

Full Length Research Paper

Economic aspects of intercropping systems of vegetables (okra, tomato and cowpea)

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Various field experiments were conducted in the cropping seasons of 2007 and 2008 to evaluate the agro-economic returns obtainable from the intercrop involving tomato, okra and cowpea at varying levels of cropping densities. The experimental design used for each of the field analyses was randomized complete block design with each of the treatments replicated three times. Average of yields over the consecutive two-year period of 2007 and 2008 covered by the current study was used for the measurement of output while the values of input and output were determined with the prevailing market price. Budgeting techniques were used as analytical tools. Results of analyses using net returns, benefit-cost ratio and increased net returns as economic indicators showed that the most favourable mix of vegetables which could be recommended for adoption to farmers was the intercrop of a pair rows of tomato with one row of cowpea (TC 2:1). The practice gave increased net returns of ₦32, 245.71 or US\$214.97(21.04%) and ₦129, 823.22 or US\$865.49(233.18%) over the sole cropping of tomato and cowpea respectively. This was also an increased net revenue of ₦46,427.07 or US\$309.51(33.38%) above TO 2:1 and ₦98,319.81 or US\$655.47 (112.78%) above OC 2:1 which were themselves optimal alternatives preferred to sole cropping of any of the vegetables involved. This result however, was in favour of extension policies towards popularizing the recommendation of alley farming for horticultural practice.

Key words: Agro-economic indicators, increased net-revenue, optimal alternatives, vegetable practice.

INTRODUCTION

Any system of cropping that can increase the rate of crop yield and or lower the cost of production will provide economic opportunity for farmers. Intercropping has been identified as a promising system that results in an effective use of land and other resources (Remison, 1982b), efficient utilization of water and soil nutrients (Sharma et al., 1979) and reduction in the cost of production (Bijay et al., 1978). It also gained wide acceptability among farmers in tropical countries (Norman, 1970; Okigbo and Greenland, 1976; Willey, 1979) because of its economic advantages (Ilobinso 1976; Baker, 1979; Dittoh; 1985, Adeniyi; 1988, 1990) resulting from the symbiotic association of legumes intercropped with other crops (Enyi, 1973; Dalal, 1974; Haizel, 1974; Ahmed and Gunasema, 1979).

Most intercropping experiments that had been carried out centered mostly on cereals (Enyi, 1973; Koli, 1975; Remison, 1982a) and root crops (Koli, 1975). A few of

such studies however involved intercropping with vegetables, but then, with little or no accent on the economics of production (Haizel, 1974). Intercropping involving legumes has been found to be most useful (De Wit and Van Den Bergh, 1965; De Wit et al., 1966; Ahmed 1976, Mendoza, 1986; Bryan and Materu, 1987). The current effort therefore was aimed at experimenting intercropping of legumes with vegetables at varying levels of cropping densities and evaluating their agro-economic performance.

The specific objectives of the study were:

1. To identify the effects of intercropping on the individual fruit yields of tomato, okra and cowpea at various cropping densities.
2. To determine the costs and returns at each level of cropping density.
3. To identify the economically modest practices and

Table 1. Cost of production of tomato-okra intercropped at various cropping densities (naira*/ha): average of 2007 to 2008 experiments.

Cost item	Treatments **				
	Control		Sole tomato-Sole okra (TO) ratio		
	Sole tomato (T)	Sole okra (O)	1:1	1:2	2:1
Fixed cost	250.00	250.00	250.00	250.00	250.00
Farm labour	32,808.50	31,043.00	30,085.00	30,391.50	29,777.50
Seeds	450.00	800.00	625.00	684.50	565.50
Insecticides	-	12,000.00	6,000.00	8,040.00	4,020.00
Total	33,508.50	44,093.00	36,960.00	39,366.00	34,613.00

Source: Field experiment 2007 to 2008 and computations there from. *Naira (₦) = Nigerian currency and \$1 is equivalent ₦135.95 as at the time of study.** Total crop production density for monoculture and mixture of tomato and okra was 37,000 plants per hectare.

based on the findings, recommend the most suitable pattern of intercropping tomato and okra and with cowpea.

