THE EFFECT OF INTERCROPPING GROUNDNUT (*Arachis hypogea* L.) WITH SORGHUM (*Sorghum bicolor* L. Moench) ON YIELD AND CASH INCOME

LANGAT M.C., OKIROR M.A., OUMA J.P., GESIMBA R.M.

Abstract

This study was carried out at Busia Farmers' Training Center during the short rains of 1998 and long rains of 1999. The objective was to come up with groundnut - sorghum intercropping spacings that are appropriate in land use efficiency, yield, and monetary returns compared to monocropping. It comprised six treatments: four intercrops (GS1-4) and two sole crops of groundnut (G) and sorghum (S). The trial was laid out in a randomized complete block design with four replications. The populations of groundnut and sorghum in the intercrop affected their performance. The highest sorghum grain yield (3846 kg/ha) was found in GS4 (two groundnut rows alternated with two sorghum rows) in 1998 and in GS3 (one groundnut row alternated with two sorghum rows) with 3825 kg/ha in 1999. The highest groundnut yield was realized in GS2 (two groundnut rows alternated with one sorghum row) with 1045 kg/ha in 1998 and (790 kg/ha) in 1999. In terms of land use efficiency, GS4 was the best pattern, with LERs of 2.12 (1998) and 2.01 (1999). Similarly, the highest cash returns were also from GS4 in both seasons. Therefore, for maximum use of land and with no crop preference, GS4 is the best combination to use. However, if priority is to maximize sorghum yield, then GS3 is recommended.

Key words: Intercropping, sorghum, groundnut, yield, cash income.

INTRODUCTION

Several constraints have been identified as limiting in groundnut production in Western Kenya (Okiror *et. al*., 1997). Amongst them are the small farm sizes (1.7 to 2.5 ha per family), and the very small proportions (0.01 to 0.12 ha per household) under groundnuts. Besides, farmers were also observed to grow several crops simultaneously, and to grow groundnut in pure stands leading to low levels of 690Kg/ha of groundnut yield. These factors, singly or collectively therefore affected groundnut production. While farm sizes and crop enterprises may be difficult to change, at least in the short term, adoption of intercropping in groundnut production is a viable option. However, the economic benefits of this farming practice to the local groundnut farmers are yet to be established. The economic implication of intercropping groundnut with such a cereal as sorghum, to the farmer, was therefore investigated in this study.

Sorghum is an important food security crop in the drier areas around Lake Victoria region, including medium and low altitude areas. This is the area where maize does poorly and sometimes fails totally due to erratic rains, pests and diseases (Salasya *et. al.*, 1996). It has also been found that in the dry highlands of Kenya, especially in the Rift Valley Province, tolerant sorghums adapted to the cold are capable of producing grain on land previously considered unsuitable for cereal crops (Enserink, 1995). Current sorghum production stands at 130,000 metric tonnes (Anon, 2003). Both maize and sorghum are always given priority over other crops through timely planting and/or cropping area size, with maize dominating in the wetter zones and sorghum in the drier zones (Rees *et. al.*, 1998).

In order to achieve self-sufficiency in cereal production and meet the demand for food by the year 2013 in Kenya, it is suggested that cereal production must increase by 6.7 million metric tonnes, of which sorghum production must increase by 360,000 metric tonnes or by 300% (Anon., 1993 a). Overcoming obstacles on land use and diminishing farm sizes has been identified as a requirement for achieving these production targets. Intercropping therefore becomes one of the options for a viable and sustainable solution as well as improving groundnut production in Kenya.

MATERIALS AND METHODS

Site : This study was conducted at Busia Farmers' Training Center (FTC) in Busia District of Kenya during the short rains of 1998 and long rains 1999. Busia is a major groundnut-growing district in western Kenya and is characterized by small altitudinal variations between 1140 and 1350 m a.s.l. It has four major agro - ecological zones (AEZs), namely, low midland zones 1 and 2 (LM1 and LM2) and upper midland zones 1 and 2 (UM1 and UM2). The study was conducted in agro-ecological zone LM1, where annual temperatures range between 21^{o}- 23^{o}C (Enserink, 1995). The area receives bimodal rainfall with an annual precipitation of 1400 - 1500 mm. Relative humidity is fairly high due to the site proximity to Lake Victoria and soils are predominantly nitisols and ferralsols (Jaetzold and Schimdt, 1983).

