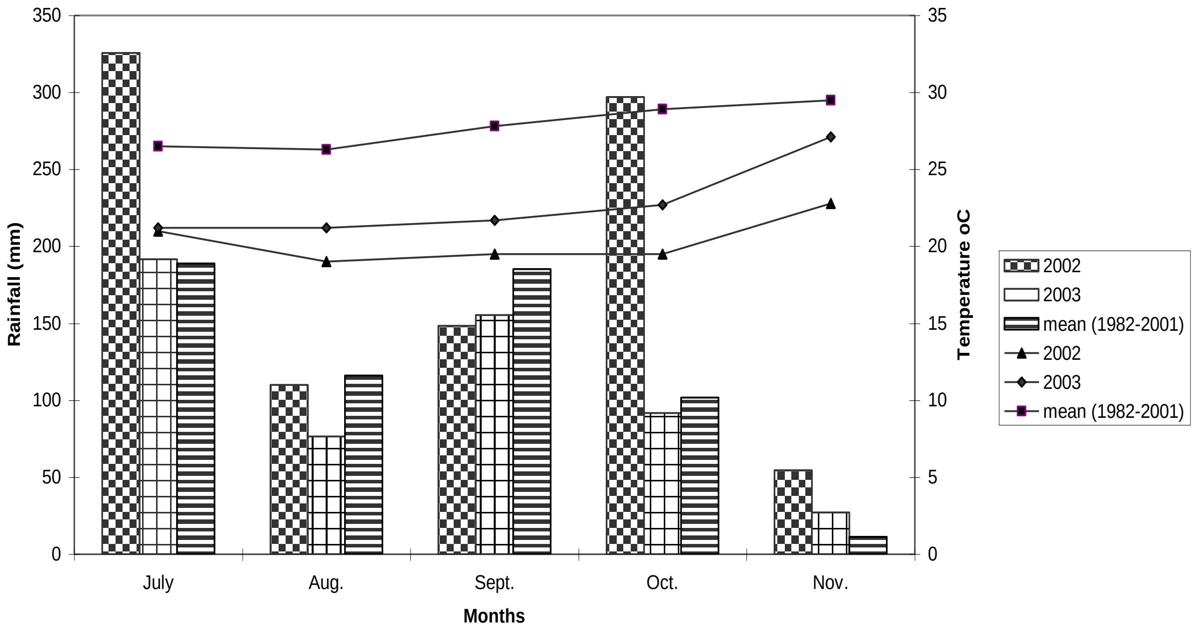

Fig. 1 Monthly rainfall and mean monthly temperatures for 2002, 2003 and mean of 1982-2001 during the late rainyseason cropping

that it was the dominant crop despite the contrasting weather conditions of both years (Tables 1 and 2).

Soybeans

The grain yield of soybeans intercropped into sunflower at V18 was significantly ($P<0.05$) lower in 2002 (Table 1). Whereas, in 2003 it was significantly lower when interseeded at all growth stages of sunflower (Table 2). The lowest yield was recorded when interseeded at V18 in both years (Tables 1 and 2).

Cowpea

Intercropping of cowpea with sunflower at SS, V10 and V18 significantly ($P<0.05$) reduced cowpea grain yield relative to sole crop in both years (Tables 1 and 2). The grain yields of cowpea sown as sole and simultaneously with sunflower in 2003 were not significantly different from each other in 2003 (Table 2). The grain yield reduction was most drastic when cowpea was interseeded at V18 in 2002 and at V10 and V18 in 2003 (Tables 1 and 2).

