E3 Journal of Environmental Research and Management Vol. 2(1). pp. 010-013, May, 2011
Available online at http://www.e3journals.org/JERM
ISSN 2141-7466 © 2011 E3 Journals

*Short Communication*

# Yields and Economic Returns on Sorghum Enterprise as Affected by Varying Level of Rice Inclusion in the Southern Guinea Savannah of Nigeria

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Accepted 12 January 2011

**Multiple cropping offers farmers the opportunity to engage nature's principles of diversity on farms. A field trial that was conducted in Nigeria, investigated the yield and economic returns that accrued to sorghum and rice; in sorghum – rice intercrop as affected by rice inclusion in the proportions: 1:1, 1:2, 1:3 and 1:4, respectively for sorghum and rice. Analysis of yield data for both cropping seasons revealed significant influence of sorghum – rice intercrop on grain yields of sorghum and rice in mixtures. Observed average sorghum yield in sole plot was 1712.39 kg ha$^{-1}$, which was progressively significantly decreased with progressive inclusion of rice rows from 1050.58 kg ha$^{-1}$ (38.65 % yield reduction) in 1:1 sorghum – rice mixture to 300.35 kg ha$^{-1}$ (82.46% yield reduction) in 1:4 sorghum – rice mixture; while grain yields of sorghum decreased with progressive rice inclusion, grain yields of rice increased per hectare with progressive increase in rice rows from 1:1 to 1:4. Considering the economic implication of intercropping sorghum with rice, income that accrued to sole crops was significantly reduced with intercropping. While all the crop combinations investigated performed better than sole cropped sorghum (in terms of revenue generation), sole rice performed better than all the intercrops. The implication of this observation is that while sorghum is better intercropped with rice to improve revenue generation, rice is best as sole crop. In conclusion, in sorghum – rice intercrop, intercropping at 1:4 is recommended as this mixture gave best intercrop result in respect to monetary return relative to other mixtures.**

**Key words:** Intercropping, monetary returns, multiple cropping. Rice, sorghum, yield

## Introduction

The deepening need for increasing productivity on farmers' plots in the African continent will be met through better understanding of crop environment, particularly as it regards to multiple cropping systems, which offer farmers the opportunity to engage nature's principles of diversity on farms. By combining crops of different growing periods, varying heights and varying uses, African farmers have evolved highly diversified cropping systems (Okigbo and Greenland, 1976; Steiner, 1982).

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However, spatial arrangements of crops, sowing rates and crop maturity date are important considerations when planning these multiple cropping systems (Sulivan, 2010). Generally, the rationale of intercropping lies in its beneficial effects. Besides allowing the farmer to grow various crops on a piece of land without necessarily preparing another land, an insurance against total crop failure, helping in the control of erosion, pests and diseases, it provides the farmer a variety of crops, thus improving his dietary intake (Kassam, 1972; Steiner, 1982; Langdale et al., 1992) and securing farmers income. Besides combined yield advantage that may come with multiple cropping, farmers should also be interested in the economic implication of the system they

**Table 1.** Average yield implication of sorghum (*Sorghum bicolor*) and rice (*Oryza sativa* L) intercrop as influenced by varying mixture proportion

| Treatment | Intercrop Effect on Crop Yield | | | | | |
|---|---|---|---|---|---|---|
| | Sorghum | | | Rice | | |
| Sorghum: Rice | Average grain yield (kg ha$^{-1}$) | Intercrop implication relative to sole crop (kg ha$^{-1}$) | Percentage yield reduction relative to sole crop | Average grain yield (kg ha$^{-1}$) | Intercrop implication relative to sole crop (kg ha$^{-1}$) | Percentage yield reduction relative to sole crop |
| Sole | 1712.39a | - | - | 1405.39a | - | - |
| 1:1 | 1050.58b | - 661.81 | 38.65% | 760.67e | - 644.72 | 45.87 |
| 1:2 | 571.83c | - 1140.56 | 66.61% | 933.82d | - 471.57 | 33.55 |
| 1:3 | 446.15d | - 1266.24 | 73.95% | 994.67c | - 410.72 | 29.22 |
| 1:4 | 300.35e | - 1412.04 | 82.46% | 1113.05b | - 292.34 | 20.80 |
| Se± | 28.623 | | | 22.050 | | |

are engaged in - what is the cost implication of such a system and the likely economic returns to the system.

The food sub-sector of Nigeria's semi-arid agriculture parades a large array of cereal crops, made possible by the diversity of agro-ecological production systems (Rowland, 1993). Presently, rice is a common dietary staple in Nigeria and individuals now consume 21 kg of rice annually, representing 9% of total caloric intake and 23% of the total cereal consumption, with an estimated 2.1 million tonnes of rice consumed annually by the populace (Ukwungwu et al., 2004). An estimated 0.4 million tonnes of rice enters the country annually (Ukwungwu et al., 2004). Sorghum is no less important, a common staple among the poor (noting that more than 70 per cent of the populace fall below the poverty line of one dollar a day) and the drier part of the country.