MATERIALS AND METHODS

Experiments involving intercropping of vegetable crops were sited at the Agricultural Research Farm of Adeyemi College of Education, a degree-awarding institution of Obafemi Awolowo University located in Ondo town (07° 05' N, 04° 55' E) South Western Nigeria in 2007 and 2008. The soil at the site was a well-drained sandy loam with the following chemical characteristics: 1.41% organic matter, 0.268% total N; 6.6 ppm available P (BRAY'S-P1): 1:14 me/100 g Ca: 0.31 me/100 g K and pH 5.5 (1:1 soil water ratio).

In the trials of both years, the following treatments were tested:

- Monoculture (Sole cropping) of tomato (T)
- Monoculture (Sole cropping) of okra (O)
- Monoculture (Sole cropping) of cowpea (C)
- Tomato intercropped with okra in alternate rows of ratio one to one (TO 1:1)
- A row of tomato intercropped with a pair row of okra of ratio one to two (TO 1:2)
- A pair row of tomato intercropped with a row of okra of ratio two to one (TO 2:1).

The same treatments as listed in (d) to (f) above were carried out using planting ratios of 1:1, 1:2, and 2:1 on each of the treatments with tomato/cowpea and okra/cowpea. Each plot measured 19.2 m. by 4.8 m. and the monoculture and mixtures of tomato and okra were spaced 60 cm. by 45 cm. to give a population density of about 56,000 plants/ha. Mixtures were achieved by "replacement series" technique of Remison (1980).

The experimental design was randomized complete blocks with three replications. One plant per stand was allowed for each crop. The tomato (Ife No 1) and okra (V 35) cultivars used in the trials were early maturing types grown in western Nigeria while the cowpea (TVX 3236) cultivar was a semi-determinate and early maturing type. Tomato seeds were sown in nursery in the middle of August 2007 and the last week of February 2008 for the first and second trials respectively and transplanting was done thirty days later. Seeds of okra and cowpea were sown simultaneously seven days before transplanting of tomato.

Weeding was done manually. Staking was done using sticks of 120 cm. long, three weeks after transplanting. The insecticides, Furadan 3 G and Nuvacron 40 EC (6 ml/litre of water) were applied to okra and cowpea plants at an interval of one week for five times,

starting on the fifth day after flower buds formation. No insect or fungal infestation was noticed in tomato plots. No fertilizer application was made.

Harvesting of mature tomato fruits started on October 15th 2007 and April 18th 2008 for both experiments with ten harvestings in 2007 and eleven in 2008. For okra fruits and cowpea respectively, harvesting started on October 29th and December 11th for the 2007 experiment and April 28th and June 5th for the 2008 experiment. There were twelve harvestings for both okra and cowpea in 2007 and thirteen in 2008. All harvestings were made at an interval of five days before the termination of the experiment.

Twenty-five plants per replicate were sampled for tomato and okra crop for the yield analysis while forty plants per replicate were sampled for cowpea. All plants sampled were taken from the middle of each replicate treatment where interaction was assumed to be at maximum. Data obtained were subjected to analysis of variance (ANOVA) and the means were tested by LSD values (Steele and Torrie, 1960). Farm budgeting analysis was used based on averages of market retail prices for the periods considered.

RESULTS AND DISCUSSION

The costs of production, yield response and economic performance of tomato-okra intercrop at various cropping densities are shown in tables 1, 2 and 3 respectively.

Table 1 shows that labour accounted for the highest proportion (more than 75%) of the total production costs in all the trials while chemicals accounted for an average of about 23 % of the total production cost when used. The observed increase in the cost of production of the intercrop could be explained in terms of the extent of use of farm chemicals. The least cost of production for the intercrop trials was recorded with tomato intercropped with okra at ratio 2:1 respectively.

As shown in Table 2, yield response was best and highly statistically significant at a planting ratio of 2:1 for tomato-okra combination. On per hectare basis, tomato fruit yield increased by 1,411.18 kg while okra has an increased yield of 9,382.12k g, other combinations had decreased fruit yield for tomatoes.

