

Sorghum-rice intercropping, a security system for the poorly drained soils of Southern Sudan

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Abstract

In parts of Southern Sudan, sorghum production varies greatly from year to year due to the occurrence of floods in some years. These floods are caused by a combination of high rainfall within a short period, poorly drained soils, and varying micro-relief.

To improve the reliability of food production, a sorghum-rice intercropping system was tested in 1980 and 1981 on an area prone to such flooding. In these experiments sorghum proved to produce good yields at the expense of rice on areas which had been little flooded, whereas on waterlogged areas sorghum produced little while rice gave good yields. It may therefore be concluded that intercropping of rice with sorghum offers a good possibility to offset the loss of sorghum in wet years.

Introduction

A large part of Southern Sudan lies in the flood plain of the Nile. Its overall topography can be characterized as flat, with small differences in elevation. Most of the soils are alfisols or vertisols with poor internal drainage and little capacity to store available moisture, rendering them prone to both flooding and drought (Ilaco, 1982). The alfisols, which have a relatively sandy top-soil, are mostly found on the higher parts and the vertisols on the lower. It is possible that the alfisols were formed through lateral washout of the fine particles towards the lower parts, increasing the fertility and water-holding capacity of the latter.

The inhabitants of the region are semi-nomadic subsistence farmers who grow some maize, cowpea, tobacco, okra and pumpkin on areas close to their huts, where flooding is rare. Their main crop, however, is sorghum, which is grown on the high and intermediate areas around these fields. The farmers try to obtain two sorghum crops per year by ratooning the first crop or sowing a second crop at the

end of the rainy season. Although differences in elevation within the fields are relatively small, the intermediate areas may be flooded from time to time during the rainy season. Fortunately, sorghum is relatively unsusceptible to flooding (Doggett, 1970), but prolonged periods of waterlogging can nevertheless seriously reduce yields or may even kill the crop. Sorghum yields will therefore be relatively high in dry years and low in wet years. This makes food production in the flood plain unreliable: in dry years sorghum production may be sufficient to sustain a family, but in wet years cattle have to be sold to buy sorghum on the market if it is available at all.

In an attempt to obtain more reliable yields, the low areas were planted to rice. Yields were satisfactory (Ilaco, 1980), but because the low-lying areas constitute only a small portion of the farmers' fields it was obvious that this was not a solution to the problem. This experience, however, prompted the suggestion that rice might also succeed on the intermediate areas in years of high rainfall, so that a sorghum-rice intercropping system would secure reliable food production: in dry years sorghum would grow well and in wet years rice would give good yields. To test these ideas a sorghum-rice intercropping experiment was set up on a field similar to those of the farmers.

The author published an earlier article on this subject outlining the general principles of this system (Struif Bontkes, 1985). The present paper elaborates on the technical background of the experiments.

Materials and methods

The experiments took place in 1980 and 1981 in a field at Anyidi, a village 25 km east of Bor. In order to compare the effects of different soil moisture conditions, a field was selected which was not entirely level: the differences were up to 20 cm. Moreover the elevation of the field did not show a regular pattern, so that not only the absolute elevation was important for the extent of flooding but the relative elevation as well.

Since the purpose of the experiments was to develop improvements which would be applicable by the local farmers, no action was undertaken to alter the irregularities of the surface.

The soil was of the alfisol type, but the top-soil of the higher parts contained more sand than the lower parts. Sorghum was dibbled at 15 cm in the rows, which were 75 cm apart. Between each row of sorghum, two rows of rice were line-sown at a distance of 25 cm. To assess the influence of different types of rice, the sorghum was combined with three rice cultivars with different characteristics: a quick-maturing short-straw cultivar (IR 24 in 1980 and IR 26 in 1981), a later-maturing short-straw cultivar (IR 269-26-3-3-3), and a photosensitive tall cultivar (Tau Ainho). In 1980 Serena, an exotic short-statured sorghum was used, but as the local population did not like its bitter taste and as the crop proved to be more susceptible to insect damage than the local cultivars, Lokarengan, an indigenous cultivar, was chosen in 1981. In line with local practice, no fertilizers or biocides were applied, and all labour was by hand. The most important data on the experiments are given in Table 1.

