Middle East Journal of Agriculture Research
ISSN 2077-4605

Volume : 08 | Issue : 01 | Jan.-Mar. | 2019
Pages:28-34

Biological and Economic benefit of Okra (*Abelmoschus esculentus* L.) Cowpea (*Vigna unguiculata* L. Walp) Intercropping in Sandy Regosol

A.K.M.R.B. Maduwanthi and Brintha Karunarathna

Department of Crop Science, Faculty of Agriculture, Eastern University, Sri Lanka

Received: 20 Dec. 2018 / Accepted 10 Jan. 2019 / Publication date: 20 Jan. 2019

ABSTRACT

A field experiment was conducted at the Crop Farm, Eastern University, Sri Lanka to study the biological and economic advantages of okra (*Abelmoschus esculentus* L.) cowpea (*Vigna unguiculata* L. Walp) intercropping in sandy regosol. Treatments were sole crop - okra (T1), sole crop - cowpea (T2), alternative planting of okra and cowpea (T3), 60/150 cm paired row planting of okra with two rows (T4) and three rows (T5) of cowpea in between paired rows and 75/120 cm paired row planting of okra with two rows (T6) and three rows (T7) of cowpea in between paired rows. The results revealed that, Land Equivalent Ratio (LER) and Area–Time Equivalent ratio (ATER) showed significant differences ($P<0.05$) and higher LER and ATER were noted in T5 as 2.71 and 2.66 respectively. Highest gross and net returns, C/B ratio were obtained by T2 followed by T5. Monetary equivalent ratio was highest in T5 (0.82) followed by T3 (0.76). The present study concluded that 60/150 cm paired row planting of okra with three rows of cowpea in between paired rows (T5) would be the most beneficial planting pattern in biological and economic aspects of okra-cowpea intercropping in sandy regosol.

Keywords: Area Time Equivalent ratio, C/B ratio, Land equivalent ratio, Monetary equivalent ratio, net return

Introduction

World population is increasing at an alarming rate and global demand for food is also increasing rapidly. But, the production of agricultural crops to fulfill this food demand is not sufficient. As a solution for that, most of the farmers in developing countries are practicing intercropping to increase the number of crops grown per unit land area. So, the need of intercropping has come into, not a need, but an essential. Intercropping is a multiple cropping system, in which two or more crops species planted simultaneously in a field during a growing season (Mousavi and Eskandari, 2011). The main objective of intercropping is to improve the productivity per unit land area per unit time with equitable and judicious utilization of land resources and farming inputs including labor without reducing base crop yield (Mareer *et al.,* 2007). Intercropping is increase the cropping intensity, productivity and profitability under optimum utilization of soil, water nutrient and sunlight in time and space. Further, intercropping helps in reduce pests, diseases and weeds damage (Mousavi, and Eskandari, 2011). With the advantage of higher land use efficiency, intercropping is regarded as more productive than sole cropping (Moradi *et al.,* 2014).

The yield advantage due to intercropping is especially important because they are achieved not by means of costly inputs, but the simple advantageous of growing crop together (Willey, 1979). Intercropping is important, when performed properly and presents economic and biological stability of the agro-ecosystem (Favacho *et al.,* 2017). Choudhuri (2011) stated that intercropping is more likely to result in production increases which will provide better economic security to the farmers. Evaluating cropping system is important to select superiority over the existing system adapted by the framers in terms of biological productivity and economic potential for particular area (Seran and Brintha, 2009). These aspects can be expressed in terms of indices, in order to get a numerical idea about the biological and economic benefit of intercropping systems.

