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# Effect of Row Arrangements on Sorghum-Cowpea Intercrops in the Semi Arid Savannah of Nigeria

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## ABSTRACT

A two year field experiments were conducted at 3 locations (Azare, Bauchi & Misau) in the savannah agroecology of Nigeria to investigate the effects of row arrangements on the yield and productivity of sorghum and cowpea intercrop. The treatments comprised one sole sorghum (*Sam-sorg* 10); one sole cowpea (*Yar-Itas* -a popular local & spreading variety) and three different sorghum/cowpea combinations arranged in replacement series within the rows of 1:2, 1:1 and 2:1 of the sorghum-cowpea combinations. The treatments were replicated five times in a randomized complete block design. Both grain and stover/haulm yields of sorghum and cowpea sole crops were higher than the intercrops. Yields of component crops in the intercrop varied with the row arrangements of crops. There was no significant difference in both the LER and SPI of 1:1 and 2:1 sorghum/cowpea arrangements. However for higher grain and stover yield stability in sorghum (primary crop) a 1:1 and 2:1 sorghum/cowpea row arrangement, respectively should be adopted in the semi-arid savannah zone of Nigeria. 

**Key Words:** Compensation ratio; Row arrangement; Replacement series; Savannah; Sorghum; System productivity index

## INTRODUCTION

Intercropping can be described as the growing of two or more crops simultaneously on the same field. In the Guinea savannah of Nigeria, the practice of growing sorghum and cowpea on the same piece of land is one of the most important cropping systems (Odo, 1991). More than 80% of all cultivated sorghum and cowpeas are grown in combination with each other or with other important field crops, principally millets and groundnuts (Norman, 1974). Elemo *et al.* (1990) observed intercropping as a common practice among traditional farmers of the Nigerian savannah. The farmers have developed and improved on the traditional systems of mixed cropping, but they have maintained relative yield stability at a low yield level. Yields could be improved if optimum cropping patterns, crop growth resource requirements and adapted varieties are known. However the depression in the yield of cereal/legume mixtures has been attributed to shading by cereal of the legume (Chui & Shibles, 1983). Killi (2004) reported that increased plant density resulted in a significant increase in seed yield of sunflower, while a decreasing trend in yield of seed cotton was observed with increasing plant spacing or reduced plant density (Anjum *et al*., 2007).

Ntare (1990) reported that farmers plant sorghum and cowpea in clusters at relatively wide spacing to avoid yield reduction in both crops. A fundamental understanding of how intercrops capture and use resources would provide a scientific basis for recommending appropriate crop combinations for intercropping at different locations. The challenge is therefore, to identify crops capable of sustaining their potential yield when grown in specific row arrangements with other crops. This study was undertaken to determine the row arrangements for optimum productivity of sorghum/cowpea mixtures in the semi-arid savannah zone of Nigeria.

## MATERIALS AND METHODS

Field experiments were carried out for 2 years during the growing seasons (June-October) at three locations (Azare & Misau both in the Sudan savanna & Bauchi in the Guinea savanna ecological zone) to determine the effects of row arrangements on the productivity of sorghum/cowpea intercrops. The physico-chemical analyses of the top soil 0-25 cm following the methods described by Jackson (1967) and mean data for the two years are presented in Table I.

The land was ploughed, harrowed and ridged after the rains have established. The treatments consisted of one sole sorghum (*Sam-sorg* 10); one sole cowpea (*Yar-Itas*), a popular local and spreading variety and three different sorghum/cowpea combinations arranged in replacement series within the rows of 1:2, 1:1 and 2:1 of the sorghum-cowpea combinations. The treatments were replicated five times in a randomized complete block design. Similar cropping density of 66,667 plants $ha^{-1}$ was maintained

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within each of the 8-row plots (6.0 x 4.5 m). The intra-row spacing was 0.45 m, while the inter-row spacing was 0.75 m. At land preparation, all the plots received basal application of 50 kg P $ha^{-1}$ and 45 kg N $ha^{-1}$ before sowing in the three locations depending on the commencement of rainfall. Each plot received additional N-fertilizer in form of urea at 45 kg N $ha^{-1}$ applied to sorghum ridges 4 weeks after sowing. Foliar pests especially aphids and *Heliothis* spp. were sprayed with Karate ED (Monocrotophos) using electro dyne sprayer at two-weekly intervals from the onset of flowering during both years and the crops were weeded manually at 30 and 60 days after planting.