Intercropping advantage Land Equivalent Ratio (LER)

Intercropping of soybean or cowpea with sunflower simultaneously and at V10 and V18 resulted in yield advantage over the sole crops (i.e LER>1.00), in 2002

Table 2. Grain yield, Land Equivalent Ratio (LER), Land Equivalent Coefficient (LEC), Monetary Equivalent Ratio (MER) and Sunflower yield

Intercropping System	Mean Grain Yield (kg/ha)	LER Sunflower	LER legume	LER sole or Total of Intercrop	LEC	MER sunflower	MER legume	MER sole or total of intercrop	Sunflower yield equivalent (kg/ha)
Sole									
Sunflower	1369	1.00	-	1.00	-	1.00	-	1.00	1369.0
Soybeans	973	-	1.00	1.00	-	-	0.57	0.57	778.4
Cowpea	410	-	1.00	1.00	-	-	0.36	0.36	492.0
Intercropping systems									
Sunflower + soybeans SS	818+124	0.60	0.13	0.73	0.08	0.60	0.07	0.67	917.2
Sunflower + soybeans V10	1560+ 27	1.02	0.03	1.05	0.03	1.02	0.02	1.04	1421.6
Sunflower + soybeans V18	893+ 18	0.65	0.02	0.67	0.01	0.65	0.02	0.67	907.4
Sunflower + cowpea SS	618+324	0.45	0.79	1.24	0.36	0.45	0.28	0.73	1006.8
Sunflower + cowpea V10	923+ 17	0.67	0.04	0.71	0.03	0.67	0.02	0.69	952.4
Sunflower + cowpea V18	1071+ 6	0.78	0.02	0.80	0.02	0.78	0.01	0.09	1078.2
SE±				0.06	0.05			0.10	94.6
LSD (0.05)				0.150	0.147			0.226	281.14

	Sunflower	Soybeans	Cowpea
Mean (kg/ha)	1013	286	189
SE-±	175.81	33.62	42.8
LSD (0.05)	405.42	106.98	136.19

Sunflower #100/kg, soybeans #80/kg, cowpea #120/kg (1US$=#134)
SS – sown simultaneously, V10-tenth true leaf stage, V18-eighteenth true leaf stage.

(Table 1). Intercropping of soybeans into sunflower at SS, V10 and V18 resulted in significantly higher LER (1.22 – 1.40) than their sole crops in 2002, while intercropping cowpea with sunflower resulted in higher LER than the sole crop when intercropped at at SS, V10 and V18 stages (Table 1). In 2003, land use advantage of sunflower/cowpea SS was significantly superior to that of sole crop and LER of sunflower/cowpea V10 and V18 was less than 1. Similarly, LER of 1.05 recorded by sunflower/soybean V10 was higher than LER values of sunflower/soybeans SS and V18 though not significant (Table 2).

Land Equivalent Coefficient (LEC)

In terms of intercrop compatibility, sunflower/soybeans at all three growth stages and sunflower/cowpea at SS recorded LEC values greater than 0.25 derived from the expected 50:50 yield ratio from a mixture of two crops (Adetiloye et al., 1983) (Table 1). LEC of the intercropping systems decreased as the sunflower growth stage advanced (Tables 1 and 2). However, in 2003, only sunflower/cowpea SS recorded LEC=0.31 which was greater than 0.25 (Table 2).

Monetary Equivalent Ratio (MER)

Intercropping of cowpea into sunflower at three growth stages resulted in small MER above 1 (MER=1.03 – 1.12) in 2002, but there were no significant differences among the cowpea treatments (Table 1). The economic efficiency of sunflower/ soybean SS, V10 and V18 intercropping systems was significantly lower than that of the most profitable sole crop (Table 2). In 2003, only economic advantage (MER=1.04) was recorded by sunflower/ soybean at V10, while it was lower than the sole crop in all other treatments (Table 2).

Sunflower yield equivalent

In 2002, grain yields in terms of sunflower yield equivalent were not significantly different among intercropping systems that involved soybeans and cowpea, respectively (Table 1). However, in 2003, sunflower/soybean V10 recorded significantly higher sunflower equivalent yield than sunflower/soybeans SS and V18 (Table 2). No significant difference was recorded among the sunflower/cowpea intercropping systems in 2003 (Table 2).