The economic performance as shown in Table 3 revealed that the best combination was to intercrop tomato with okra at a planting ratio of 2 to 1. This gave an

Table 2. Yield response of tomato-okra intercropped at various cropping densities (average of 2007 to 2008 experiments).

Treatment	Yield (kg/ha)						Increase in yield (kg/ha equivalent)	
	2007		2008		Average yield		Tomato	Okra
	Tomato	Okra	Tomato	Okra	Tomato	Okra		
Sole tomato +	17,798.60	-	14,909.69	-	16,354.15	-	-	-
Sole okra +	-	6,730.99	-	7,184.66	-	6,957.83	-	-
TO 1:1	8,268.58	3,623.49	6,528.15	3,773.41	7,398.37	3,698.45	-1,557.41	439.07
TO 1:2	4,745.78	2,435.79	3,970.50	2,589.02	4,358.14	2,512.41	-3,279.73	-3,189.22
TO 2:1	12,729.17	5,598.27	10,957.93	5,295.03	11,843.55	5,446.65	1,411.18	9,382.12
LSD (P=0.01)	1,202.70	551.92	848.42	777.98	1,002.65	675.21		

Source: Field experiment 2007 to 2008 and computations there from + control.

Table 3. Economic performance of tomato-okra intercropped at various cropping densities. Average of 2007 to 2008 experiments.

Items	Treatment (₦/ha)				
	Tomato (T)	Okra (O)	Tomato-Okra (TO) ratio		
			1:1	1:2	2:1
Value of yield	171,391.49	63,316.25	111,190.82	68,536.24	173,684.92
Cost of production	33,508.50	44,093.00	36,960.00	39,366.00	34,613.00
Net returns	137,882.99	19,223.25	74,230.82	29,170.24	139,071.92
Increased net returns:					
Tomato-based	-	-	-63,652.17	-108,712.75	1,188.93
Okra-based	-	-	55,007.57	9,946.99	119,848.67
Benefit-cost ratio	5:1	1.4:1	3:1	1.7:1	5:1

increased net return of ₦121,037.60 (US\$806.92) per hectare farm. It also gave a favourable benefit-cost ratio of 5:1 and ₦139,071.92 (US\$927.15) returns per investment. The trials with tomato intercropped with cowpea at different cropping densities gave results on costs of production, yield response and economic performance which are presented in Tables 4, 5 and 6 respectively.

As shown in Table 4, the highest labour and production costs were incurred on sole cowpea

farms. This is expected since cowpea required additional costs on chemicals and labour for spraying before any appreciable yield could be forthcoming (Hays and Raheja 1977; Ojomo and Raji 1981; Faluyi, 1987). However, least costs were recorded on farms with higher planting population of tomato relative to that of cowpea.

Table 5 shows the best yield response with tomato intercropped with cowpea at a planting density of 2 to 1 and the least with 1:2 tomato-cowpea intercropping patterns. On per hectare

basis, the 2:1 planting pattern produced an increased fruit yield of 1,673.29 kg for tomato and 2,496.33 for cowpea – above the sole crops. Statistical analysis also revealed that the best combination for tomato-cowpea intercrop is that involving two rows of tomato with one row of cowpea. Closely following this is that combination of one row of tomato with one row of cowpea while TC 1:2 is least in the series. The best economic performance can be achieved, as shown in Table 6, when a pair rows of tomato is

Table 4. Costs of production of tomato-cowpea intercropped at various cropping densities (N/ha): Average of 2007 to 2008 experiments.

Cost item	Treatment				
	Control		Sole tomato-Sole cowpea (TC) ratio		
	Sole tomato (T)	Sole cowpea (C)	1:1	1:2	2:1
Fixed cost	250.00	250.00	250.00	250.00	250.00
Farm labour	33,453.75	43,318.25	38,386.75	38,881.50	35,610.00
Seeds	450.00	3,600.00	2,025.00	2,562.00	1,488.00
Insecticides	-	12,000.00	6,000.00	8,040.00	4,020.00
Total	34,153.75	59,168.25	46,661.75	49,733.50	41,368.00

Source : Field experiments 2007 to 2008 and Computations there from.

Table 5. Yield response of tomato-cowpea intercropped at various cropping densities (average of 2007 to 2008 experiments).

