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Effect of intercropping sunflower with soybean at different inter-row and intra-row spacing on land use efficiency

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Abstract

Sunflower (*Helianthus annuus* L.) and soybean (*Glycine max*) were relatively new crops of economic significance in Uganda before 1990s compared to traditional cash crops such as cotton, tea and coffee. By 2000 many smallholder farmers in the Mid-Northern Agro-ecological Zone of Uganda started planting sunflower and soybean as sources of household income. However, sunflower and soybean are planted in same piece of land using different planting patterns that may lead to differences in yields. This study evaluated the effect of inter-row and intra-row spacing on yields of sunflower and soybean intercrop. A 4 x 4 factorial experiment in a randomized complete block design was used to determine performance of sunflower and soybean under four inter-row spacings (75, 90, 105 and 120 cm) and four intra-row spacings (30, 40, 50 and 60 cm) and sole sunflower and sole soybean. Under intercrop, a ratio of 1:1 sunflower/soybean was used. Sole sunflower was planted at 90 cm x 30 cm; while sole soybean was planted at 50 cm x 25 cm. Mean yields of sunflower from intercrop were 2517 and 1219 kg ha^{-1}, compared to 3241 and 1655 kg ha^{-1} from sole sunflower at Acwec Omio and Ngetta Zonal Agricultural Research and Development Institute (NgeZARDI), respectively. Yield of soybean was 1100 and 2978 kg ha^{-1} ($p<0.01$), compared to 3364 and 2590 kgha^{-1} from sole soybean at Acwec Omio and NgeZARDI, respectively. The highest Land Equivalent Ratios (LER) were 1.29 at inter-row spacing of 90 cm between rows and 1.25 at intra-row spacing of 30 cm within rows. The lowest LER of 0.8 was from 120 cm x 60 cm spacing. An intercrop between sunflower and soybean at a spacing of 90 cm between rows and 30 cm within rows, was the most appropriate, since LER were above 1.2, an indication that land was efficiently utilized. Sunflower can be intercropped with soybean, enabling farmers to raise income by cultivating two crops in same piece of land, above all conserve the fertility of land.

Key words: Households, income, yield, LER, conserve

Introduction

Sunflower (*Helianthus annuus* L.) is one of the important oil crops as well a non-traditional cash crops in Uganda. Its use as raw material for oil industry has increased probably due to increased demand for oil in the country (Laker-Ojok,

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1996). Before 1990s, sunflower varieties that were being grown were ornamental/ confectionary types of Russian and Kenyan origin, with low (10-30%) oil content. These varieties were brought by religious organisations mainly to Karamoja region. Sunflower became a popular crop with the release of new sunflower variety called Sunfola in 1995 (Laker-Ojok 1996). Since sunflower was a relatively new crop of economic significance in Uganda, there was little information about how it fitted into the farming systems. As a result, formal research tended to isolate it to just a sole crop, ignoring the mix and intercropping practices (Boquet *et al.*, 1982 Duncan, 1986).

Then many farmers grew sunflower in lines; majority of the fields were intercropped with other crops. Mead and Willey, 1980 reported that the land equivalent ration (LER) concept is considered for situations where intercropping has to be compared with growing each crop in pure stand. Soybean is an important crop referrel to as a miracle crop in the world and has significant amount of oil as a grain legume Tukamuhabwa 2001). Although soybean was introduced in Uganda by 1908, it production was emphasized after the second world war, thereafter much work was development of new lines. Bashaasha 1992, indicated that it was by 1993 that integrated soybean project aimed at promoting soybean production and utilization started with identifying socio-economic constraint.

Sunflower and soybean are becoming important in the farming system as source of raw material for oil. The objective of this study was to determine appropriate spacing to enable sunflower and soybean (*Glycine max*) to express their yield potentials and, therefore, make efficient use of limited land in Uganda.