Indices are helpful for researchers to summarize, interpret, and display the results from plant competition trials. Indices can express various characters of competition in plant communities,

Corresponding Author: Brintha Karunarathna, Department of Crop Science, Faculty of Agriculture, Eastern University, Sri Lanka. E-mail: ilbrintha@yahoo.co.in

including competition intensity, competitive effects and the outcome of the competition (Gendy *et al.,* 2017). Land Equivalent Ratio (LER) and Area Time Equivalent Ratio (ATER) can be used to evaluate the biological benefits of an intercropping system (Rana and Rana, 2011). At the same time, intercropping systems should be economically viable and profitable to be performed by farmers. Therefore, economic indices also should be taken in to consideration in practicing intercropping. Economic indices such as total cost, gross return, net profit, cost-benefit ratio, MER and per day return give the efficiency of intercropping, as well as sole cropping.

Okra (*Abelmoschus esculentus* L) belongs to the family *Malvaceae* and an economically vital vegetable crop grown in tropical and sub-tropical parts of the world (Ajayi *et al.,* 2017). In Sri Lanka, okra is successfully grown in wet, intermediate and dry zone. Okra contains high fiber, vitamin A, C, and K and minerals such as Calcium, Iron, Magnesium and Potassium (Kumar *et al.,* 2013). Okra has several potential health beneficial effects on vital human diseases, especially cardiovascular disease, type 2 diabetes, digestive diseases and cancers (Dubey and Mishra, 2017).

Cowpea (*Vigna unguiculata* L. Walp.) belongs to the Phaseoleae tribe of the *Leguminosae* family. In Sri Lanka, cowpea is mostly cultivated in dry environments. Cowpea is very much important due to the higher proportion of protein compared to the cultivated other legumes. The mature grain have 20 to 25% of protein, 1.3 to 1.5% lipid and 5.1 to 5.8% crude fiber (Basaran *et al.,* 2011). Cowpea contains minerals such as Iron, Copper, Phosphorus and Tryptophan and vitamins such as vitamin B. Due to low fat and high fiber in cowpea, it reduces heart diseases by reducing low density lipoproteins (Timko *et al.,* 2007).

Objective of this study is to assess the benefit of okra cowpea intercropping in terms of biological and economic aspects.

Methodology

The field experiment was conducted at the crop farm, Eastern University, Sri Lanka, in 2018 to study the biological and economic benefits of okra (*Abelmoschus esculentus* L.) cowpea (*Vigna unguiculata* L. Walp) intercropping in sandy regosol. The experiment site is situated between 81° 34' latitude and longitude and 7° 48' longitude which come under the agro ecological zones of low country dry zone. The soil type in the experimental site is sandy regosol. This experiment was carried out using Randomized Complete Block Design (RCBD) having seven treatments with four replicates. Okra variety *Haritha* and cowpea variety *Waruni* was used for the experiment. Treatments were sole crop of okra with the spacing of 90 cm × 90 cm (T1), sole crop of cowpea with the spacing of 30 cm × 15 cm (T2), alternative planting of okra and cowpea (T3), 60/150 cm paired row planting of okra with two rows (T4) and three rows (T5) of cowpea in between paired rows and 75/120 cm paired row planting of okra with two rows (T6) and three rows (T7) of cowpea in between paired rows. Okra and cowpea were harvested at maturity stage which was continued for three pickings in five days interval. Cumulative yields were measured. Biological indices such as Land Equivalent Ratio (LER) and Area Time Equivalency ratio (ATER) and economic indices like total cost, gross return, net return, Cost Benefit ratio, Monetary Equivalent Ratio and per day return were calculated by using relevant equations.

Land Equivalent Ratio (LER) and Area Time Equivalency ratio (ATER)

$$\text{LER} = \frac{\text{Yield of intercrop okra}}{\text{Yield of monocrop okra}} + \frac{\text{Yield of intercrop cowpea}}{\text{Yield of monocrop cowpea}} \qquad 1$$

$$ATER = \frac{L_O * T_O + L_C * T_C}{T} \qquad 2$$

Where,
Lo = Partial LER of okra in intercrop
To = Duration (in days) of okra
Lc = Partial LER of cowpea in intercrop

Tc = Duration (in days) of cowpea
T = Total duration of the intercropping system (in days)

Cost of cultivation

Cost of cultivation was taken into account by calculating total expenses incurred for inputs such as seeds, fertilizers and chemicals, to reach particular level of output.

