Biological efficiency of intercropping in okra (*Abelmoschus esculentus* (L.) Moench)

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Received 6 June 2004; received in revised form 10 February 2005; accepted 11 February 2005

Abstract

An investigation to assess the feasibility of raising intercrops in association with okra was carried out at Vellanikkara during the *kharif* and *rabi* seasons of 2000. The results showed favourable land equivalent ratio (LER), land equivalent coefficient, area time equivalency ratio, aggressivity values and total biomass production for the intercropping treatments implying their intrinsic advantages over sole crops. LER was consistently greater than unity in all treatments; aggressivity values, however, showed that cowpea and amaranth were dominant over okra, while cucumber was dominated. Equivalent yield, total biomass production of okra and net returns were highest for the combination involving okra+cowpea at 60×45cm spacing during both *kharif* and *rab*i seasons.

Keywords: Cropping system, land equivalent ratio, land equivalent coefficient, area time equivalency ratio, aggressivity

Introduction

Intercropping ensures efficient utilization of light and other resources, reduces soil erosion, suppresses weed growth, and thereby helps to maintain greater stability in crop yields. It also guarantees greater land occupancy and thereby higher net returns. The main crop, however, should be amenable to growing additional crops in the interspaces even in an additive series. Although some researchers (Kalarani, 1995; Balan, 1998) have evaluated the effects of intercropping of common vegetable crops, there is still paucity of information on this. In particular, information on okra intercropping is not available from the central Kerala, despite the crop is grown at relatively wide spacing (60x45 cm; KAU, 1996). An investigation was, therefore, undertaken to assess the feasibility of raising intercrops with okra (*Abelmoschus esculentus* (L. Moench) to maximise productivity and returns per unit area.

Materials and methods

Two field experiments were conducted at the Vegetable Research Farm, Vellanikkara, Thrissur (10°31'N and 76°16' E) during the *kharif* and *rabi* seasons of 2000. The site is situated at 40 m above mean sea level and experiences a warm humid tropical climate with a sandy clay loam soil. Okra (cv. 'Arka Anamika') was planted at two spacing and in association with three intercrops viz., *Amaranthus tricolor* (L.) (cv. CO 1), *Vigna unguiculata* (cv. 'Bhagyalekshmi') and *Cucumis sativus* var. *conomon* (cv. 'Mudicode'). The eleven treatment combinations were: sole crops of okra at 60×45 cm and at 100×45 cm, okra at 60×45 cm+amaranth, cowpea or cucumber, okra at 100×45 cm with the same intercrops; and sole crops of amaranth (20 cm spacing), cowpea (at 25×15 cm) and cucumber (at 2×1.5 m). In the intercropping treatments, however, cowpea and amaranth were planted at 20 cm distance and cucumber at 1 m

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interval in a single line between two rows of okra. The experiment was laid out in randomized block design with three replications. Plot size was 19.2 m^2. *Kharif* crop was planted on 21 June 2000 and the *rabi* crop on 14 October 2000 and managed as per local crop management recommendations (KAU, 1996).

At maturity, the total fresh weights of main crop and intercrops were estimated on per plot basis after uprooting the plants, besides their economic yields. The yield and biomass production values were then scaled up to a per ha basis. Net returns were also worked out to evaluate the economics of the system. Intercropping efficiency was evaluated by comparing the productivity of a given area of intercropping with that of sole crops using the competition functions described below.

Land equivalent ratio, $LER = \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}}$

Where, Y_{ab} and Y_{ba} are the individual crop yield in intercropping and Y_{aa} and Y_{bb} are their yields as sole crop (Willey, 1979).

Land equivalent coefficient $(LEC) = LA \times LB$

Where, LA = LER of main crop and LB = LER of intercrop (Adetiloye et al., 1983)

Area time equivalency ratio,

$$ATER = \frac{(Ry_a \times t_a) + (Ry_b \times t_b)}{T}$$

Where, Ry = Relative yield of species *'a'* or *'b'* i.e., yield of intercrop/yield of main crop, t = duration (days) for species *'a'* or *'b'* and T = duration (days) of the intercropping system (Hiebsch and McCollum, 1987)

Aggressivity, $A_{ab} = \left[\frac{Y_{ba}}{Y_{bb} \times Z_{ba}} - \frac{Y_{ab}}{Y_{aa} \times Z_{ab}} \right]$

Where, Y_{ab} and Y_{ba} are the individual crop yields in intercropping and Y_{aa} and Y_{bb} are their yields as sole crop. Z_{ab} and Z_{ba} were proportion of land area occupied on intercropping when compared to sole crop for species *'a'* and *'b'* respectively (Mc Gilchrist ,1965).

