African Crop Science Conference Proceedings, Vol. 11. pp. 73 - 77
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ISSN 1023-070X/2013 $ 4.00
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Intercropping sunflower with beans, groundnuts, maize and sorghum in Uganda

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Abstract Intercropping experiments involving sunflower with beans, groundnuts, maize and sorghum at different ratios were conducted at the National Semi Arid Resources Research Institute (NaSARRI) in 2006 and 2007. Treatments were organized in a randomized complete block design (RCBD) replicated 4 times and plots measured 11.0 m wide by 5.5 m long. The best intercropping ratios in decreasing order as per LER values were: (a) Ratio 1:1 for sunflower/beans intercrop with yields of 1619 and 430 kg ha^{-1} for sunflower and beans respectively with LER of 1.48 and total income of 1,110,500 UgShs ha^{-1}; (b) Ratio 3:1 for sunflower/maize intercrop where the yields were 2415.9 and 686.1 kg ha^{-1} for sunflower and maize, respectively, with LER of 1.26 and total income of 1,413,780 Ug Shs ha^{-1}; (c) Ratio 2:2 for sunflower/sorghum intercrop with yields of 1495.4 and 722.2 kg ha^{-1} for sunflower and sorghum, respectively, with LER of 1.24 and total income of 892,140 UgShs ha^{-}; (d) Ratio 2:1 for sunflower groundnuts intercrop where the yields were 2299.9 and 144.4 kg ha^{-1} for sunflower and groundnuts, respectively, with LER of 1.16 and total income of Uganda Shillings 1,309,970 ha^{-1}.

Key words: LER, total income, yields

Introduction

Edible oil production has mainly been from oil palm and soybeans, which remain inadequate to sustain the demand of the growing population (FAO, 2003). Sunflower (*Helianthus annuus* L.) is an introduced crop that has fitted well in the farming systems of Africa in general and Uganda in particular. Its oil is considered premium because of its light colour, mild flavor, low saturated fat levels and the ability to withstand high cooking temperatures (Olowe & Adebimpe, 2009). Research on sunflower in Uganda is geared towards increasing household incomes, alleviating poverty among the rural poor farmers and to produce sufficient seed for the producers and oil millers. This is in line with Uganda's government policy on Plan for Modernization of Agriculture (PMA). Sunflower has, therefore, become one of the most profitable crops in Uganda especially, in the north eastern and northern parts of the country where most production carried out. In the north, small and large-scale processing companies have established themselves throughout the region, in particular for sunflower cotton, sesame and groundnuts (MAAIF, 2010).

The area under production has been increasing from mid-1990s. This is partly due to the number of oil mills installed in areas where sunflower is merely grown. For example, there were more than 18 oil mills in Lira town by 2002 (Bindraban *et al*., 2006). Despite the increasing production in the country, the yields have remained low at farm level. The main factors that have caused low yields are lack of high yielding varieties/hybrids, poor agronomic practices, inability of farmers to use agricultural inputs like fertilizers and plant large acreages. The average yields of sunflower in farmers' fields are about 750-900 kg ha^{-1} whereas, yields of the best open pollinated varieties at NaSAARI are about 1,500-2,000 kg ha^{-1} under good management and hybrids can reach 3,000 kg ha^{-1} (NARO, 1999-2000). This yield trend is similar for most crops. Beans for example yield 150-450 kg ha^{-1} under farm field conditions yet potentials of 2,000-4,000 kg ha^{-1} exist under on station research conditions with improved varieties. Maize farmers record 900-1500 kg ha^{-1} compared to 8,000 kg ha^{-1} of hybrids (NARO, 1999-2000).

Besides, farmers grow several other crops such as cotton, sesame, pigeon peas, beans, groundnuts, maize, finger millet, sorghum, cassava and sweet potatoes among others. All those crops are rain-fed and require labour from the same farmer almost at the same time. Many farmers have resorted to intercropping various crops in attempts to offset the problems of labour and shortage of land. However, they get very low yields from the intercropping systems. Research elsewhere has shown advantages of intercropping when proper component crops, patterns and ratios are used, hence increasing productivity. Ramos & Curbelo (1996) who focused on intercropping systems of sunflower, oats (*Pisum arvense*) and peas (*Pisum sativum*) found out that dry matter production was similar between the sunflower grown alone (8.62 t ha^{-1}), peas + oats (7.72 t ha^{-1}), and the peas + oats + sunflower (7.05 t ha^{-1}) systems.