Treatment	Yield (kg/ha)					
	2007		2008		Average yield	
	Tomato	Cowpea	Tomato	Cowpea	Tomato	Cowpea
Sole tomato (T)+	20,127.88	-	15,636.82	-	17,882.35	-
Sole cowpea (C) +	-	1,705.65	-	1,972.88	-	1,839.27
TC 1 : 1	9,784.89	958.68	7,086.24	1,191.43	8,435.57	1,075.06
TC 1 : 2	6,249.30	776.68	4,765.05	894.34	5,507.18	835.51
TC 2 : 1	15,373.87	1,394.38	10,700.31	1,496.02	13,037.09	1,445.20
LSD (P = 0.01)	864.31	58.53	1,169.12	32.71	904.61	63.04

Source: Field experiment 2007 to 2008 and computations there from + control.

intercropped with a row of cowpea at ratio 2 to 1 (TC 2:1).

It results in an increased net returns of ₦129,823.22(US\$865.49) for cowpea-based intercrop and ₦32,245.71(US\$214.97) for tomato-based combination. The Benefit-cost ratio of 5.5:1 is also a favourable result for TC 2:1 intercrop. The results of experiments on okra and cowpea intercrop showing production costs, yield response and economic performance are shown

in Tables 7, 8 and 9 respectively. As shown in Table 7, among the sole crop enterprises, raising cowpea was more labour intensive while an intercrop of okra with cowpea at planting population of 33 and 67% respectively also required the highest labour use intensity. Labour costs covering about 70% of the total production costs however appeared to be the most critical to the various treatments. An average of about 23 % of the total production cost incurred on

insecticides was constant for all the treatments. The yield response for okra and cowpea as shown in Table 8 was best (p = 0.01) for the intercrop of a pair rows of okra with a row of cowpea.

At the prevailing average market price of ₦9.10 (US\$0.06) per kilogram of okra and ₦62.44 (US\$0.42) for cowpea, the economic returns for the various treatments are shown in Table 9. The intercropping of okra with cowpea at a ratio of one to two respectively resulted in the least economic

Table 6. economic performance of tomato-cowpea intercropped at various cropping densities: average of 2007 to 2008 experiments.

Items	Treatments (₦/ha)				
	Tomato	Cowpea	Tomato-Cowpea ratio		
			1:1	1:2	2:1
Value of yield	187,407.03	114,844.02	155,531.52	109,884.49	226,866.99
Cost of production	34,153.75	59,168.25	46,661.75	49,733.50	41,368.00
Net returns	153,253.28	55,675.77	108,869.77	60,150.99	185,498.99
Increased net returns:					
Cowpea based	-	-	53,194.00	4,475.22	129,823.22
Tomato based	-	-	- 44,383.51	-93,102.29	32,245.71
Benefit/cost ratio	5.5:1	1.9:1	3.3:1	2.2:1	5.5:1

Source: Field experiments 2007 to 2008 and computations there from.

Table 7. Costs of production of okra-cowpea intercropped at various cropping densities (₦/ha): Average of 2007 to 2008 experiments.

Cost item	Treatments*				
	Control		Sole okra-Sole cowpea (OC) ratio		
	Sole okra (O)	Sole cowpea (C)	1:1	1:2	2:1
Fixed cost	250.00	250.00	250.00	250.00	250.00
Farm labour	31,043.00	43,563.50	37,318.00	38,672.00	35,936.75
Seeds	800.00	3,600.00	2,200.00	2,676.00	1,716.00
Insecticides	12,000.00	12,000.00	12,000.00	12,000.00	12,000.00
Total	44,093.00	59,413.50	51,768.00	53,598.00	49,902.75

Source: Field experiments 2007 to 2008 and computations there from.* The total crop production density for monoculture and mixtures of okra and cowpea was 56,000 plants per hectare.

returns ₦11,951.62 (US\$79.68), while the ₦87,179.18(US\$581.19) realized from OC 2:1 was best in the series. As the okra component of the mixture increased, net returns also increased. The benefit-cost ratio of 4:1, for OC 2:1 was also the highest among the trials. The fairly high ratio observed for sole cowpea could not make it enticing in view of the high production cost involved in addition to the enormous risk attendant to sole cropping in case of total crop failure. The

increased net return was most favourable for intercrop of two rows of okra with one row of cowpea.