Methods and materials

A field experiment was conducted with the Acwec Omio Farmer group and Ngetta Zonal Agricultural Research and Development Institute (NgeZARDI) in 2007 and 2008, in northern Uganda in a randomised complete block design, replicated four times. Soybean variety called Nam 1 was used in 2007 and Nam 2 was used in 2008 because the smaller size of Nam 1 made it less acceptable (Laker-Ojok 1996). Sunflower variety called Sunfola was used throughout the study. Sunflower was planted at inter-row spacing of 75, 90, 105 and 120 cm and intra-row spacing of 30, 40, 50 and 60 cm. Soybean was planted between two rows of sunflower at an intra-row spacing of 25 cm. Sole sunflower was planted at 90 cm between the rows and 30 cm within row. Sole soybean crops were planted at 50 cm between the rows and 25 cm within the row. Both sunflower was thinned to one plant per hill and soybean was also thinned to one plant per hill after first weeding.

Data on plant height, head diameter, yield per plant, seed weight and yield per ha were collected for sunflower. Data that were collected on soybean were plant height, number of branches per plant, number of pods per plant, seed weight and yield per ha. Land use efficiency of intercropping was determined using Land Equivalent Ratio (LER). LER equals to Partial Land Equivalent Ratio (PLER) for sunflower plus PLER for soybean. While PLER was derived by dividing yield of sunflower and soybean from intercrop by yield of the sole crops (Willey, 1979).

Analysis of all variables by ANOVA was performed using GenStat package Version 3.2. The significance of difference between treatments was determined using LSD at P<0.05 (Snedecor and Cochram, 1980; Steel and Torrie, 1980).

Results

Effect of inter- and intra-row spacing on plant height, head diameter, yield plant^{-1} and 100 seed weight of sunflower are presented in Tables 1 and 2. Height of plants was not significantly affected by inter-row and intra-row spacing (Table 1). Unlike plant height, head diameter was significantly affected by inter- and intra row-spacing. Wider heads of 18.06 cm, 17.93 cm and 18.69 cm were obtained from 90, 105 and 120 cm-wide spacings, respectively; compared with 16.28 cm from 75 cm-wide spacing (Table 1). Head diameter was smaller (16.35 cm) when intra-row spacing was 30 cm compared to 40 and 60 cm (Table 2).

Yield per plant was also affected by inter- and intra-row spacing. Higher yield per plant was obtained when inter-row spacing were 90, 105, 120 cm than 75 cm-wide (Table 1). Similarly, significantly

Table 1. Effect of inter-row spacing on sunflower plant parameters

Inter-row (cm)	Plant height (cm)	Head diameter (cm)*	Weight per plant (g)*	100 seeds weight (g)*
75	167.4a	16.28b	5.03b	6.04b
90	169.84a	18.06a	6.47a	6.54ab
105	163.97a	17.93ab	6.53a	7.09a
120	163.23a	18.69a	6.93a	6.99a
LSD (0.05)	7.46	1.30	1.05	0.65
CV (%)	6.27	10.62	26.21	14.22

* Numbers in a column followed by same letter are not significantly different at P<0.05

Table 2. Effect of intra-row spacing on sunflower parameters

Inter-row (cm)	Plant (cm)	Head diameter (cm)*	Weight per plant (g)*	100 seeds weight (g)*
30	167.93a	16.35b	5.21b	6.35a
40	172.13a	17.53a	5.65a	6.56a
50	167.00a	17.48a	5.72a	6.48a
60	167.48a	18.23a	6.25a	6.79a
LSD (0.05)	0.32	1.06	0.55	0.65
CV (%)	6.27	10.62	26.21	14.22

* Numbers a in column followed by same letter are not significantly different at P <0.05

higher yield per plant was obtained from 40, 50 and 60 cm-wide spacing compared to 30 cm (Table 2). The high yield per plant at wide spacing indicated that there was low competition among plants.

One hundred seed weight was significantly affected by inter-row spacing (Table 1). Heavy seeds were obtained from 90, 105 and 120 cm-wide (Table 2). Seed weight from 90 cm and 75 cm-wide spacing were not significantly different. Intra-row spacing did not have significant effect on 100 seed weight.