Experimental Design and Treatments

The experiment was laid out in a randomized complete block design with four replicates. It comprised six spatial arrangements: four sorghum (S) and groundnut (G) mixtures and sole crops, one for each crop. These treatments were designated, G, S, GS1, GS2, GS3 and GS4. The sorghum variety Seredo and groundnut variety Red Valencia were planted. Treatments 1 - 4 represent the various combinations, the details of which are as follows:

GS1: 1 row of groundnut alternated with 1 row of sorghum with sorghum sown at a spacing of 90 x 25 cm and groundnut at 90 x 10 cm, giving a final plant population of 50% of each crop in the mixture.

GS2: 2 rows of groundnut alternated with 1 row of sorghum, with sorghum sown at a row spacing of 135 x 30 cm and groundnut at an average spacing of 67.5 x 9 cm, giving a final plant population of 25% sorghum and 75% groundnut.

GS3: 1 row of groundnut alternated with 2 rows of sorghum, with sorghum sown at a row spacing of 82.5 x 20 cm and groundnut at an average row spacing of 165 x 20 cm with 2 seeds per hole, giving a final plant population of 75% sorghum, and 25% groundnut.

GS4: 2 rows of groundnut alternated with 2 rows of sorghum, with sorghum sown at a row spacing of 105 x 17.5 cm and groundnut at a row spacing of 105 x 9 cm, giving a final plant population of 60% sorghum and 40% groundnut.

Sole sorghum was spaced at 75 x 15 cm and sole groundnut at 45 cm x 10 cm. Therefore in forming intercrop mixtures. 2.5 groundnut plants were equivalent to one sorghum plant.

Data collection and analysis

Data on grain yield (Kg/ha), tillers per plant, panicles per plant and 1000-grain weight was collected for sorghum while seeds per pod, pods per plant, number of primary branches per plant, 100-seed weight and shelling percentage were obtained for groundnut. These data were subjected to analysis of variance tests using SAS software (SAS, 1995). Treatment means that were significant were separated using the Duncan's multiple range test (DMRT) at p = 0.05.

Land equivalent Ratio (LER): To determine land use efficiency LERs were calculated thus:

$$LER = La + Lb = Ya / Sa + Yb / Sb$$

Where La and Lb = Partial LERs of crop a (sorghum) and b (groundnut)

Ya and Yb = Individual crop yields in intercropping,

Sa and Sb = Individual crop yields in sole crop and intercrop.

Competitive Indices: Two measures of competitiveness of crops in intercropping, namely, competitive ratio (CR) and the relative crowding coefficient (RCC) were calculated as follows:

(i) Competitive Ratio, CR

$$CRa = Yab/Yaa \times Zab + Yba/Ybb \times Zba$$

$$CRb = Yba/Ybb \times Zba + Yab/Yaa \times Zab$$

Where:

'a' refers to sorghum and 'b' refers to groundnut.

Yab is the yield/unit area of crop 'a' intercropped with crop 'b' (expressed for the area occupied by both crops)

Yaa is the yield /unit area of crop 'a', Yba is the yield / unit area of crop 'b' intercropped with 'a' (expressed for the area occupied by both crops)

Zab is the proportion of intercropped area initially allotted to crop 'a'

Zba is the proportion of intercropped area initially allotted to crop 'b'

CRa is the competitive ratio of 'a' species, and

CRb is the competitive ratio of 'b' species.

(ii) Relative Crowding Coefficient, RCC

$$RCCab = Yab/Yaa - Yab \times Zba/Zab$$

$$RCCba = Yba / Ybb - Yba \times Zab / Zba$$

Where:

'a' refers to sorghum and 'b' refers to groundnut

RCCab is the relative crowding coefficient of crop 'a' intercropped with crop 'b', and

RCCba is the relative crowding coefficient of crop 'b' intercropped with crop 'a'.