Gross return

Gross return was taken as the total amount of revenue that can be obtained by the yield of both okra and cowpea during the total life time of the plants. For that, the farm gate price of unit weight of okra and cowpea was multiplied by the total yield.

Net profit

$$\text{Net profit} = \text{Total cost} - \text{Gross return} \quad (3)$$

Cost-benefit ratio

$$\text{Cost-benefit ratio} = \frac{\text{Gross return}}{\text{Total cost of cultivation}} \quad (4)$$

Monetary equivalent ratio (MER)

$$MER = \frac{ro + rc}{Ro} \quad (5)$$

Where,
ro = Monetary returns of okra
rc = Monetary returns from cowpea
Ro = Highest sole crop monetary return

Per day return

$$\text{Per day return} = \frac{\text{Net returns}}{\text{Cropping period}} \quad (6)$$

The calculated data were analyzed by using statistical software.

Results and Discussion

Biological indices

Land Equivalent Ratio (LER)

LER is defined as the relative land area required in monocropping producing the same yields in intercropping. It can be used to measure yield advantages. As well, individual LERs can be compared to indicate competitive effects (Alfa and Musa, 2015). There was significant difference ($P<0.05$) in LER among tested intercropping treatments is shown in Table 1. Highest value was obtained by T5 (2.71), while lowest value was noted by T7 (1.14). All the intercropping systems showed higher LER than monocropping. This indicates that, sole cropping may need more land area to cultivate to get the similar yield as intercropping yield of okra and cowpea. This can be described as that photosynthesis under field conditions, and consequently total dry matter assimilation, is limited by the amount leaf canopy of the intercrops may make better use of light in this respect. In the same time, the beneficial effects of combined leaf canopy of the intercrops can be achieved through more efficient use of light rather than greater light interception (Zyada, 2016). Also, being harmony to the present results, Choudhuri and Jana (2016) stated that the LER was higher in okra and cowpea intercropping system than sole cropping in both okra and cowpea.

Area – Time Equivalent Ratio (ATER)

ATER gives more realistic comparison of the yield advantage of intercropping over monocropping than LER as it considers variation in time taken by the two crops of different intercropping systems (Gendy *et al.,* 2017). There was significant variation (P<0.05) in ATER among tested intercropping treatments is shown in Table 1. Maximum and minimum ATER were recorded in T5 (2.66) and T7 (1.25) respectively. ATER is an important index that determines the productivity of a crop in time basis. As well, this is very much important to determine the competition of both crops in intercropping for basic growth resources such as nutrients, water and solar radiation (Matwally *et al.,* 2016). Zyada (2016) stated that higher ATER values were observed in okra cowpea intercropping in 1:1 ratio while Ijoyah and Usman (2013) has reported that ATER is higher in okra and cassava intercropping, with defined number of cassava plants and a low density of okra plants than sole cropping and higher okra plant density.

Table 1: Biological efficiency of intercropped treatments

Treatment	LER	ATER
T3	1.78∓0.25ba	1.38∓0.25ba
T4	1.89∓0.16ba	1.78∓0.16ba
T5	2.71∓0.62a	2.66∓0.62a
T6	1.50∓0.21b	1.54∓0.21b
T7	1.14∓0.10b	1.25∓0.10b
F test	*	*

Value represent mean ∓ standard error of four replicates.
F test: - *: P<0.05
Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Economic indices

Total cost

Total cost of cultivation determines the economic expenditure for the intercropping systems. It was found that, there was significant difference (P<0.01) among treatments for total cost (Table 2). Total cost is high in T5 (Rs. 36,500) and lower in T2 (Rs. 15,800). Total cost of cultivation was high in all the intercropping systems compared to sole cropping, since higher input may require establishing and maintaining intercropping. Total cost was increased with the increase of plant density. Adeniyi (2011) stated that, cost of production including fixed costs, labor costs, cost for seeds and insecticides was higher in sole cowpea than sole cropping okra, as well intercropping arrangements of okra and cowpea in 1:1, 1:2 and 2:1 ratios. Choudhuri (2011) found that, total cost including fixed cost and variable cost was high in okra and cowpea intercropping system than sole cropping of both okra and cowpea. Qasim *et al.* (2013) reported that, a higher total cost was incurred by pea and garlic intercropping than pea alone.