Conclusion

All the three economic indicators tested in these analyses – net return, benefit-cost ratio and increased net return show promising results for

intercropping of vegetables as against planting them sole. The planting of a pair row of tomato with a single row of cowpea was most favoured across the various trials. The Net revenue per hectare of ₦185, 498.99 (US\$1,236.66), a benefit-cost ratio of 5.5:1 and an increased Net return of between ₦32, 245.71(US\$214.97) and ₦129, 823.22(US\$865.49) above the sole enterprises make it best among the various trials. Planting of tomato-okra at ratio 2:1 planting density was also

Table 8. Yield response of okra–cowpea intercropped at various cropping densities (average of 2007 to 2008 experiments).

Treatments	Yield (kg/ha)					
	2007		2008		Average	
	Okra	Cowpea	Okra	Cowpea	Okra	Cowpea
Sole okra (O) +	7,277.57	-	7,903.25	-	7,590.41	-
Sole cowpea(C)+	-	1,754.67	-	1,946.39	-	1,850.53
OC 1 : 1	3,579.31	884.00	4,180.26	958.67	3,879.79	921.34
OC 1 : 2	2,394.25	658.58	2,809.29	682.65	2,601.77	670.62
OC 2 : 1	5,053.83	1,354.00	5,540.09	1,492.87	5,296.96	1,423.44
LSD (P = 0. 01)	146.26	52.01	301.34	131.49	262.30	100.01

Source: Field experiments 2007 to 2008 and computations there from.

Table 9. Economic performance of okra–cowpea intercropped at various cropping densities: average of 2007to 2008 experiments.

Items	Treatments (₦/ha)				
	Okra	Cowpea	Okra-Cowpea ratio		
			1:1	1:2	2:1
Value of yield	69,072.73	115,547.09	92,834.56	65,549.62	137,081.93
Cost of production	44,093.00	59,413.50	51,768.00	53,598.00	49,902.75
Net returns		56,133.59	41,066.56	11,951.62	87,179.18
Increased netreturns:					
Cowpea based	-	-	-15,067.03	-44,181.97	31,045.59
Okra based	-	-	16,086.86	-13,028.08	62,199.48
Benefit/cost ratio	1.6:1	1.9:1	1.6:1	1.1:1	2.5:1

Source: Field experiments and computations there from.

also ideal and it gave a Net revenue of ₦139,071.92(US\$927.15) per hectare with a benefit-cost ratio of 5:1 while two rows of okra could also be intercropped with one row of cowpea to give a net revenue of ₦87,179.18(US\$581.19) per hectare and benefit-cost ratio of 2.5 to 1.

In extending the modest cultural practice on horticultural farming to farmers therefore, it could be recommended that the most viable pattern of intercropping vegetables based on economics of

production is to plant tomato and cowpea at a density of two rows to one row respectively. Other suitable but less efficient alternatives available to farmers are the intercropping of two rows of tomato with one row of okra or okra-cowpea intercropped at ratio two to one planting density. These latter cropping patterns could at least produce a better economic reward over and above the sole cropping of each of the individual vegetables.

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Appendix I. Average price of input used (2007 to 2008).

Input	Amount used per hectare	Value (₦)
Tomato seeds	3 kg	450.00
Okra seeds	10 kg	800.00
Cowpea seeds	30 kg	3,600.00
Furadan 3G insecticides	10 litres	12,000.00
Navacron 40FC insecticides	10 litres	12,000.00
Labour (man h)	Variable	50.00

Source: World bank financed agricultural development project (ADP) zonal office, agricultural input supply company (A. I. S. C.), Ondo, 2007 to 2008.

Appendix II. Average market price of output.

Output	Market measure (Kg)	Price (naira/Kg)
Tomato	1. 53	10.48
Okra	1. 10	9.10
Cowpea	1. 26	62.44

Source: Market survey 2007 to 2008.*US\$1 =135.95 Naira (#) as at the time of study. Naira (#) is the Nigerian currency.