Economic Analysis: To determine the most profitable groundnut-sorghum intercropping pattern, economic analysis was done through partial budgeting.

RESULTS AND DISCUSSION

(A) Yield and Yield Components

Sorghum:

The performance of sorghum in both intercrop and sole crops in respect to yield and its components is given in Table 1. Intercropping significantly affected the yield of sorghum. The highest grain yields of intercropped sorghum were in GS4 (3846 kg/ha) in 1998 and GS3 (3825 Kg/ha) in 1999. The high yields of sorghum in GS4 (double sorghum rows alternated with double groundnut rows, with 60% sorghum population in the mixture) could be due to the row arrangement. In GS3, every two sorghum rows were separated by a single groundnut row. This means GS3 had a higher sorghum density than GS4, and hence competition for soil moisture and nutrients could have been high and might have caused the yields of sorghum to drop significantly in GS3 in 1998. In 1999, there was no moisture stress, and sorghum yields in GS3 were higher than in GS4. However, the difference was not significant. These yields (GS3 and GS4) were comparable to those attained in pure stands of sorghum. The lowest yield of sorghum in both seasons was in GS2 (Double groundnut rows alternated with single sorghum rows). The low proportion of sorghum in the intercrop (25%) might have caused this difference.

Intercropping significantly affected the yield components of sorghum; the number of tillers and viable panicles per plant were generally higher in intercrops than in pure stands. The intercrop pattern with the most tillers and viable panicles per plant in 1998 was the one with the lowest sorghum population i.e. GS2. This could be due to a wider inter-row and intra-row spacing between any 2 sorghum plants in this treatment. Since sorghum roots extract moisture from a deeper soil horizon than groundnut, sorghum plants had a wider area to derive water and nutrients in this treatment (GS2) than sorghum in both sole and the other intercrop treatments. There was little difference in 1000-grain weight between the treatments.

Groundnut:

The highest yield of intercropped groundnut was 1045 and 790 kg/ha in 1998 and 1999 seasons respectively and both yield figures were in treatment GS2 (75% groundnut and 25% sorghum) (Table 2) – same plant densities were used in both seasons. However, these yields were not significantly different from those of sole groundnut. Proportionately, yields declined with declining proportion of groundnut in the mixture except in GS4. Intercropping also significantly affected the number of seeds per pod. In 1998 the highest number of seeds per pod was in GS4 (2.8). However, this was not significantly different from those of GS2 and GS3. In 1999, the highest number of seeds per pod (2.3) was in GS2 (75% groundnut and 25% sorghum) and was comparable to that of GS4. In both seasons groundnut (G) and GS1 treatments had the lowest number of seeds per pod. This is despite both having the highest proportions of groundnuts.

In the 1998 season, groundnut produced an average of 17 pods per plant in GS3 when 75% of the groundnut was replaced with 75% sorghum in the mixture. The lowest number of pods was realized in GS1 and in pure groundnut. The lowest pod number was in pure groundnut (8) and GS1 (12). In 1999, the highest number of pods per plant, though much lower than in 1998, was in GS2 (7.0 pods/plant). This could have been due to shading which could have affected soil moisture levels. This finding agrees with that of Reddy and Reddy (2000) that the number of pods per plant is influenced by moisture. One hundred seed weight results followed a trend almost similar to that of the number of pods per plant. The number of primary branches was significantly lower in intercrops than in sole groundnut plots in 1998 except GS3. However, there were no significant differences between the intercrops and sole groundnut in 1999. The highest shelling percent was 68% in 1998 from GS1 and 67% in 1999 in GS4. Sole groundnuts had a significantly low shelling percentage (37%) in 1999 and the highest (75%) in 1998. Since the seed yield, seeds per pod, pods per plant, and 100 seed weight were generally lower in the long rains compared to the short rains it seems that groundnut production is more suited for the short rains than the long rains in the study area.