DISCUSSION

The grain yield of sunflower was not significantly affected by intercropping with either soybeans or cowpea during the late cropping season of 2002. Yield difference between sole crop and intercropped sunflower with soybeans and cowpea at V10 and V18 stages in 2002 was not substantial. This indicated that sunflower being the dominant crop was well established before the introduction of the legumes. Similar results were obtained by Kandel *et al*., (1997) that sunflower yield was not significantly reduced when legumes were interseeded at V4 (29 days after planting) and V10 (46 days after planting) in Fargo, USA. The grain yields of sunflower (618 – 880 kg ha^{-1}) sown simultaneously with the legumes in both years were lower than the African (947 kg ha^{-1}) and Nigerian (1,000 kg ha^{-1}) averages reported by FAO (2004) and Ogunremi (2000), respectively. Nevertheless, other sunflower intercrop yields (893 – 1,400 kg ha^{-1}) compared favorably with these averages, thus suggesting the potential for sunflower in the transition zone of Nigeria. Sunflower yield performance under relatively dry and hot weather conditions of 2003 was almost equal to that of 2002 when weather conditions were more favorable because sunflower is a moderately drought tolerant crop due to its deep tap root system and ability to extract water from depths not attained by roots of the other components (Myers and Minor, 1993).

Intercropping soybeans into sunflower at V18 in 2002 and SS, V10 and V18 in 2003 significantly reduced its grain yield by 67, 87, 97 and 98% relative to its sole, respectively. The yield of the test soybean variety TGx 1448-2E was generally lower than the African (885 kg ha^{-1}) average reported by FAO (2004), except the sole crop of 2003 (973 kg ha^{-1}). The low yield of intercropped soybean was apparently due to the shading effect of the vigorously growing local adapted sunflower variety (Funtua) which resulted in reduced growth and yield of soybeans intercropped especially at V10 and V18 growth stages of sunflower. This suggests that interseeding of soybeans into sunflower at V10 and beyond might likely result in poor performance of the intercrop. Earlier reports have attributed yield reduction of soybeans intercropped with sunflower to decreased dry matter production and shading effect of the dominant tall growing sunflower crop (Srivastara *et al.,* 1980; Shivaramu and Shivashankar, 1992).

Intercropping cowpea with sunflower at the three stages significantly reduced cowpea grain yield compared with the sole in both years, except that sown simultaneously in 2003. Yield reduction was most severe: 88 & 94% and 96 & 99% when cowpea was interseeded at V10 and V18 in 2002 and 2003, respectively. Low grain yield of intercropped cowpea could be attributed to poor growth of cowpea introduced at V10 and V18 and the shading effect of much taller sunflower plants. Similar findings on yield reduction up to 50-78% of late sown cowpea into established maize have been reported in the tropics by Nangju (1979) and Blade *et al*., (1997). The sole crop of cowpea and to some extent the cowpea sown simultaneously with sunflower in both years recorded comparable yields with Nigerian average (460 kg ha^{-1}) and actual farm yields in West African region (25 – 100 kg ha^{-1}) as reported by NAS (1997) and Rachie (1985). Our results, however, are much lower than the sole crop potential grain yield of 1.5 – 3.0 tons ha^{-1}). These results suggested that the productivity of cowpea being the dominated crop in the system could be improved either by introducing the cowpea much earlier and using improved and adapted varieties without necessarily using additional inputs.

The land use advantage (LER>1.00) ranged between 1.22 – 1.40 and 1.04 – 1.50 among sunflower/soybean and sunflower/cowpea intercropping systems, respectively in 2002. However, in 2003 only sunflower/cowpea SS and sunflower/ soybean V10 recorded LER=1.24 and 1.05, respectively. In both years, the relative yields of the legumes were very low, particularly those interseeded at V10 and

V18 stages of sunflower. This apparently contributed to the low LERs recorded relative to the sunflower/legumes sown simultaneously. The three intercropping systems that involved soybeans in 2002 and sunflower/cowpea SS in 2002 and 2003 exhibited intercrop compatibility to some degree. The other intercropping systems that recorded LEC<0.25 could be described as not giving complementary yield. The effect of the dominant crop (sunflower) on the intercrops (soybeans and cowpea) with LEC>0.25 showed competitive complementarity. This indicates that in order to improve the mixture productivity of the intercropping systems, efforts should be geared towards improving the productivity of the dominated components.