Relative crowding coefficient, $RCC = K_{ab} \times K_{ba}$

Where, $K_{ab} = \frac{Y_{ab}}{Y_{aa} - Y_{ab}}$ and $K_{ba} = \frac{Y_{ba}}{Y_{bb} - Y_{ba}}$

K_{ab} and K_{ba} are the RCC for species *'a'* and *'b'* respectively (de Wit, 1960). Okra yield equivalent was calculated as follows (Prasad and Srivastava, 1991).

$$\text{Okra equivalent yield (kg ha}^{-1}\text{)} = \frac{\text{Yield of intercrop}}{\text{Market price of okra}} \times \text{Market price of intercrop}$$

Results and discussion

Intercrops, spacing treatments and their interaction effects significantly influenced LER, LEC and ATER during the *kharif* season (Table 1). In all treatment combinations, LER was greater than unity, thus demonstrating yield advantages for the intercropped plots. In particular, okra+ cucumber combination gave the highest LER of 1.85, implying that 85% more land would be required as sole crops to produce the yield obtained under intercropping situations. It was, however, statistically on par with okra +cucumber and okra+amaranth at 60×45 cm spacing. During the *rabi* season, however, okra+cowpea at 100×45 cm spacing gave the highest LER of 2.69, followed by this combination at 60×45 cm spacing, albeit the differences were not significant. Okra+amaranth combinations, incidentally gave lower LER values of 1.77 and 1.91 at wider and closer spacing respectively. LEC and ATER values followed a trend similar to that of LER. This is consistent with the findings of Ofori and Stern (1987).

Negative aggressivity values (Table 1) were obtained for all treatments except those intercropped with cucumber, signifying that cowpea and amaranthus were dominant over okra, while cucumber was dominated. This may be due to the differential growth habit of the associated species. In addition, the aggressivity values were significantly influenced by the intercrops and spacing treatments during both seasons. For instance, okra+ cucumber treatments showed higher aggressivity values. Conversely, the lowest values were obtained for okra+ amaranth at wider spacing in *kharif* (-0.73) and okra+ cowpea during *rabi* (-4.24). Again, LER, LEC, ATER and agressivity were greater during the *rabi* season, presumably because of the greater number of harvests made during that season. The negative RCC values observed for okra+amaranth at wider spacing (-0.33), okra+cucumber at closer spacing (-13.27) in *kharif* (Table 1) and in all combinations except okra+cucumber at closer spacing during *rabi* implies potential yield reduction in the intercropping situations compared to that of the sole crops. The differences in this respect, however, were not statistically significant.

A comparison of the data presented in Table 2 also show that total biomass production, yield equivalent and net returns were significantly greater for the okra+cowpea combinations, which is consistent with the general trend in competition indices, especially in the *rabi* season. Biomass production in the okra+cowpea intercropping system at lower spacing was 26328 and 27000 kg ha^{-1} during the *kharif* and *rabi* season respectively. This was, however, statistically at par with okra+cowpea at wider spacing, okra+cucumber at lower spacing and okra+ amaranth at lower spacing during the *kharif* season. As regards to yield levels, among the different treatments, okra in combination with cowpea at lower spacing gave the highest 'okra yield equivalent' (7907 and 8709 kg ha^{-1} in the *kharif* and *rabi* season respectively). During both the seasons the lowest okra equivalent yield was recorded by okra+amaranth at a higher spacing (1012 and 1314 kg ha^{-1}), implying the general unsuitability of amaranth as an intercrop in okra-based production systems. The highest net returns were also obtained for the okra+cowpea combination at 60×45 cm spacing (Rs 33456 and Rs 43329 ha^{-1} during *kharif* and *rabi* seasons respectively). A plausible explanation for this is the better utilization of the site resources and the higher economic value of cowpea. Based on the present results, cowpea can be advocated as a promising intercrop in okra-based production systems.