The objectives of the study were: (i) Determine crops that would be best for intercropping with sunflower under rain fed conditions in Uganda, (ii) Establish appropriate ratios that would allow optimum performance and yields of the component crops, and (iii) Determine monetary values of different intercropping systems with sunflower in Uganda.

Materials and methods

Intercropping experiments involving sunflower with beans (*Phaseolus vulgaris*), groundnuts (*Arachis hypogea*), maize (*Zea mays*) and sorghum (*Sorghum bicolor*) at different ratios were conducted at the National Semi Arid Resources Research Institute (NaSARRI) in Uganda during the first rains of 2006 and 2007. *NaSARRI* is located at 01° 31' N; 33° 27' E; and 114 m above sea level.

Four experiments were conducted in one field during each rainy season. These included intercropping systems of sunflower and beans, sunflower and maize, sunflower and groundnuts, and sunflower and sorghum. In each of them, six intercropping ratios were involved that were compared comparison with pure stands of the various component crops. The ratios were a) one row of sunflower and one of x (1:1), b) two rows of sunflower and two of x (2:2), c) three rows of sunflower and one of x (3:1), d) one row of sunflower and three of x (1:3), e) two rows of sunflower and one of x (2:1) and f) one row of sunflower and two of x (1:2) (where x was maize, sorghum, beans or groundnuts).

Each experiment was set in a Randomized Complete Block Design (RCBD) replicated four times. Plots measured 11.0 x 5.5 m. Where sunflower was intercropped, the inter-row spacing between any two rows was 37.5 cm. In pure stands sunflower and maize were spaced at 75 x 50 cm, beans at 37.5 x 30, groundnuts at 37.5 x 10 and sorghum at 60 x 30 cm. Except for beans which was thinned to 2 per hole, the rest of the crops remained at 1 plant per hole. The varieties of crops used were the open pollinated *Sunfola* for sunflower, *Longe-5* for maize the *Local Yellow* for beans and the *Local brown* sorghum variety.

At full maturity of each crop, yields were taken from 8.0 x2.0 m areas from each plot. The crops were dried, threshed and weighed. Partial Land Equivalent Ratios (PLERs) for the component crops and Total Land Equivalent Ratios (TLERs) for the intercropping systems were then calculated as:

$$PLERs = si/sp \quad \text{Equation 1}$$

$$PLERx = xi/xp \quad \text{Equation 2}$$

$$TLER = PLERs + PLERx \quad \text{Equation 3}$$

Where:

si = Yield of sunflower when intercropped
sp = Yield of sunflower when pure planted
xi = Yield of the other crop (maize, sorghum, beans or groundnuts) when intercropped
xp = Yield of the other crop when pure planted.

Data analysis. The values for PLER and Total LER, together with other variables were subjected to statistical analysis using GenStat computer program. The mean prevailing prices of the various crops were used to estimate the incomes from the different systems.

Results and discussion

Crop yields. Mean values for different ratios are presented in Tables 1 and 2. Intercropped sunflower yields at different ratios were significantly lower than yields in pure stands (Table 1). Yields from the different ratios were not significantly different from each other, but the lowest yields were recorded from ratio (1:3). Based on sunflower yields, the ratios were generally ranked from "best" to "worst" in the order of 3:1, 2:1, 1:1, 2:2, 1.2 and 1:3. The trend described above was similar to systems in sunflower was intercropped with beans, maize, groundnuts or sorghum. The decrease in sunflower yields with ratios was a result of the prevailing sunflower populations in the systems. Ratio 1:3 gave the lowest plant population, hence the corresponding lowest yield.

Yields of the other four food crops varied remarkably when intercropped with sunflower (Table 2). Generally intercropped yields of all the four were lower than their pure stand counterparts. Beans, maize and sorghum performed worst at ratio 3:1 and 2:1 while, groundnuts were worst at ratio 1:1 and 3:1. For food crops other than sunflower, ratio 3:1 reduced their populations so much

Table 1. Mean yields (kg/ha) of sunflower intercropped with 4 other food crops at different ratios in NaSARRI during the first rains of 2006 and 2007.