The economic efficiency of most of the intercropping systems were low (MER<1.00) because the contributions of soybeans and cowpea to the systems were very low, particularly when interseeded at V10 and V18. Sunflower/cowpea SS,V10 and V18 in 2002 and sunflower/soybeans V10 in 2003 were the only intercropping systems that resulted in MER>1.00, even though their LER and LEC values were not the highest in the respective years. These findings confirmed earlier reports that often times identified agronomic advantages do not give corresponding high economic advantage (Adetiloye and Adekunle, 1989 and Jagtap and Holkar, 1995). Consequently, it is suggested that MER should take precedence over LER and LEC since economic advantage is more pertinent to resource poor farmers than agronomic advantage. Sunflower/cowpea SS and sunflower/soybeans V10 recorded the highest MER and also the maximum yield in terms of sunflower yield equivalent in both years.

CONCLUSIONS

In general, the overall output of the intercropping systems was higher during the more favorable weather conditions of 2002 than 2003. Agronomic advantage (LER>1.00) ranged between 1.04 – 1.40 and 1.05 – 1.24 relative to the sole crops in 2002 and 2003, respectively. Sunflower/ soybeans SS, V10 and V18 in 2002 and sunflower/cowpea SS in 2003 resulted in marginal intercrop compatibility (LEC>0.25). The highest MER values of 1.12 (sunflower/cowpea SS) and 1.04 (sunflower/soybeans V10) corresponded with the highest sunflower yield equivalent of 1349.2 and 1421.6 kg ha^{-1}, in 2002 and 2003, respectively. The recorded agronomic advantages (LER>1.00 and LEC>0.25) did not translate into increased economic advantage (MER>1.00). Results nonetheless indicated that the potential exists to increase the overall productivity of the intercropping systems if the productivity of the dominated legumes could be enhanced.

REFERENCES

Adetiloye, PO, Ezedima FOC and Okigbo BN 1983 A land equivalent coefficient concept for the evaluation of competitive and productive intercations in simple to complex crop mixtures. Ecol. Modelling. 19: 27-39.

Adetiloye PO and Adekunle AA 1989 Concept of monetary equivalent ratio and its usefulness in the evaluation of intercropping advantages.

Trop. Agric. 66:337-341.

Adetunji IA and Amanze CO 2001 Intercropping sunflower with local varieties of cassava in a moist savanna site of Nigeria. African J. of Root and Tuber Crops 4: 26-31.

Agele SO, Olaore JB and Idris O 2002 Water use, growth and yield performance of sunflower affected by incorporation of organic wastes in an Alfisol in the late season period in a rainforest zone of Nigeria. Trop. Oilseeds J. 7:12-24

Blade SF, Shetty SVR Terao T and Singh BB 1997 Recent developments in cowpea cropping systems research.In: Singh, B.B., Mohan Raj, D.R Dashiell, K.E., Jackai, L.E.N. (Eds), Advances in cowpea research. IITA, Ibadan and JIRCAS, Japan, pp 114-128.

Bello NJ 1999 Investigating the optimum planting date for sorghum in the forest-savanna transition zone of Nigeria. Exp. Agric. 35:461-470.

De Wit CT 1960 On competition. Agric. Res. Report 66. Proceedings. Wageningen, 82p.

Donald CM 1963 Competition among crop and pasture plants. Advances in Agron.15: 1-118.

Fagbayide JA 2000 Growth and seed Yield of sunflower in intercropping system with maize and cassava. Moor J. of Agric. Res. 1:1-5

Fehr WR and Caviness CE 1977 Stages of soybean development. Special report

80. Iowa State University, Amen, Iowa. 12pFood and Agricultural Organisation of the United Nations. 2004 FAOSTAT Database http:/apps.fao.org/default.htm

Fukai S and Trenbath BR 1993 Processes determining intercrop productivity and yields of component crops. Field Crops Res. 34: 247-271.

Hiebsch CK and Mc Collum ER 1987 Area-Time Equivalent Ratio: A method for evaluating the productivity of intercrops. Agron. J. 79:15-22.