Gross return

Gross return is an important economic index that determines the profit or benefit that a farmer can obtain. Table 2 shows that, there was a significant difference (P<0.01) in gross return among tested treatments. Highest gross return value was obtained in T2, while least value was given by T1. Kumar *et al.* (2013) stated that gross return was higher in okra-radish intercropping in 1:2 ratio planting. Choudhuri (2011) found that, superior gross return was given by okra and cowpea intercropping systems than sole cropping of both okra and cowpea. Ijoyah and Usman (2013) reported that gross return was higher in okra and cassava intercropping than sole cropping of both okra and cassava.

Net profit

Net return reflects the actual income of farmer. There was significant difference (P<0.01) in net profit with the different planting patterns is shown in Table 2. Net return was higher in T2 and low in T1. However, no significant differences among treatments T2, T3 and T5 in net profit. Adeniyi (2011) stated that net profit was higher in the treatment 2:1 of okra and cowpea intercropping than sole cropping and other planting patterns. Ullah *et al.* (2007) reported that net return was high in intercropping system of 90 cm spaced double row strips of maize with soybean, than in sole cropping and other crop arrangements. John and Mini (2005) found that, net return was higher in okra cowpea intercropping systems, than monocropping of okra. Abou-Hussein *et al.* (2005) cited that, intercropping of green bean + green onion + lettuce earned higher net income than sole cropping of sole green bean, green onion and lettuce.

Cost Benefit ratio (C/B ratio)

Cost Benefit ratio is an index that shows the comparative explanation about the investment by a farmer. Cost Benefit ratio was significantly different (P<0.01) among the tested treatments is shown in Table 2. Cost Benefit ratio was highest in T2 (79.49) followed by T5 (31.73) and low in T1 (5.64). Kumar *et al.* (2013) found that, benefit cost ratio was higher when okra and radish intercropped in 2:3 ratio. Choudhuri and Jana (2016) stated that, cost benefit ratio was superior in okra cowpea intercropping system than sole cropping of both okra and cowpea. Cost benefit ratio was not significantly affected by the intercropping systems of maize and legumes (Kheroar and Patra, 2014). Ajayi *et al.* (2017) cited that, cost benefit ratio was superior in okra and groundnut intercropping than okra and cowpea intercropping, as well sole okra.

Monetary Equivalent Ratio (MER)

This can be used to interpret intercropping efficiency when the objective of the end user is monetary advantage. There was significant variation (P<0.01) in Monetary equivalent ratio among tested treatment (Table 2). Maximum value was observed in T5 (0.82) followed by T3 (0.76). Minimum value was obtained by T7 (0.38). There was no significant variation (P>0.05) in MER among T4, T6 and T7. MER was higher in cowpea and maize intercropping systems with higher plant population (Afe and Atanda, 2015). Mbah and Ognodo (2013) stated that, MER was increased in sweet corn and vegetable cowpea with the increase of plant population of both sweet corn and vegetable cowpea.

Per day return

This index is important for those who willing the monetary advantage from an intercropping system. So, this may be very much valuable for small scale farmers. There was significant difference (P<0.01) in per day return among the tested treatments. Per day return was high in T2 and low in T1 (Table 2). In contrast, Kheroar and Patra (2014) explained that, per day return was not significantly affected by the intercropping systems of maize and legumes.