Treatment	Sunflower under beans	Sunflower under groundnuts	Sunflower under maize	Sunflower under sorghum
Sunflower/ x (1:1)	1619.0	1917.6	1776.9	1266.7
Sunflower/ x (2:2)	1425.0	1565.7	1372.2	1495.4
Sunflower/ x (3:1)	1742.0	2216.7	2415.9	1456.4
Sunflower/ x (1:3)	689.0	1196.3	686.1	724.7
Sunflower/ x (2:1)	1877.0	2299.9	1853.6	1126.5
Sunflower/ x (1:2)	1078.0	1335.7	679.6	777.3
Pure sunflower	2709.0	2568.5	2559.7	1970.4
Mean	1591.0	1871.5	1620.6	1259.0
Lsd	519.2***	597.3 ***	480.0 ***	399.8 ***
CV (%)	21.9		27.9	21.3

X in column 1denotes beans, maize, groundnuts and sorghum in columns 2, 3 and 4 as the crops intercropped with sunflower.

that they could not perform to their full potential. Based on their yields in the systems, therefore, the ratios were ranked from "best" to "worst" in of 1:3, 1:2, 2:2, 1:1, 2:1 and 3:1. This trend is absolutely the reverse of that based on sunflower yields.

Land Equivalent Ratios. LER values showed that intercropping sunflower with beans was advantageous at all ratios except 3:1; groundnuts 2:1; with maize 1:3; and sorghum 3:1 and 2:1 (Table 3).

Incomes. Tables 4-6 present monetary incomes from the different systems. Prices of the various crops played a significant role in determining the incomes from the different systems. As an example, yields from groundnuts were very low compared to the other crops but its good price raised the incomes from systems that had it as a component. However, because of low market prices, other crops especially maize and sorghum registered lower incomes even when yields were high. Food prices vary a lot from harvesting time to sowing and from place to place depending on demand. Using incomes may over-estimate or under-estimate the benefit of a system depending on the price of the commodity therefore must be used with a lot of caution.

Table 2. Mean yields (kg/ha) of 4 other food crops intercropped with sunflower at different ratios in NaSARRI during the first rains of 2006 and 2007.

Treatment	Beans	Groundnuts	Maize	Sorghum
Sunflower/ x (1:1)	430.0	51.8	1319.4	629.6
Sunflower/ x (2:2)	431.0	92.6	1231.5	722.2
Sunflower/ x (3:1)	159.0	29.6	686.1	123.7
Sunflower/ x (1:3)	493.0	144.5	1557.0	1270.2
Sunflower/ x (2:1)	222.0	88.9	726.4	388.9
Sunflower/ x (1:2)	448.0	144.4	1548.9	1383.8
Pure other food crops	482.0	328.0	2146.3	1481.5
Mean	368.0	126.0	1317.0	857.1
Lsd	97.2**	81.6 ***	374.6 ***	386.8**
CV (%)	17.7	43.7	19.1	29.6

X in column 1denotes beans, maize, groundnuts and sorghum in columns 2, 3 and 4 as the crops intercropped with sunflower.

Table 3. Land Equivalent Ratios (LERs) when sunflower was intercropped with four other food crops at different ratios in NaSARRI during the first rains of 2006 and 2007.

Treatment	Beans	Groundnuts	Maize	Sorghum
Sunflower/ x (1:1)	1.48	0.89	1.03	1.06
Sunflower/ x (2:2)	1.41	0.89	0.89	1.24
Sunflower/ x (3:1)	0.96	0.89	1.26	0.82
Sunflower/ x (1:3)	1.27	0.91	0.99	1.23
Sunflower/ x (2:1)	1.15	1.16	1.06	0.83
Sunflower/ x (1:2)	1.31	0.96	0.98	1.32

X in column 1denotes beans, maize, groundnuts and sorghum in columns 2, 3 and 4 as the crops intercropped with sunflower.

Table 4. Incomes (Uganda Shillings/Ha) from sunflower intercropped with four other food crops at different ratios in NaSARRI during the first rains of 2006 and 2007.

Treatment	Sunflower under beans	Sunflower under groundnuts	Sunflower under maize	Sunflower under sorghum
Sunflower/ x (1:1)	809,500	958,800	888,450	633,350
Sunflower/ x (2:2)	712,500	782,850	686,100	747,700
Sunflower/ x (3:1)	871,000	1,108,350	1,207,950	728,200
Sunflower/ x (1:3)	344,500	598,150	343,050	362,350
Sunflower/ x (2:1)	938,500	1,149,950	926,800	563,250
Sunflower/ x (1:2)	539,000	667,850	388,650	388,650
Pure sunflower	1,354,500	1,284,250	985,200	985,200

Prices for sunflower, beans, maize, groundnuts and sorghum were Uganda Shillings 500, 700, 300, 1800 and 200/kg respectively.