The effect of inter- and intra-row spacing on plant height, number of branches per plant, number of branches with pods, number of pods per plant and 100 seed weight of soybean are presented in Tables 3 and 4. Inter-row spacing had a significant effect on soybean height. Soybean planted at 75 and 90 cm were significantly ($P<0.05$) taller than those planted at 105 and 120 cm. There was no significant difference ($P>0.05$) in height among soybean plants spaced at 120 and 105 cm (Table 3). Intra-row spacing had no significant effect on soybean height.

Number of branches with pods was affected by inter-row spacing. There were significantly ($P<0.05$) more branches with pods from soybean planted at 120 and 105 cm compared to 90 and 75cm. But the number of branches with pods from 90 cm was not significantly different ($P>0.05$) from number of branches with pods planted at 75 cm (Table 3). The intra-row spacing had an effect ($P<0.05$) on number of branches with pods; whereby the number of branches with pods was significantly more from soybean plants spaced at 50 and 60 cm compared to 30 and 40 cm (Table 4).

The number of pods per plant followed a similar trend like the number of branches with pods. The number of pods per plant was significantly ($P<0.05$) more from plants spaced at 120 cm than at 75 and 90 cm spacing; although it was not significantly different from those planted at 105 cm spacing (Table 3).

Intra-row spacing had a significant effect on number of pods per plant (Table 4). Soybean plants from 30 cm and 40 cm-wide spacing had significantly ($P<0.05$) fewer pods per plant than to 50 and 60 cm-wide spacing. The number of pods per plant were not significantly different from 40 and 30 cm-wide spacing (Table 4). Planting at 50 and 60 cm had no significant difference in the number of pod per plant.

Table 3. Effect of inter-row spacing on soybean parameters

Intra-row (cm)	Plant height (cm)*	Branches with pods*	Pods per plant*	100 seeds weight (g)
75	66.92a	2.53b	43.77b	19.54a
90	65.48ab	2.74b	45.19b	18.43a
105	63.52b	3.27a	50.19ab	18.84a
120	62.17b	3.28a	53.79a	18.88a
LSD (0.05)	2.15	0.35	7.21	1.24
CV (%)	16.27	13.21	17.45	8.06

* Numbers in a column followed by same letter are not significantly different at 0.05

The effect of inter- and intra-row spacing on yield of sunflower followed a similar trend at both Acwec Omio and NgeZARDI (Fig. 1). The highest yield was obtained from a 90 cm spacing, followed by a 75 cm spacing at both Acwec Omio and NgeZARDI. The yield of plants from sole planting was significantly (P<0.05) higher than that from intercropped.

The result across the years indicated that higher yields were obtained at Acwec Omio compared to Ngetta. Yield of soybean was not different at both Ngetta and Acwec Omio study sites (Fig. 2). There was, however, interaction between inter-row and locations. At 75, 90 cm spacing and sole crop, the yield of soybean was higher at Ngetta than at Acwec Omio site. But at 105 and 120 cm spacing,

Table 4. Effect of intra-row spacing on soybean parameters

Intra-row (cm)	Plant height (cm)*	Branches with pods*	Pods per plant*	100 seeds weight (g)
30	75.4a	1.98b	26.09b	12.58a
40	57.9b	2.18b	25.84b	12.42a
50	55.3b	2.5a	29.08a	12.46a
60	58.2b	2.78a	29.51a	12.39a
LSD (0.05)	3.11	0.36	3.76	0.21
CV (%)	16.27	13.21	17.45	8.06

* Numbers in a column followed by same letter are not significantly different at P<0.05