Table 2: Economic efficiency of treatments

Treatment	Total cost (Rs/ha)	Gross return (Rs/ha)	Net profit (Rs/ha)	C/B ratio	MER	Per day return (Rs/ha)
T1	26.200f	1.47.900c	121.700c	5.64d	-	2.028c
T2	15.800g	1.256.065a	1.240.265a	79.49a	-	20.671a
T3	35.260c	1,016.295a	981.035a	28.82b	0.76a	16.350a
T4	35.520b	691.332b	655.812b	19.46c	0.45b	10.930b
T5	36.500a	1.158.407a	1.121.907a	31.73b	0.82a	18.698a
T6	34.280e	588.704b	554.424b	17.17c	0.39b	9.240b
T7	34.940d	582.986b	548.006b	16.69c	0.38b	9.133b
F test	**	**	**	**	**	**

Value represent mean ∓ standard error of four replicates.
F test: - **: P<0.01
Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Conclusion

The present study revealed that, there was a significant difference (P<0.05) in LER in tested treatments. The highest LER (2.71) and ATER (2.66) were found in T5. In case of economic indices, total cost showed a significant difference (P<0.01) and high in T5. Highest gross and net returns were obtained by T2 followed by T5 and T3. C/B ratio was significantly different (P<0.01) while showing highest values in T2 (79.49) followed by T5 (31.73). MER was highest in T5 (0.82) followed by T3 (0.76). Per day return showed a significant difference (P<0.01) among the treatments. Higher per day return was obtained by T2 and it was statistically par with T5 and T3. The present study concluded that, 60/150 cm paired row planting of okra with three rows of cowpea in between paired rows (T5) would be the most beneficial planting pattern in biological and economic characteristics in sandy regosol.

References

Abou-Hussein, S.D., S.R. Salman, A.M.R. Abdel-Mawgoud and A.A. Ghoname, 2005. Productivity, quality and profit of sole or intercropped green bean (*Phaseolus vulgaris* L.) crop. Jounal of Agronomy, 4(2): 151-155.

Adeniyi, O.R., 2011. Economic aspects of intercropping systems of vegetables (okra, tomato and cowpea). African Journal of Plant Science, 5(11): 648-655

Afe, A.I. and S. Atanda, 2015. Percentage yield difference, an index for evaluating intercropping efficiency. American Journal of Experimental Agriculture, 5(5): 459-465.

Ajayi, E.O., I.B. Adeoye and O.A. Shittu, 2017. Economic analysis of intercropping okra with legumes. Journal of Agricultural Sciences, 62(2): 193-202.

Alfa, A.J. and U.T. Musa, 2015. Assessing the land equivalent ratio (LER) and stability of yield of two cultivars of sorghum (*Sorghum bicolor* L. Monech) soybean (*Glycine max* L. Merr) to row intercropping system. Journal of Biology, Agriculture and Healthcare, 5(18): 144-149.

Basaran, U., I. Ayan, Z. Acar, H. Mut, and O.O. Asci, 2011. Seed yield and agronomic parameters of cowpea (*Vigna unguiculata* L.) genotypes grown in the Black Sea region of Turkey. *African Journal of Biotechnology,* 10(62):13461-13464

Choudhuri, P. (2011). Growth, yield, quality and economic impacts of intercropping in vegetableand spice crops. Ph.D. thesis. Uttar Banga Kirishi Viswavidyalaya, India.

Choudhuri, P., and J.C. Jana, 2016. Intercropping in okra for sustainable vegetable production. International Journal of Bio-resource and Stress Management, 7(4): 837-840.

Dubey, P. and S. Mishra, 2017. Effect of okra seed in reduction of cholesterol. Journal of Entomology and Zoology Studies, 5(4): 94-97.

Favacho, F.S., J.S.S. Lima, F.B. Neto, J.N. Silva and A.P.B. Junior, 2017. Productive and economic efficiency of carrot intercropped with cowpea vegetable resulting from green manure and different spatial arrangements. Revista Ciencia Agronomica, 48(2): 337-346.