The importance of sorghum and rice in the diet of most Nigerians justify a study on these crops. Especially, considering that rice have risen to a position of pre-eminence. The fact that over 75 per cent of cultivated land in Nigeria is, sown to more than one crop type, justifies a study on multiple cropping system. This research thus investigated the income that accrued to sorghum-rice enterprise in response to varying mixture combinations with the aim of finding the most profitable mixture combination for adoption by farmers.

#### Materials and Methods

On farm trials conducted in 2006 and 2007 wet seasons in Loko, Tudu Uku Local Government Areas of Nasarawa State, Nigeria; Southern guinea savanna agro-ecological Zone (Latitude $8^0$ $00^1$ $19^0$N; Longitude $7^0$ $50^1$ $39^0$E) investigated the response of sorghum and rice to varying levels of intercropping. The field was ploughed and harrowed without ridging. Sorghum: SAMSORG 14 (KSV8), sourced from the Institute for Agricultural research (IAR), Zaria was sown 25 by 90 cm intra and inter row for sole crop plots. For intercropped plots, rice variety: ITA 257 was dibbled between sorghum rows at 30 by 30 cm inter and intra row spacing at 1:1; 1:2; 1:3 and 1:4 rows, respectively for sorghum and rice, using row substitution method as reported by Yahaya et al. (2005). One, two, three and four rows of sorghum stands were replaced with rice in the proportions of 1:1, 1:2, 1:3 and 1:4, respectively in line with Yahaya *et al*. (2005). Three and six seeds of sorghum and rice respectively, were sown and thinned to one plant/stand of sorghum and four plant/stand of rice two weeks after sowing. Sorghum crop received fertilizer application: 64 kg N, 13.2 kg P and 26.4 kg K in two split doses at planting and 6 WAS to sorghum, while rice received 80 kg N as against the fertilizer rate given to sorghum with other nutrients maintained as in sorghum crop.

Data was collected on crop yield, yield implication of intercropping relative to sole cropping (kg ha$^{-1}$), percentage, yield implication of intercropping relative to sole cropping, monetary implication of the cropping systems and monetary implication of intercropping relative to sole cropping. Returns on sorghum enterprise was calculated based on an average of ₦50 kg$^{-1}$ of grain sorghum as at October 2010 while rice enterprise was based on an average of ₦140 kg$^{-1}$ of rice grains kg$^{-1}$ within the same period. Thus, economic returns to the enterprise were, derived as in the formulae:

$R_s = Y_s \times C_s$
$R_r = Y_r \times C_r$
Where $R_s$ = Revenue that accrued to sorghum (₦)
$Y_s$ = Yield of sorghum per ha (Kg)
$C_s$ of sorghum per kg
$R_r$ = Revenue that accrued to rice (₦)
$Y_r$ = Yield of rice per ha (Kg)
$C_r$ = Cost of rice per kg (₦)

### Results and Discussion

Analysis of yield data for both cropping seasons revealed significant influence of sorghum – rice intercrop on grain yields of sorghum and rice in various mixtures. Observed average sorghum yield in sole plot was 1712.39 kg ha$^{-1}$, which was progressively significantly decreased with progressive inclusion of rice rows from 1050.58 kg ha$^{-1}$ (38.65% yield reduction) in 1:1 sorghum – rice mixture to 300.35 kg ha$^{-1}$ (82.46% yield reduction) in 1:4 sorghum – rice mixture (Table 1). While grain yields of sorghum decreased with progressive rice inclusion, grain yields of

**Table 2.** Monetary returns on sorghum (*Sorghum bicolor*) - rice (*Oryza sativa* L) enterprise ($ ha$^{-1}$) as influenced by varying mixture proportion

| Treatment | Intercrop Effect | | | | | |
|---|---|---|---|---|---|---|
| | Sorghum | | | Rice | | |
| Sorghum: Rice | Average grain yield (kg ha$^{-1}$) | Monetary implication (₦) | Intercrop implication relative to sole crop (₦) | Average grain yield (kg ha$^{-1}$) | Monetary implication (₦) | Intercrop implication relative to sole crop (₦) |
| Sole | 1712.39a | 85,619.50 | - | 1405.39a | 196,754.60 | - |
| 1:1 | 1050.58b | 52,529.00 | - 33,090.50 | 760.67e | 106,493.80 | -90,260.80 |
| 1:2 | 571.83c | 28,591.50 | -57,028.00 | 933.82d | 130,734.80 | -66,019.80 |
| 1:3 | 446.15d | 22,307.50 | -63,312.00 | 994.67c | 139,253.80 | -57,500.80 |
| 1:4 | 300.35e | 15,017.50 | 70,602.00 | 1113.05b | 155,827.00 | -40,927.60 |
| Se± | 28.623 | | | 22.050 | | |

*Exchange rate: ₦150.6024 to $1

rice increased per hectare with progressive increase in rice rows from 1:1 through to 1:4. However, the highest grain yields for both sorghum and rice were, observed in sole plots, which significantly decreased with intercropping.