At maturity, all plants of the central 6 rows were harvested for grain and stover/haulm yield determination. Harvesting was done by cutting the stem immediately above ground when the plants were partially dried in the field. The two crops matured at different times in the three locations and the harvest days were approximately 80-85 days and 130-140 days for cowpea and sorghum, respectively. The dry grain yield was determined by hand shelling the cowpea pods and threshing of sorghum heads after drying to 13-14% moisture contents during both years to compute the land equivalent ratio (LER), system productivity index (SPI) and trade or compensation ratio (T) for the crop combinations. For LER, the formula of Mead and Willey (1980) was used: (sorghum yield in mixture/sorghum yield in sole) + (cowpea yield in mixture/cowpea yield in sole. SPI was calculated following Odo (1991) as SPI = (SA/CB x Cb) + Sa, where SA and CB are mean yields of sorghum and cowpea sole and Sa and Cb are their yields in mixtures, respectively. The major advantage of SPI is that it standardizes the yield of the secondary crop (legume) in terms of the primary crop (cereal). The trade or compensation ratio for sorghum was calculated as described by Ntare and Williams (1992) as T (sorghum) = Si/(Cs-Ci); where Si=yield of sorghum intercrop and Ci and Cs= yields of cowpea intercrop and sole, respectively. The data collected for the 2 cropping seasons were averaged and statistically analysed using the analysis of variance (ANOVA) techniques. Differences among the treatment means were compared using LSD at 0.05% level of probability, where the 'F' test was significant according to Steel and Torrie (1980).

## RESULTS AND DISCUSSION

**Grain and stover/haulm yields:** The grain yields (Table II) and Stover/haulm yields (Table III) of both sorghum and cowpea were higher in sole than the intercrop in all the 3 locations. This agreed with the findings of Lesoing and Francis (1999) in corn-soybean and grain sorghum-soybean intercrops, where the sole crop components yielded higher than the corresponding crops in intercropping situation. The highest grain yield of sorghum was obtained in the 2:1 sorghum/cowpea row arrangements but not significantly different from 1:1 arrangement in all the 3 locations, while that of cowpea occurred in the 1:2 sorghum/cowpea row arrangements (Table II), except in Bauchi, where it occurred at the 2:1 sorghum/cowpea row arrangements, which contradicts the findings of Mutungamiri *et al*. (2001) who reported decreased grain yield in beans as maize population increased. Generally a mean yield reduction of 69.7% in sorghum and 55.3% in cowpea were obtained in the sorghum/cowpea intercrops in the 3 locations compared to sole crops. Similarly the stover and haulm yields of both sorghum and cowpea follow the same trend as grain yields in all locations. This observation reflect an inter-specific relationship of mutual inhibition in which both crops in the mixture yielded less than their potential (expected) yields in monoculture. This agreed with the findings of Mead and Willey (1980) who reported that in a sorghum/cowpea intercrop, not only the yield of cowpea is depressed by sorghum but cowpea can also depress the yield of sorghum. Yunusa (1989), Odo, (1991) and Pal *et al*. (1993) had earlier reported yield reductions in intercropped cereal/legume compared to sole cereal and legume in the Nigerian savannah. However yield reduction due to intercropping often depended on the crop component ratios, which in part reflect the effects of decreased population density on the yield of component crops.

**LER, SPI and compensation ratio:** The LER values as a means of determining the productivity of the land averaged over all locations indicated that intercropping sorghum/cowpea at 1:1 row arrangement resulted in higher LER compared to 1:2 or 2:1 row arrangement (Table IV), which showed an example of mutual cooperation among the component crops where the total LER is higher than the expected value of 1.

However the largest LER value of 1.16 was obtained in Misau in the 1:1 row arrangement, where sorghum and cowpea achieved 70% and 45% of their sole crop yield, respectively which indicated a higher bio economic efficiency of 1:1 row arrangement of sorghum/soybean over the other two arrangements. This agreed with the findings of Ofosu-Anim and Limbani (2007) who reported a slightly higher LER for 1 row than 2 row okra-cucumber intercrop. Odo (1991) reported LER value of 1.50 in sorghum/cowpea intercrops in the Sudan savanna of Nigeria. The SPI, which standardized the legume grain yield in terms of sorghum grain yield and also identified the combinations that utilized the growth resources most effectively and maintained a stable yield performance showed that the 1:1 row arrangement gave the highest value compared to the other row arrangements and monocultures (Table IV), except in Bauchi, where the highest value was obtained in the 2:1 sorghum/cowpea row arrangement. Similarly the trade or compensation ratio for sorghum followed the trend of SPI for the different mixtures in all locations, which indicated that row arrangements affected the competitive effect of sorghum on cowpea.

It may therefore, be suggested that mixed cropping, which is very popular among the subsistence farmers in the

**Table I: Physico-chemical soil properties of experimental sites (mean of 2 years)**

| Soil Property | Azare | Bauchi | Misau |
|---|---|---|---|
| Clay % | 16.6 | 18.5 | 17.3 |
| Silt % | 14.3 | 16.0 | 15.4 |
| Sand % | 69.1 | 65.5 | 67.3 |
| pH (water) | 6.0 | 6.3 | 6.2 |
| Organic carbon % | 0.44 | 0.56 | 0.48 |
| Total nitrogen % | 0.09 | 0.08 | 0.09 |
| Available P (meq $100^{-1}$ g soil) | 6.37 | 7.45 | 6.57 |
| C.E.C. (meq $100^{-1}$ g soil ) | 6.46 | 6.24 | 6.33 |
| Ca (meq $100^{-1}$ g soil) | 1.97 | 2.57 | 2.04 |
| Mg (meq $100^{-1}$ g soil) | 0.92 | 0.84 | 0.91 |
| K (meq $100^{-1}$ g soil) | 0.17 | 0.23 | 0.18 |
| Na (meq $100^{-1}$ g soil) | 0.13 | 0.11 | 0.11 |