(B) Measuring intercropping productivity

Competitive Indices

Relative Crowding Coefficient (RCC). The RCCs for sorghum (RCCab) were consistently higher than those for groundnut (RCCba) in intercrops in 1998 and 1999 (Table 3). This indicated a generally more competitive ability of the cereal over the legume component. The RCCs above unity mean that by introducing groundnut into sorghum fields, groundnut will not have a negative effect on the sorghum. Also an RCC less than unity means that higher yield than expected has been realized.

Competitive Ratios. All competitive ratios (CRs) were less than 1 in all intercrop treatments in both years (Table 3). This index measures the existence of a yield advantage, such that if the competitive ratio is less than 1, then there is an advantage in intercropping (Willey, 1981). Thus in this study, all intercropping patterns were advantageous over sole cropping.

Land Equivalent Ratio (LER). The **v**alues of LERs indicated better land use in all intercrop treatments in both seasons (Table 4). Yield advantages of between 39% (LER = 1.39) in GS3 and 112% (LER = 2.12) in GS4 were registered in 1998 and between 32% (LER = 1.32) in GS1 and 101% (LER = 2.01) in GS4 in 1999. Therefore in both seasons, GS4 had a yield advantage above 100%. This is the treatment which had double rows of groundnut alternated with double rows of sorghum. However, both crops had the best yield compensations when their proportions were lowest (25%), that is treatment GS3 for groundnut and GS2 for sorghum (Tables 1 and 2). This resulted in their final yields being much less than that of their sole crops leading to significantly low partial LERs. GS4 had a well-balanced yield compensation for both crops, which translated to reasonably good yields for both of them; and hence best land use efficiency (Table 4). The higher yield advantages realized in intercropping in this study were possibly because the vegetative and reproductive phases of the component crops did not coincide. Groundnut matured earlier than sorghum.

(C) Economic analysis

Monetary returns for the various cropping systems and seasons are presented in Table 5. Most intercrop combinations were more profitable than sole crops. Groundnut had a significant monetary contribution because its price to the farmer (Kshs. 5454 per 100 kg bag) was good and stable during both seasons. The highest net return was in 1998 from treatment GS4 (Kshs. 78,486). Though much less, the highest cash returns of Kshs. 48,832 was also realized in GS4 in 1999. These net returns were higher than those from sole sorghum (Kshs 11,874 and Kshs. 21,080) and sole groundnut (Kshs 27,790 and Kshs 2674) in both seasons respectively. It was apparent that cultivating groundnut alone during the long rains results in very low net returns, about Kshs. 3,000/ha compared to approximately Kshs. 29,000 in the short rains. Since groundnut prices did not fluctuate much between seasons, groundnut production is profitable during the long rains season if grown as an intercrop. However, the short rains groundnut can be grown profitably both as a sole and as an intercrop.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study has shown that intercropping sorghum and groundnut may increase, decrease or not affect yields of sorghum and groundnut depending on the spatial arrangements of the intercrops. However, growing sorghum and groundnut in intercrop enhances land use efficiency and increases monetary returns.

Recommendations

1. For a farmer interested in getting maximum yield from sorghum, the crop pattern GS3 (2 rows of sorghum alternated with one groundnut row) would be the best to use in both seasons. If groundnut is the choice crop, GS2 spacing would be ideal. The individual crop yields obtained in these treatments are not significantly different from those of the pure stands, but their total yields were higher than those of the sole crops.
2. Where there is no crop bias and the preference is to maximize land use and or to obtain maximum income, GS4 (2 sorghum rows and 2 groundnut rows) is the better mixture for both seasons.
3. Only one population level was used for the different patterns of this study. An expanded study with different population levels is proposed to determine whether there are greater benefits or yield increases at other levels than those observed at this level.

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Corresponding author

Prof. Margaret C. Langat
Unilever Tea (K) Limited,
P. O. Box 20,
Kericho.
E mail: marglangat@yahoo.com