The observed yield reduction in the intercrops were not necessarily the result of reduction in yield capacity of individual stands, but rather the effect of reduced individual component crop population with intercropping (Oyewole, 2004). It should be noted that in crops that tiller, such as sorghum and rice, reduction in plant population, which accompanies intercropping, may actually boost yields of individual crop stands as a result, of profuse tiller formation with lowered population (Oyewole *et al*., 2010). This fact is glaring when one observes the percentage yield reduction that accompanied progressive rice inclusion in the intercrop shown on Table 1. With 1:1 row mixture, grain yield reduction was 38.65%, which almost doubled with 1:2 row mixtures (66.61% yield reduction). However, the differences in grain yields between 1:2 and 1:3 and between 1:3 and 1:4 row mixtures were less than 10%. An indication that reduction in sorghum population must have prompted a boost in stand yields in the intercrops, either as a result of profuse tiller formation or heavier seed weight. Usually, the profitability of multiple cropping rests on the ability of the component crops to compensate for yield reduction through attainment of better combine yield. Where this occurs, observed reduction in individual crop is often over-matched, by the combined yields of component crops in the mixture. The combined effect of individual crop yield is difficult to quantify except where expressed in monetary terms. Thus, Table 2 attempts an interpretation of what is contained on Table 1 in monetary terms. This is to give a common scale of measurement to this different enterprise upon which to assess enterprise profitability.

Considering the economic implication of intercropping sorghum with rice, income that accrued to sole crops was ₦85, 619.50 and ₦196, 754.60, respectively for sorghum and rice, which were significantly reduced with intercropping (Table 2). The least monetary return on sorghum enterprise was in 1:4 cropping ratios (₦15, 017.50), ₦70, 602.00 less the return in sole plots, while the least monetary return on rice enterprise was in 1:1 crop combination (₦106, 493.80), ₦ 90,260.80 less the return on sole cropped rice. Combined monetary return on sole crops was ₦282,374.10 which decreased by ₦123,351.30 in 1:1 cropping ratios, by 123,047.80 in 1:2 cropping ratios, by ₦120,812.80 in 1:3 crop combination while 1:4 cropping ratios recorded ₦111,529.60 reduction in income in comparison with sole crops (Table 3). Thus 1:1 cropping ratios recorded the highest revenue reduction in comparison with sole crops, while the least revenue reduction was in 1:4 crop combination. While all the crop combinations investigated performed better than sole cropped sorghum (in terms of revenue generation), sole rice performed better than all the intercrops (Table 3). The implication of this observation is that while sorghum is better intercropped with rice to improve revenue generation, rice is best as sole crop.

## Conclusion

Trial conducted in Nasarawa State, Nigeria, investigated yield and economic returns that accrued to sorghum and rice in sorghum – rice intercrop as affected by rice inclusion in the proportions of: 1:1, 1:2, 1:3 and 1:4, respectively for sorghum and rice. Analysis of yield data for both cropping seasons revealed significant influence of sorghum – rice intercrop on grain yields of sorghum and rice. Grain yield of sorghum decreased with progressive rice row inclusion, while grain yield of rice increased per hectare with progressive increase in rice rows.

Considering the economic implication of intercropping sorghum with rice, income that accrued to sole crops was

**Table 3.** Monetary returns on sorghum (*Sorghum bicolor*) - rice (*Oryza sativa* L) enterprise (₦ $ha^{-1}$) as influenced by varying mixture proportion

| Treatment | Monetary Implication of the Intercrop (₦) | | | |
|---|---|---|---|---|
| | Sorghum | Rice | Total | Intercrop implication relative to sole crop |
| **Sorghum: Rice** | | | | |
| Sole | 85,619.50 | 196,754.60 | 282,374.10 | - |
| 1:1 | 52,529.00 | 106,493.8 | 159,022.80 | -123,351.30 |
| 1:2 | 28,591.50 | 130,734.80 | 159326.30 | -123,047.80 |
| 1:3 | 22,307.50 | 139,253.80 | 161,561.30 | -120,812.80 |
| 1:4 | 15,017.50 | 155,827.00 | 170,844.50 | -111,529.60 |

* Exchange rate: ₦150.6024 to $1

significantly reduced with intercropping. While all the crop combinations investigated performed better than sole cropped sorghum (in terms of revenue generation), sole rice performed better than all the intercrops. The implication of this observation is that while sorghum is better intercropped with rice to improve revenue generation, rice is best as sole crop. In conclusion, in sorghum – rice intercrop, intercropping at 1:4 is recommended as this mixture gave best intercrop result in respect of monetary return relative to other mixtures.

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