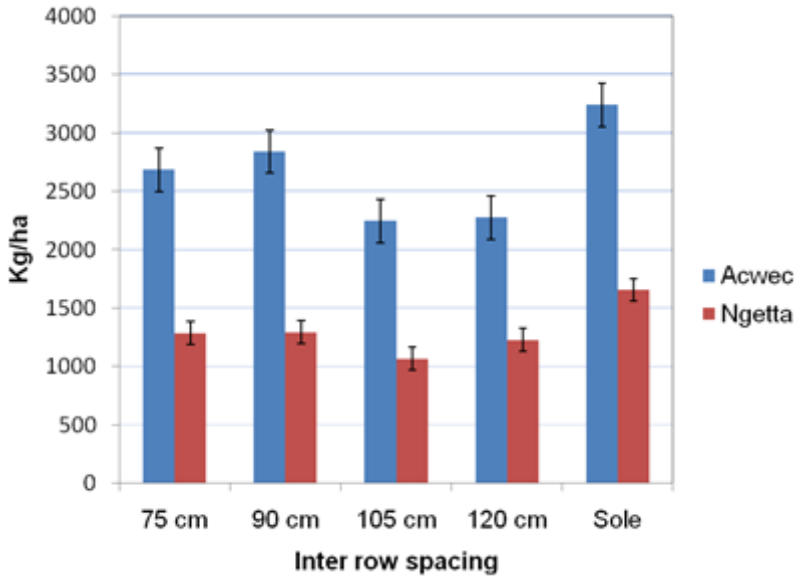

Figure 1. Grain yield of sunflower at Acwec Omio and Ngetta ZARDI sites at different inter-row spacing in Uganda.

higher yield of soybean was obtained at Acwec Omio compared to Ngetta.

The study revealed that higher yields of sunflower were obtained from 30 and 40 cm spacing compared to 50 and 60 cm (Fig. 3). The result (Fig. 3) also indicated an interaction between intra and inter-row spacing. At 75 cm spacing, yield from 30 and 40 cm spacing was similar, but there was higher yield from 30 cm compared to 40 cm spacing, when the inter-row spacing was 90 cm. At 105 and 120 cm inter-row, higher yield was from 40 cm compared to 30 cm.

Higher yield of soybean was obtained from 50 cm and 60 cm wide spacing

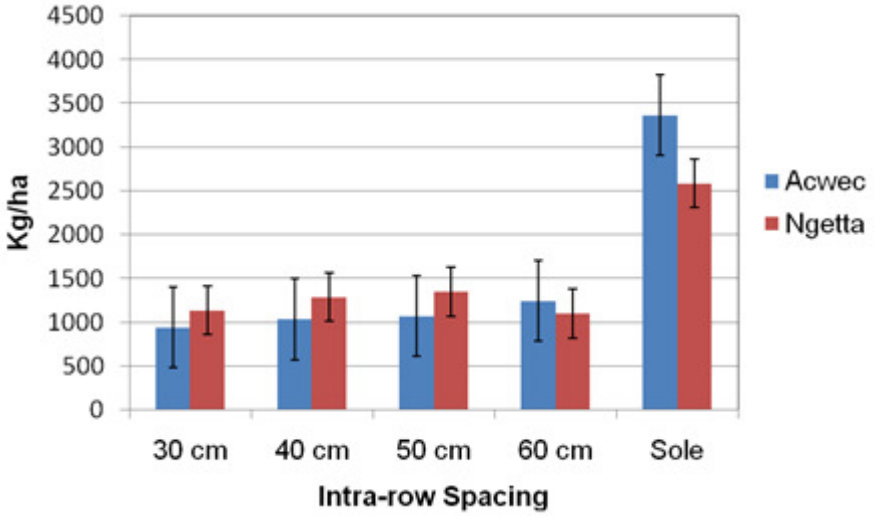

Figure 2. Grain yield of soybean at Acwec Omio and Ngetta ZARDI sites at different intra-row spacing in Uganda.

