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Crop Performance and Yield of Groundnut, Sesame and Roselle in an Agroforesty Cropping System with *Acacia senegal* in North Kordofan (Sudan)

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Abstract

Crop performance and yield of groundnut (*Arachis hypogea*), sesame (*Sesamum indicum*) and roselle (Hibiscus sabdariffa) were investigated in an intercropping system with *Acacia senegal* and compared with sole cropping. The study was conducted in North Kordofan (Sudan) on loamy sand. Experimental design was a randomized complete block with split plots.

Crop performance and crop yield of groundnut, sesame and roselle were significantly ($p < 0.05$) reduced in the intercropping system compared to sole cropping. However, yield reduction in groundnut (53%) was much higher than in sesame (6%) and roselle (14%).

The reduction in yield of the intercropping plots could be due to the high tree density, which results in water and light competition between the trees and the agricultural crops.

Keywords: *Arachis hypogea*, 'Hashab', *Hibiscus sabdariffa*, parkland cropping, *Sesamum indicum*, soil conservation, Sudan, yield reduction

1 Introduction

Greater Kordofan lies within the Savanna zone of Central Sudan. Most of the rural people depend on production of their own agricultural crops. The traditional rainfed agriculture involves a bush-fallow system (shifting cultivation) on the sandy soil (HUSSEIN, 1983). However, in recent years, successive droughts, desertification and the decline in soil fertility mean that there is a need for a new concept for rational use of resources for sustainable agricultural production, such as agroforestry systems.

The concept of rational use of natural resources for sustainable production has captured international attention. In this respect, the significant role of agroforestry has been emphasized as a rational farming practice, particularly in fragile ecosystems similar to Kordofan (NOEL *et al.*, 1990; FADL, 1999).

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Acacia senegal (L., Willd.), locally known as 'Hashab', of the family Leguminosae is an important multipurpose tree species for the Sudan and other tropical countries. It is the main producer of 'Gum Arabic' and also provides firewood, building material and fodder. Trees such as *A. senegal* play a considerable environmental role in combating desert encroachment and minimizing soil erosion in North Kordofan (NAS, 1986).
Among the main cash crops in the North Kordofan area are groundnut, sesame and roselle. Groundnut and sesame are used for producing oil. The fleshy calyx of the roselle is used for local drinks and is exported to different countries (Bashir, 2001).
The purpose of the field experiment was to determine the effects of *A. senegal* on the growth performance and yield of groundnut (*Arachis hypogea* var. Sodari), sesame (*Sesamum indicum* var. Harihri) and roselle (*Hibiscus sabdariffa* var. Shaloft Elnaga) in an agroforestry system.

2 Material and Methods

2.1 Study area

El Demokeya forest reserve is located 30 km east of El Obeid town (latitude 13° 11' N, longitude 30° 12' E). The forest covers more than 3150 ha and is naturally dominated by *Acacia senegal*. The soil is classified as Entisol, according to the USDA Soil Survey and locally known as 'Goz'. The soil texture is loamy sand, where the sand fraction amounts to more than 90%. The concentrations of organic matter, nitrogen and phosphorus are very low, less than one percent. The annual rainfall in this area ranges between 280 and 450 mm in the months from July to September. The mean relative humidity is 34% and varies between 14% in the dry season and 60% in the wet season. Evaporation is 15.5 mm and increases to 20.0 mm in hot summer months. The mean annual minimum and maximum temperatures range between 20°C and 35°C, respectively.

2.2 Experimental design

The study was conducted in a 15 year-old parkland plantation of *Acacia senegal* within the El Demokeya forest reserve. The trees had an average height of 247 cm and an average crown width of 205 cm.
The experimental design was a randomized complete block with split plots and four replications. Each block was divided into six plots: three plots represented the intercropping, while the other three represented the sole cropping (control). Plot size was 20 × 20m. Intercropping plots had an average of 20 trees per plot. Initially, the experimental sites were manually cleared of undesirable vegetation and fenced as necessary. Seeds of groundnut, sesame and roselle were sown on 15th of July 1999. Plant holes were manually dug with a hoe at the spacing 60 × 20 cm, 50 × 30 cm and 50 × 50 cm for groundnut, sesame and roselle, respectively. The seed rate for groundnut and roselle was 2 seeds per hole and for sesame 3 seeds per hole. The spacing and seed rate were applied according to the standard practice of El Obeid Agricultural Research Station. Two weedings were done at both sites after 14 and 30 days after sowing.
The crops were harvested at physiological maturity during November (groundnut, sesame) and December (roselle) in the same year. Plant height, number of leaves and

capsules, and crop yield were measured after harvesting the plants.
Data were analysed by using the *MSTAT-C statistical package* (version 2.10) developed by Michigan State University. For the parameters showing significant differences, the means were compared by the least significant differences (LSD at 0.05).

3 Results

Results of plant height are shown in Table 1. Analyses of variance indicate significant differences ($p < 0.05$) between the two cropping systems in the sesame and roselle crop. In the groundnut crop the plant height was not significantly reduced in the intercropping system.
Table 2 shows the number of leaves per plant in the intercropping and sole cropping system of the tree crops. Numbers of leaves were significantly reduced in the intercropping system for all crop species. The highest reduction was recorded for sesame.
Numbers of capsules in the intercropping and sole cropping of groundnut, sesame and roselle are shown in Table 3. In all crops there were lower numbers of capsules per plant in the intercropping. However, the difference for roselle was not significant. The

Table 1: Plant height of groundnut, sesame and roselle as affected by cropping system (cm).

crop	*intercropping*	*sole cropping*
groundnut	17.2 ^{a}	18.4 ^{a}
sesame	44.8 ^{a}	58.2 ^{b}
roselle	63.7 ^{a}	67.1 ^{b}

Means within a row followed by different letters are significantly different ($p < 0.05$) according to LSD test.