Table 1. Effect of intercropping and spacing on land equivalent ration, land equivalent coefficient and area time equivalency ratio in okra based cropping system

Treatments	Land equivalent ratio		Land equivalent coefficient		Area time equivalency ratio		Aggressivity		Relative crowding coefficient	
	K	R	K	R	K	R	K	R	K	R
Okra (60x45 cm)+amaranth	1.45^{ab}	1.91	0.93 (0.38)^{b}	0.97 (0.45)	1.41^{ab}	1.79	2.08^{b} (-0.06)	2.86^{b} (-1.79)	1.744 (6.07)	1.69 (-1.17)
Okra (100x45 cm)+amaranth	1.12^{b}	1.77	0.85 (0.22)^{b}	0.92 (0.35)	1.09^{b}	1.65	2.07^{b} (-0.73)	2.88^{b} (-1.73)	1.70 (-0.33)	1.69 (-1.54)
Okra (60x45 cm)+cowpea	1.05^{b}	2.62	0.88 (0.27)^{b}	1.17 (0.89)	1.05^{b}	2.45	2.22^{b} (-0.04)	2.46^{bc} (-3.92)	1.72 (2.02)	1.69 (-1.39)
Okra (100x45 cm)+cowpea	1.08^{b}	2.69	0.88 (0.28)^{b}	1.13 (0.78)	1.08^{b}	2.53	2.10^{b} (-0.58)	2.36^{c} (-4.24)	1.72 (2.33)	1.69 (-1.16)
Okra (60x45 cm)+cucumber	1.71^{a}	2.01	1.07 (0.65)^{ab}	1.21 (1.01)	1.67^{a}	1.98	2.69^{a} (2.30)	3.71^{a} (3.76)	1.46 (-13.27)	1.62 (11.66)
Okra (100x45 cm)+cucumber	1.85^{a}	2.24	1.15 (0.88)^{a}	1.27 (1.13)	1.80^{a}	2.21	2.85^{a} (3.14)	3.73^{a} (3.95)	1.69 (0.32)	1.54 (-14.37)
Interaction	S	NS	S	NS	S	NS	S	S	NS	NS

K- *kharif*; R- *rabi*, NS- not significant; Values having same superscripts do not differ significantly; For *LER* and *LEC*, $\sqrt{x + \frac{1}{2}}$ transformed values are given in parenthesis; aggressivity values were transformed to $\sqrt{x + 5}$ during *kharif* and $\sqrt{x + 10}$ during *rabi*; *log (x + 50)* transformation was used for the relative crowding coefficients.

Table 2. Effect of intercropping and spacing on total biomass production and okra equivalent yield in okra based intercropping system

Treatments	Total biomass production (kg ha^{-1})		Okra yield equivalent (kg ha^{-1})		Net returns (Rupees ha^{-1})	
	K	R	K	R	K	R
Okra sole crop at 60x45 cm	13484 [cd]	5787 [e]	7100	2070	17391	8465 [a]
Okra sole crop at 100x45 cm	10469 [d]	3198 [f]	5060	1560	11708	6041 [c]
Okra (60x45 cm)+amaranth	18958 [abc]	11141 [d]	1521 [c]	1512 [b]	14314	538 [c]
Okra (100x45 cm)+amaranth	10432 [d]	6620 [e]	1012 [c]	1314 [b]	9539	785 [c]
Okra (60x45 cm)+cowpea	26328 [a]	27000 [a]	7907 [a]	8709 [a]	33456	43329 [a]
Okra (100x45 cm)+cowpea	22719 [ab]	23031 [b]	6007 [ab]	7683 [a]	300007	27789 [ab]
Okra (60x45 cm)+cucumber	20151 [abc]	16932 [c]	4101 [b]	7740 [a]	27465	22290 [b]
Okra (100x45 cm)+cucumber	15953 [bcd]	12547 [d]	5102 [b]	8104 [a]	29687	30469 [ab]
Interaction	S	S	S	S	NS	S

K= *kharif*, R= *rabi*, NS- not significant; Values with the same superscripts do not differ significantly

Acknowledgements

This paper forms a part of the MSc (Hort) thesis submitted to the Kerala Agricultural University by the first author.

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