Hildebrand PE 1976 Multiple cropping systems are dollars and “sense” agronomy. In: Stelly MS Kral DM Elsele LC and Nanseef JH eds. Multiple Cropping, American Society of Agronomy (ASA). Special publication No. 27:347-371.

Jagtap JG and Holkar S 1995 Soybean + Pigeonpea – A remunerative intercropping system for Malwa Region of Madhya Pradesh, India. Inter. Pigeonpea Newsletter. 2:63-64.

Kandel, HJ Schneiter AA and Johnson BL 1997 Intercropping legumes into sunflower at different growth stages. Crop Sci. 37:1532-1537.

Mc Gilchrist CA and Trenbath BR 1971 A revised analysis of plant competition experiments. Biometrics 27:659-671.

Myers RL and Minor HC 1993 Sun

flower:An American Native. http:\\muextension.missouri.edu.xplor.agguides/crops/g04290/htm

Nangju DJ 1979 Effect of density, plant type and season on growth and yield of cowpea.J. of the American Society of Hort. Sci. 104: 466-470.

Ogunremi, EA 1984 Response of sunflower to nitrogen, phosphorus and potassium fertilizers in southern Nigeria. East Afric. Agric. & Forest. J. 45:264-268.

Ogunremi EA 1986 Effect of nitrogen fertilization and harvest time on sunflower yield and hollow seededness. Field Crop Res. 13: 45-53.

Ogunremi EA 2000 Sunflower, Kenaf and Sugar-cane in Nigeria: My Experiences In: Agronomy in Nigeria. (Ed. MO Akoroda). University of Ibadan, Ibadan, Nigeria. pp 130-142.

Okeleye KA and Ariyo OJ 2000 Effects of strip intercropping and insecticide spray on the performance of cowpea (*Vigna unguiculata* (L.) Walp) in a cowpea/maize intercrop. Niger. Agric. J. 31:23-32.

Olanite, JA Ibikunle BAO and Jolaosho AO 2002 Effect of intercropping on yield and yield components of maize and sunflower in the southern guinea savanna zone of Nigeria. Moor J. of Agic. Res. 3:169-174.

Olowe VIO, Okeleye KA Durojaiye SA Elegbede O Oyekanmi AA and Akintokun PO 2003 Optimum plant densities for soybean (*Glycine max* (L.) Merrill) and sesame (*Sesamum indicum* L.) in maize based intercropping system in south western Nigeria. ASSET Series A. 3:79-89.

Rachie KO 1985 Introduction. In: Singh SR and Rachie KO (Eds). Cowpea:Research, production and utilization. John Wiley and Sons, Chichester, UK. pp 21-28.

Reddy MN and Chetty CKR 1984 Staple land equivalent ratio for assessing yield advantage from intercropping. Exp. Agic. 20: 171-177.

Robinson RG 1984 Sunflower for strip, row and relay intercropping. Agron. J. 76: 43-47.

Schneiter AA and Miller JF 1981 Description of sunflower growth stages. Crop Sci. 21: 901-903.

Shivaramu HS and Shivashankar K 1992 Performance of sunflower (*Helianthus annuus*L.) and soybean (*Glycine max* (L.) Merrill) in intercropping with different plant populations and planting patterns. Indian J. of Agron. 37:231-236.

Srivastava, VC Soven C and Shahani MN 1980 Performance of soybean in association with companion crop. Trop. Grain Legume Bul. 20:11-14.

Steel RGD and Torrie JH 1980 Principles and procedures of statistics: A Biometrical approach. 2nd ed. New York. McGraw-Hill International Book Company, 633p

Willey RW 1979 Intercropping – Its importance and research needs. Part1. Competition and yield advantages. Field Crop Abs. 31:1-84.

Willey RW and Rao MR 1980 A competitive ratio for quantifying competition between intercrops. Exp. Agric. 16:117-125.

Zekeng P 1980 Intercropping tall crops and legumes. M.S. thesis. North Dakota State Univ., Fargo. USA.