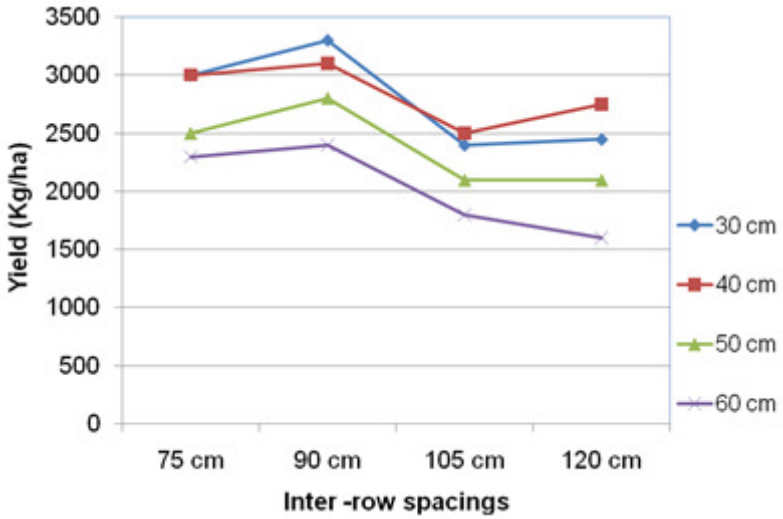

Figure 3. Effect of inter- and intra-row on average grain yield of sunflower in an intercrop with soybean at Acwec Omio and Ngetta ZARDI in Uganda.

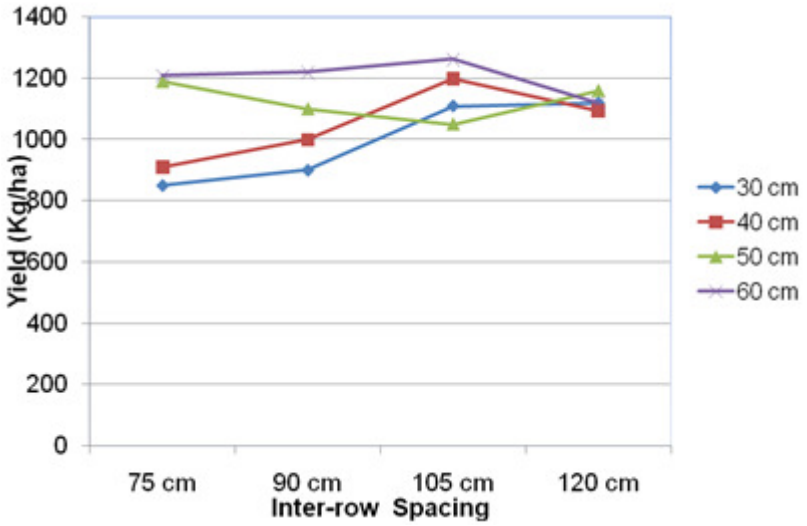

Figure 4. Effect of inter- and intra-row spacing on average grain yield of soybean in an intercrop with sunflower at Acwec Omio and NgeZARDI in Uganda.