Table 1. Summary of the materials and methods of the sorghum-rice intercropping experiments in 1980 and 1981.

	1980	1981
Sorghum cv.	Serena	Lokarengan
Rice cv.	IR 24 IR 269-26-3-3-3 Tau Ainho	IR 26 IR 269-26-3-3-3 Tau Ainho
Plot size	5.0 m × 3.75 m	5.0 m × 3.75 m
Replications	6	6
Date of sowing	17 May	6 May
<i>Date of harvesting</i>		
Sorghum	16 September	9 September
IR 24/IR 26	4 October	27 September
IR 269-26-3-3-3	16 October	10 October
Tau Ainho	24 October	17 October

In order to establish whether variations in yield were due to differences in the hydrological condition of the plots, observations regarding the soil moisture conditions were made three times during the growing period. On the basis of these observations the plots were classified into three categories:

- dry, with on average 0-25 % of the plot flooded;
- medium, with on average 25-75 % of the plot flooded;
- wet, with on average 75-100 % of the plot flooded.

As soil moisture conditions are partly a result of rainfall, the monthly rainfall was also recorded. For the statistical analysis of the results, two factors were taken into consideration: the rice cultivar and the replication, the latter representing the variation in field conditions. It was assumed that this variation would mainly be caused by the differences in soil moisture in different plots. The hypothesis, then, was that the rice and sorghum yields of the individual plots would vary significantly between the replications, but that the combined plot yields of both crops would not. This would mean that intercropping of sorghum and rice promotes stable production, little affected by varying moisture conditions. However, although the soil moisture characteristics of the plots turned out to be similar within some replications, there appeared to be differences within others. This renders it more difficult to prove that the hypothesis is correct but would not invalidate such an outcome.

Results and discussion

In both years there was prolonged flooding of the lower parts of the experimental area, while the highest parts were little flooded. Although the rainfall in 1980 and 1981 remained below average, the rainfall during the period May-September in these two years slightly exceeded that of the average rainfall in these months (Table 2). However, monthly rainfall figures may not give sufficient information regarding the soil moisture condition because this condition depends not only on the total monthly rainfall but also on the distribution of the rainfall over that month.

Table 2. Average monthly rainfall at Bor (1931-1970) and actual monthly rainfall at Anyidi, 1980 and 1981.

	Bor 1931-1970	Anyidi 1980	Anyidi 1981
January	5	0	0
February	7	0	0
March	35	3	32
April	77	35	39
May	113	189	108
June	112	161	159
July	145	109	156
August	130	119	160
September	125	71	82
October	114	151	54
November	30	?	?
December	6	0	0
Total	899	≅838	≅790

Source: Ilaco (1981).

During the growing period in 1980 it was noticed that weeds did not constitute a serious problem on the wet areas, whereas these areas are usually severely infested with weeds when sorghum is the only crop.

The yields per plot for 1980 and 1981 are given in Table 3 and Table 4 respectively.

The analysis of variance of the 1980 experiment shows that the sorghum yield varies significantly ($P < 0.01$) with the rice cultivar with which it was combined, but that the rice cultivars had no significant influence on the rice yields nor on the total yield per plot. The yield of sorghum and rice varies significantly per replication ($P < 0.01$), but the combined plot yield is not influenced by the replication.

The analysis of variance of the 1981 experiment shows that the rice cultivar had no significant influence on the yield of sorghum, rice or the two combined. Here

Table 3. Plot yields (kg/ha) of sorghum and rice in the sorghum-rice intercropping experiment, related to rice cultivar and replication, 1980.¹

Combination	Replication					
	I	II	III	IV	V	VI
1. Sorghum	170w	340m	40w	250m	360m	1060d
IR 24	2560	1060	2910	1310	2250	1220
2. Sorghum	90w	860m	130w	970d	1190d	1490d
IR 269-26-3-3-3	3050	1690	4010	1310	1820	1280
3. Sorghum	40m	430d	0w	330m	0w	860d
Tau Ainho	2720	1390	2190	2000	3360	820

¹ d = dry, m = medium, w = wet.