**Table II: Effect of Row Arrangements on grain yields of sorghum/cowpea mixtures (mean of 2 seasons)**

| | Grain yield (t $ha^{-1}$ ) | | | | | |
|---|---|---|---|---|---|---|
| | Azare | | Bauchi | | Misau | |
| Row arrangement | Sorghum | cowpea | Sorghum | cowpea | Sorghum | cowpea |
| Sole sorghum | 4.56 | 0.00 | 3.05 | 0.00 | 3.53 | 0.00 |
| Sole cowpea | 0.00 | 0.86 | 0.00 | 0.83 | 0.00 | 0.89 |
| 2:1 sorghum/cowpea | 3.18 | 0.24 | 1.93 | 0.47 | 2.70 | 0.27 |
| 1:1 sorghum/cowpea | 2.95 | 0.37 | 1.60 | 0.37 | 2.48 | 0.40 |
| 1:2 sorghum/cowpea | 1.81 | 0.45 | 0.98 | 0.45 | 1.64 | 0.51 |
| LSD (5%) | 1.33 | 0.64 | 1.16 | 0.57 | 1.10 | 0.64 |

**Table III: Effect of Row Arrangements on the stover and haulm yields of sorghum/cowpea mixtures (mean of 2 seasons)**

| | Stover/Haulm yield (t $ha^{-1}$ ) | | | | | |
|---|---|---|---|---|---|---|
| | Azare | | Bauchi | | Misau | |
| Row arrangement | Sorghum | cowpea | Sorghum | cowpea | Sorghum | cowpea |
| Sole sorghum | 8.86 | 0.00 | 5.27 | 0.00 | 6.21 | 0.00 |
| Sole cowpea | 0.00 | 0.97 | 0.00 | 1.42 | 0.00 | 0.89 |
| 2:1 sorghum/cowpea | 7.12 | 0.43 | 5.35 | 0.58 | 5.12 | 0.52 |
| 1:1 sorghum/cowpea | 4.69 | 0.53 | 3.30 | 0.92 | 3.16 | 0.82 |
| 1:2 sorghum/cowpea | 2.73 | 0.77 | 1.91 | 0.97 | 2.15 | 0.94 |
| LSD (5%) | 1.44 | 0.44 | 1.12 | 0.54 | 1.20 | 0.38 |

**Table IV: Effect of row arrangement on L.E.R., S.P.I and compensation ratio (T) of sorghum/cowpea mixtures, (mean of 2 seasons)**

| | Azare | | | Bauchi | | | Misau | | |
|---|---|---|---|---|---|---|---|---|---|
| Row arrangement | LER | SPI | T | LER | SPI | T | LER | SPI | T |
| Sole sorghum | 1.00 | 4.56 | 0.00 | 1.00 | 3.05 | 0.00 | 1.00 | 3.53 | 0.00 |
| Sole cowpea | 1.00 | 4.56 | 0.00 | 1.00 | 3.05 | 0.00 | 1.00 | 3.53 | 0.00 |
| 2:1 sorghum/cowpea | 0.98 | 4.45 | 5.13 | 0.94 | 3.66 | 5.36 | 1.06 | 3.77 | 4.50 |
| 1:1 sorghum/cowpea | 1.08 | 4.91 | 6.02 | 1.02 | 2.96 | 3.64 | 1.16 | 4.07 | 5.06 |
| 1:2 sorghum/cowpea | 0.92 | 4.20 | 4.41 | 0.88 | 2.64 | 2.58 | 1.04 | 3.66 | 4.32 |
| LSD (5%) | 0.19 | 0.42 | 0.83 | 0.19 | 0.52 | 1.09 | 0.23 | 0.40 | 0.57 |

Nigerian savannah by providing a more stable food source overall from the same field in an event of un-foreseen environmental hazard affecting the yield of one crop. The farmers can modify the row arrangement patterns to suit the component crops involved as well as the particular environment. Thus for maximum productivity of sorghum/cowpea mixtures in the semi-arid savannah zone of Nigeria, a 2:1 row arrangement should be adopted.

## CONCLUSION

The results of the present study can serve as a guiding index in the use of row arrangements for obtaining higher grain and stover yield stability of sorghum when intercropped with cowpea. Thus for achieving maximum grain yield advantage and net income $ha^{-1}$ in sorghum (primary crop) in sorghum/cowpea intercrop in the Nigerian savanna, a 1:1 sorghum/cowpea row arrangements should be adopted, while a 2:1 row arrangement would suffice for higher stover yields.

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