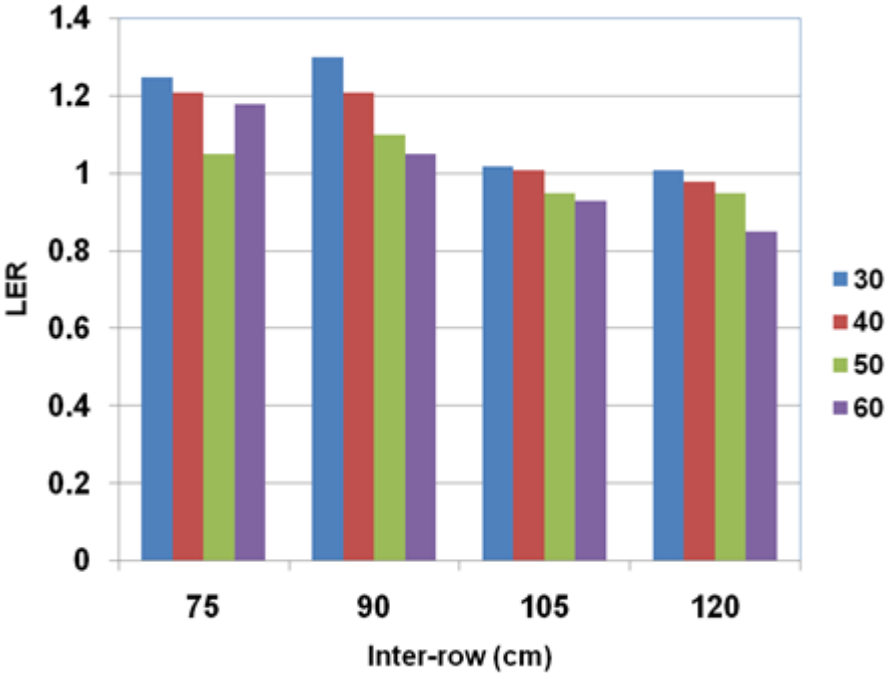

Figure 5. Effect of inter- and intra-row spacing on average Land Equivalent Ratio in a sunflower/soybean intercrop at Acwec Omio and Ngetta ZARDI in Uganda.

compared to 30 and 40 cm, when the inter row spacings were 75 and 90 cm. When intra-row spacings were 30 and 40 cm, yield of soybean increased as the inter-row spacing increased up to 105 cm; and decreased when the inter-row was 120 cm-wide. At wider intra-row spacing, the average yield of soybean was not significantly affected (Fig. 4).

Land equivalent ratio was more than 1 at most spacing, except at 105 cm x 60 cm, 105 cm x 50 cm, 120 cm x 60 cm and 120 cm x 50 cm spacing (Fig. 5). Planting sunflower/ soybean intercrop was, therefore, appropriate at 30 and 40 cm wide-spacing, since LER were above 1.

Discussion

The results indicated that average yields of sunflower and soybean were higher from Acwec Omio compared to NgeZARDI (Fig. 1). Fields in Ngetta had no records of crop rotation, suggesting some soil exhaustion due to lack of proper land use; while in Acwec Omio the land was newly cultivated. Yields of soybean and sunflower were not seriously affected by sunflower/soybean intercropping at Acwec Omio.

LER ranged from 1.29 to 0.8 at 90 cm x 30 cm and 120 cm x 60 cm, respectively; an indication that soybean can be used as intercrop with sunflower (Mead *et al*., 1980; Olowe *et al*., 2006). The low LER values below 1.0 at 105 cm x 50 cm, 105 cm x 60 cm, 120 cm x 50 cm and 120 cm x 60 cm spacing were due to low plant densities of both sunflower and soybean. This was substantiated by the high yield per plant and number of branches with pods (Olowe and Adebimpe, 2009).

The significant interaction between 30 and 40 cm intra-row spacing need more verification. However, intercropping with sunflower spaced at 90 cm x 30 cm gave the highest yield of sunflower and 105 cm x 40 cm gave the highest yield of soybean. Higher yield obtained from 30 and 40 cm-wide spacing than 50 and 60 cm intra-row spacing when inter row was 90 cm, would suggest that planting at 30 and 40 cm spacing would be more profitable when sunflower is the main crop.

From the result of this study, soybean can be intercropped with sunflower, since LER in most spacing is above 1 (Olowe and Adebimpe, 2009). Sunflower gave similar yield under a wide range of population density indicating its high yield elasticity (Robinson *et al*., 1982), hence, it is a good candidate for intercropping.

The larger the intra row spacing, the higher the yield of soybean (Fig 4). This was due to reduced competition for light and moisture.

The results from this study suggest that planting sunflower at 90 cm-wide and 30 cm between plant was more efficient in utilising land under sunflower/soybean intercrop (Fig. 5). Since sunflower is becoming a major crop in the northern and eastern part of Uganda, and land pressure is increasing, there is need for a study on the nutrient balance after harvesting the intercrops.

Acknowledgement

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