Gendy, A.S.H., W.S. Nosir and A.S. Nawar, 2017. Evaluation of competitive indices between roselle and cowpea as influenced by intercropping systems and bio-fertilization type. *Middle East Journal of agriculture*, 6(1): 199-207.

Ijoyah, M.O. and U.A. Usman, 2013. Okra: a potential intercrop for farmers in Nigeria. Journal of Global Biosciences, 2(6): 222-235.

John, S.A., and C. Mini, 2005. Biological efficiency of intercropping in okra (*Abelmoschus esculentus* (L.) Monech). Journal of Tropical Agriculture, 43(1-2): 33-36.

Kheroar, S. and B.C. Patra, 2014. Productivity of maize - legume intercropping systems under rainfed situation. African Journal of Agricultural Research, 9(20): 1610-1617.

Kumar, D.S., D.E. Tony, A.P. Kumar, K.A. Kumar, D.B.S. Rao and R. Nadendla, 2013. A review on: *Abelmoschus esculentus* (okra). International Research Journal of Pharmaceutical and Applied Sciences, 3(4): 129-132.

Mareer, S.B., B.S. Lingaraju and G.B. Shashidhara, 2007. Productivity and economics of maize and pigeon pea intercropping under rainfed condition in northern transitional zone of Karnataka. Karnataka Journal of Agricultural Science, 20(1): 1-3.

Matwally, A.A., A. A. Abuldahab, M.N. Shereif and M.M. Awad, 2016. Productivity and land equivalent ratio of intercropping cotton with some winter crops in Egypt. American Journal of Experimental Agriculture, 14(1): 1-15.

Mbah, E.U., and E.N. Ognodo, 2013. Assessment of intercropped sweet corn (*Zea mays* var. saccharata) and vegetable cowpea (*Vigna unguiculata* (L.) Walp) using competitive indices in the derived savannah in south-eastern Nigeria. Journal of Biology, Agriculture and Healthcare, 3(3): 84-93.

Moradi, H., M. Noori, A. Sobhkhizi, M. Fahramand and K. Rigi, 2014. Effect of intercropping in agronomy. Journal of Novel Applied Sciences, 3(3): 315-320.

Mousavi, S. R. and H. Eskandari, 2011. A general overview on intercropping and its advantages in sustainable agriculture. Journal of Applied Environmental and Biological Sciences, 1(11): 482-486.

Mousavi, S.R. and H. Eskandari, 2011. A general overview on intercropping and its advantages in sustainable agriculture. Journal of Applied Environmental and Biological Sciences, 1(11): 482-486.

Qasim, S.A., M.A. Anjum, S. Hussain and S. Ahmad, 2013. Effect of pea intercropping on biological efficiencies and economics of some non - legume winter vegetables. Pakistan Journal of Agricultural Sciences, 50(3): 399-406.

Rana, S.S. and M.C. Rana, 2011. Cropping System. Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, pp 80.

Seran, T. H., and I. Brintha, 2009. Study on biological and economic efficiency of radish (*Raphanus sativus* L.) intercropped with vegetable amaranthus (*Amaranthus tricolor* L.). Open Horticulture Journal, 2: 17-21.

Timko, M.P., J.D. Elhers and P.A. Roberts, 2007. Genome mapping and molecular breeding in plants. Springer-Verlag. Berlin Heiidelberg. 49-67.

Ullah, A., M.A. Bhatti, Z.A. Gurmani and M. Imran, 2007. Studies on planting patterns of maize (*Zea mays* L.) facilitating legumes intercropping. *Journal of Agriculture Researches,* 45(2): 113-118.

Willey, R.W., 1979. Intercropping _ its importance and research needs. Part-1. Competition and yield advantages. Field crops Abstracts, 32: 1-10.

Zyada, H.G., 2016. Growth, Yield and its Components, Chemical constituents, correlation coefficient and competition indices of okra and cowpea as influenced by different intercropping systems. Middle East Journal of Agriculture Research, 5(4): 726-738.