Table 5. Incomes (Uganda Shillings/Ha) from four food crops intercropped with sunflower at different ratios in NaSARRI during the first rains of 2006 and 2007.

Treatment	Beans	Groundnuts	Maize	Sorghum
Sunflower/ x (1:1)	301,000	93,240	395,820	125,920
Sunflower/ x (2:2)	301,700	166,680	369,450	144,440
Sunflower/ x (3:1)	111,300	53,280	205,830	24,740
Sunflower/ x (1:3)	345,100	260,100	467,100	254,040
Sunflower/ x (2:1)	155,400	160,020	217,920	77,780
Sunflower/ x (1:2)	313,600	259,920	468,670	276,760
Pure other food crops	337,400	590,400	643,890	296,300

Prices for sunflower, beans, maize, groundnuts and sorghum were Uganda Shillings 500, 700, 300, 1800 and 200/kg respectively.

Table 6. Total mean incomes (Uganda Shillings/Ha) when sunflower was intercropped with four other food crops at different ratios in NaSARRI during the first rains of 2006 and 2007

Treatment	Sunflower with beans	Sunflower with groundnuts	Sunflower with maize	Sunflower with sorghum
Sunflower/ x (1:1)	1,110,500	1,052,040	1,284,270	759,270
Sunflower/ x (2:2)	1,014,200	949,530	1,055,550	892,140
Sunflower/ x (3:1)	982,300	1,161,630	1,413,780	752,940
Sunflower/ x (1:3)	689,600	858,250	810,150	616,390
Sunflower/ x (2:1)	1,093,900	1,309,970	1,144,720	641,030
Sunflower/ x (1:2)	852,600	927,770	665,410	

Prices for sunflower, beans, maize, groundnuts and sorghum were Uganda Shillings 500, 700, 300, 1800 and 200/kg respectively.

Table 7. Summary of most profitable ratios for intercropping sunflower with four other food crops based on LER and Total Incomes at NaSARRI during the first rains of 2006 and 2007.

Combination	LER	Total income	Best ratio
Sunflower/beans	1.48 (1)	1,110, 500 (1)	1:1
Sunflower/maize	1.26 (1)	1,413,780 (1)	3:1
Sunflower/groundnuts	1.16 (1)	1,309,970 (1)	2:1
Sunflower/ sorghum	1.24 (2)	892,140 (1)	2:2

Figures in brackets under LER and Total Income indicate ranks as compared to the other treatments.

Discussion

These results agree with finding elsewhere. Agbaje *et al*. (2002) reported that yields of sole crops are usually higher than intercropped due to lower intra-competition for available resources unlike inter-competition that exists between different crop species when intercropped. The overall productivities of intercropped systems were reported higher. Intercropping has long been recognized as the common practice among subsistence small scale farmers. It is characterized with semi-intensive system of agriculture with low inputs and lack of sufficient land/ or capital (Vandermeer, 1992).

Acknowledgement

Special thanks to all the staff who involved in this work most especially Ms. Mellen Akurut and Ms. Loyce Arigo who were involved in data collections.

References

Agbaje, G.O., Ogunbodede, B.A. & Makinde, J.O. 2002. Biological and economic efficiency of maize and soybean intercrop patterns in rainforests and savanna areas of Nigeria. Moor J. Agric. Res. **3,** 37-40.

Food and Agricultural Organization (FAO), 2003. The state of food insecurity in the world (FAOSTAT website) 8p.

Ministry of Agriculture, Animal Industry & Fisheries, 2010. Agriculture Sector Development Strategy and Investment Plan: 2010/11-2014/15. pp. 48.

NARO Report, 1999-2000. Addressing the challenges of poverty eradication and modernization of agriculture. Improved technologies by NARO, 1999-2003.

Olowe V.I.O & Adebimpe O.A, 2009. Intercropping sunflower with soyabeans enhances total productivity. Biological Agriculture and Horticulture **26,** 365-377.

Bindraban, P., Mutunga, j., Kamuhanda, R., Muyind, G. & Agong, R. 2006. Weaving the oilseed web. Report of a

scoping mission January 20th –January 31st 2006. pp. 34.

Ramos, N. & Curbelo, F. 1996. Productive performance and quality of Avena sativa, Pisum arvense and sunflower (Helianthus annuus).Cuban Journal of Agricultural-Science **30(1),** 107-113.

Vandermeer, J.H. 1992. The ecology of intercropping. Cambridge University Press, Cambridge, UK.