Table 4. Plot yields (kg/ha) of sorghum and rice in the sorghum-rice intercropping experiment, related to rice cultivar and replication, 1981.¹

Combination	Replication					
	I	II	III	IV	V	VI
1. Sorghum	700w	1940m	2140d	180w	380w	2060d
IR 26	2360	900	240	2240	2400	280
2. Sorghum	570w	1750d	1930d	120w	610w	2770d
IR 269-26-3-3-3	2210	590	590	2580	1610	390
3. Sorghum	120w	2040d	1370m	30w	1730d	2250d
Tau Ainho	3250	930	760	3790	1180	200

¹ d = dry, m = medium, w = wet.

again the replication had a significant influence ($P < 0.01$) on the sorghum and the rice yields but not on the yields of the two crops combined.

Fig. 1 shows how the yields of rice, sorghum and the two crops combined vary with the soil moisture conditions. The averages of these yields are plotted against the soil moisture conditions for both years. Fig. 1 suggests that the yields of rice and

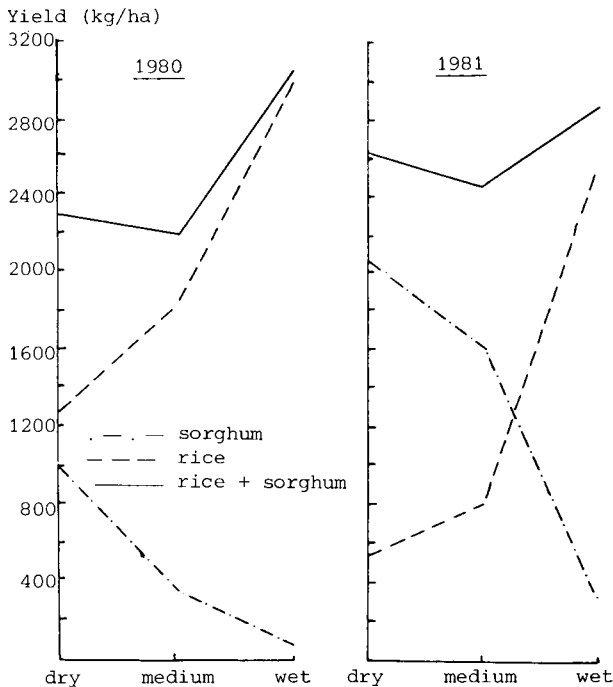


Fig. 1. The average yields of rice, sorghum, and rice plus sorghum under different soil moisture conditions in 1980 and 1981.

sorghum are seriously affected by the soil moisture conditions but that a combination of the two crops gives a fairly constant yield.

It is also noticed that the sorghum yields were higher and the rice yields lower in 1981 than in 1980, although there was not much difference in the total rainfall during the growing season. The explanation for this difference should probably be sought in the detailed distribution of the rainfall during this period, but information on this is not available. Similarly, the fact that the rice cultivar influenced the sorghum yield in 1980 but not in 1981 may also be attributable to the distribution of rainfall.

Conclusions

Crop mixtures which include rice are found mainly in areas with high rainfall and well-drained soils (IRRI, 1974, p. 336-339; IRRI, 1978, p. 370-373; Steiner, 1982). Intercropping of rice and sorghum is not usual, as sorghum does not grow well in areas of high rainfall, while rice grows poorly in the drier areas suitable for sorghum. The results of these experiments show, however, that sorghum-rice intercropping may be useful under conditions of moderate rainfall combined with poorly drained soils. The main advantage is that rice grows well on areas which are subject to flooding, while sorghum yields better on drier areas. Areas which are sometimes flooded and sometimes dry produce intermediate yields for both crops. In this way it is possible to achieve a food production system which is less dependent on rainfall pattern. Other advantages are: (1) that rice suppresses growth of weeds on wet areas and (2) that by cultivating rice, optimum use is made of the high fertility of the low areas, which is brought about by the accumulation of fertile material from the higher areas.

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