Table 2: Number of leaves of groundnut, sesame and roselle as affected by cropping system.

crop	*intercropping*	*sole cropping*
groundnut	22.7 ^{a}	29.3 ^{b}
sesame	26.0 ^{a}	51.0 ^{b}
roselle	40.7 ^{a}	57.0 ^{b}

Means within a row followed by different letters are significantly different ($p < 0.05$) according to LSD test.

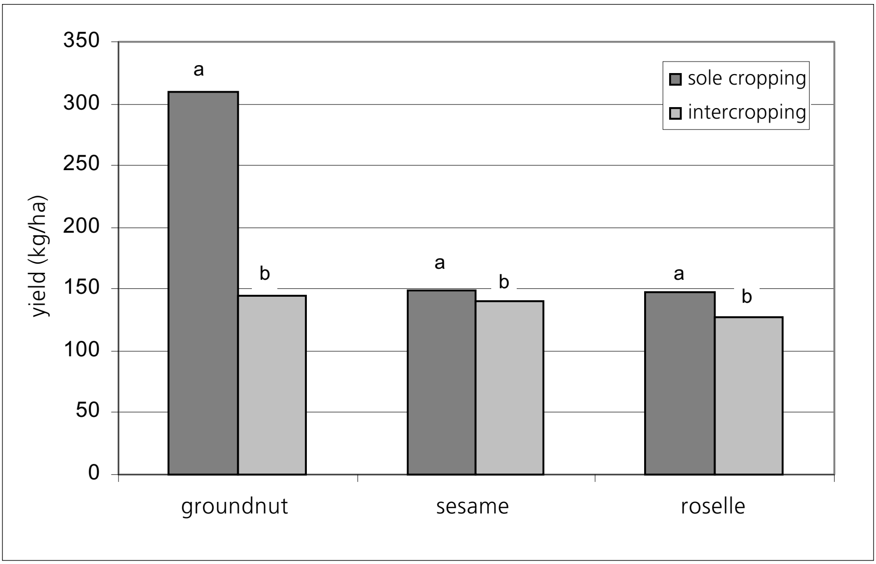
Table 3: Number of capsules of groundnut, sesame and roselle as affected by cropping system.

crop	*intercropping*	*sole cropping*
groundnut	10.3 [a]	14.0 [b]
sesame	12.3 [a]	14.0 [b]
roselle	26.3 [a]	26.7 [b]

Means within a row followed by different letters are significantly different ($p < 0.05$) according to LSD test.

comparative yields of groundnut, sesame and roselle in the intercropping plots and sole crop plots are shown in Figure 1. The difference in yield was highest in the groundnut crop. Intercropping reduces the yield by 53% from 309.9 kg/ha to 144.5 kg/ha. The yield reduction in sesame and roselle was only 6% and 14%, respectively. However, the differences were still significant.

Figure 1: Yield of groundnut, sesame and roselle as affected by cropping system. Means with different letters are significantly different ($p < 0.05$) according to LSD test.



4 Discussion

Trees are considered to have a positive influence on the soil physical properties and the soil nutrient content. Investigations in a plantation of *A. senegal* on sandy soils in Kordofan have recently shown that the soil was much richer in organic matter and in the major nutrient elements (AHMED and NIMER, 2002). The higher N level in the soil is often attributed to the ability to fix atmospheric nitrogen in symbiosis with rihzobium in root nodules of Acacia spp. (ZHANG *et al.*, 1992). Nitrogen input levels are particularly important, since many dry soils are nitrogen deficient (JAMES and JURINAK, 1978; NOEL *et al.*, 1990).

Nevertheless, the growth and yield of each crop species were depressed when combined with *A. senegal* because of interspecific competition, which in some instances may become detrimental (RUSSEL, 1955). In the growing season 1999 the annual rainfall was exceptionally low with less than 300 mm. Competition for water results in adverse effects of trees on intercrops under moisture stress conditions (ICRISAT, 1987).

The water deficiency effect was especially high in the groundnut crop resulting in the highest reduction in growth and yield. During the experiment it was already observed that the groundnut plants suffered from water deficiency in the intercropping plots (wilting).

This can be attributed to the shallow root system of the groundnuts. Generally sandy soils are characterized by a high infiltration rate. After heavy rain the upper soil layer often dries within a few hours. The high competition between the roots of the crop and the tree in the upper soil layer probably results in the high yield reduction in the groundnut crop. Sesame and roselle are characterised by a tap root system, which allows them to reach water in deeper soil layers.

Shading can also be seen as a factor which can lead to a reduction in crop performance and yield in the intercropping systems (NEWMAN *et al.*, 1998; RAO *et al.*, 1998). Groundnuts are a rather short crop reaching a maximum height of 20 cm above soil level on the sandy soils in Kordofan. The negative effect of tree shading was strongest in the groundnut crop, because the low height of the crop means that it has very limited possibilities to grow out of the shade. In contrast to groundnuts, sesame and roselle have much higher vertical growth (Table 1) and therefore have a much higher ability to reach available light. The high tree density also results in a greater cultivable area being sacrificed to the trees, which leads to a reduced yield per ha.

However, agroforestry systems including *A. senegal* provide a good household income from 'Gum Arabic' production (US$ 346 per ha and season) which can easily compensate for the yield losses. Also, *A. senegal* in Central Sudan serves a major role in soil conservation, preventing erosion restoring fertility and providing fuel wood and fodder as a multipurpose tree (BUNDERSON *et al.*, 1990).

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