International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; SP6: 36-40

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(Special Issue -6)
3rd National Conference
On
PROMOTING & REINVIGORATING AGRI-HORTI, TECHNOLOGICAL INNOVATIONS [PRAGATI-2019]
(14-15 December, 2019)

Effect on yield and economics of okra [*Abelmoschus esculentus* (L.) Moench] under different intercropping system

Sachin Kumar and Dharmpal Kerketta

Abstract
The objective of the study was to evaluate yield performance and economics of Okra under intercropping with Palak, Fenugreek, Greengram and Radish. The field experiment was carried out at Indira Gandhi Krishi Vishwavidyalaya, Raipur during *spring* season of 2007. The experiment was laid out in randomized complete block design with three replication. Okra was grown as main crop on plot with palak, fenugreek, greengram, radish as intercrop. In Okra all the growth parameters and yield attributes were relatively higher under sole cropping which ultimately registered the higher fruit yield as compared to intercropping treatments. However, among intercropping, it was observed that growth parameters, yield attributes and yield were higher under Okra: Fenugreek (1:2) ratio. Further, it was observed that, highest land equivalent ratio was registered under okra: greengram and okra: fenugreek at 1:2 row ratio. Maximum gross return (Rs. 187800 ha^{-1}), net return (Rs. 165238 ha^{-1}) and okra equivalent yield (15.65) were recorded from the intercropping of okra: radish at 1:2 row ratio and maximum Benefit Cost ratio (Rs. 7.73) was recorded from intercropping of okra: radish at 2:3 row ratio.

Keywords: Growth parameters, light intensity, light transmission ratio, land equivalent ratio, okra equivalent yield, benefit cost ratio

Introduction
Intercropping is practiced with the aim of maximizing plant cooperation rather than plant competition for maximum crop yields (Sullivan, 2001) [22]. Interplanting of crops by smallholder and peasant farmers has been a common practice throughout the years. Mono-cropping or pure stands have been emphasized, because of its advantages (Anderson *et al.*1980; Gondwe, 1992) [2, 11]. Despite the advantages of mono-cropping almost all smallholder or peasant farmers in the developing world still practice intercropping. This practice may allow complementary interactions in crops that have greater system resilience (Theunissen, 1997; Wolfe, 2000) [23, 25] greater production at crop edges (Ghaffarzadeh *et al.*, 1997) [7] reduce insect-pest incidence (Theunissen & Schelling, 1996; Ramert, 2002) [24, 18] reduce disease transfer (Finckh & Wolfe, 1997; Garrett & Mundt, 1999; Wolfe, 2000) [25, 5, 6] and deliver environmental benefits such as greater soil and water conservation potential (Gilley *et al.*, 1997; Theunissen, 1997; Poudel *et al.*, 1999; Gilley *et al.*, 2002) [8, 16, 23, 9].
Vegetables are rich sources of essential biochemicals and nutrients such as carbohydrates, carotene, protein, vitamins, calcium, iron, ascorbic acid and palpable concentration of trace minerals (Salunkhe & Kadam, 1995) [19]. Okra (*Abelmoschus esculentus* L. Moench) is a member of *malvaceae* family and is one of the most important vegetable crops, which is

grown throughout the year in India. It is cash crop and fetches higher prices during spring summer season when other vegetables are short in supply in the market. Palak (*Spinacia oleracea*) is an important leafy vegetable. Its succulent leaves and stems form a nutritious dish after cooking. Fenugreek (*Trigonella foenumgraecum)* is an important spice crop. Besides seed production, it is also grown for green leaves and forage. Greengram (*Vigna radiata)* is one of the most important pulse crops of India. Being a short duration crop it fits well in various multiple and intercropping system. Radish (*Raphanus sativus*) is an important root vegetable crop in the country. It is therefore important to find after suitable most economical intercrop with okra for Chhattisgarh during stain season. Hence an attempt was made to know the yield performance and economic evaluation of okra under efficient intercrop.

Materials and Methods

The field experiment was carried out at Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) during *spring* season 2007. The soil of experimental field was clayey (*Vertisols*) in texture, locally known as "*Kanhar*. Raipur the capital of C.G. state comes under dry moist, sub humid region. The region receives 1200-1400 mm rainfall annually out of which about 88% received during the rainy season (June to September) and the rest 12% during winter season (October to February). January is the coolest and May is the hottest month. Soil surface temperature of this region crosses 60^0C, air temperature to 48^0 C and humidity drops up to 3 to 4 per cent during summer season and the mercury level drops to as low as 6^0C during December and January.

The experiment was laid out in randomized complete block design with three replications. The experiment consisted of 13 treatments of sole and intercropping system, *viz*., T_1- Okra (sole)- 45cm, T_2- Palak (sole)-20cm, T_3- Fenugreek (sole) - 20cm, T_4- Greengram (sole) -30cm, T_5- Radish (sole)-30cm, T_6- Okra+ Palak (1:2)- 45:25cm, T_7- Okra+ Fenugreek (1:2)- 45:25cm, T_8- Okra+ Greengram (1:2)- 45:25cm, T_9- Okra+ Radish (1:2)- 45:25cm, T_{10}- Okra+ Palak (2:3) paired (30:75), T_{11}- Okra+ Fenugreek (2:3) paired (30:75), T_{12}-Okra+ Greengram (2:3) paired (30:75), T_{13}- Okra+ Radish (2:3) paired (30:75). The crops were sown on 17 January 2007. The size of plot was 6 x 2.7 m^2. A uniform dose of 100 kg N, 60kg P_2O_5 and 60 kg of K_2O per ha was applied. Four summer irrigation was given to sole okra and okra intercropping. Cultural operation was carried out as per local recommendation for the crops. The observations of growth parameters such as plant height and dry matter accumulation were taken in 30, 50, 70 and 90 DAS, where as light intensity, light transmission ratio, land equivalent ratio, Okra equivalent yield, net returns and B: C ratio was calculated using following equations.

On field observations

Growth parameters (Plant height and Dry matter accumulation)

The height was recorded from three tagged plants. Height was measured in centimeter from ground surface to the top of the leaf of main shoot. Mean height was then worked out by dividing the summation by three. Three randomly selected plants uprooted for dry matter accumulation from each plot, and then samples were kept separately in paper bags in an oven at 60^0C. After 48 hours when reaching at constant dry weight, each sample was weighted by using electrical balance then average dry matter accumulation $plant^{-1}$ was calculated

Light intensity

Intensity of light is being taken by lux meter. At first lux meter kept on top surface of plants then it become kept on bottom surface. These procedures were done three times on randomly selected plants. Then how much light is intercepted is calculated by following equation-

$$\text{Light intensity (\%)} = \frac{\text{Light intensity on top - Light intensity on bottom}}{\text{Light intensity on top}} \times 100$$

Light transmission ratio

Light transmission ratio is calculated by following equation-

$$\text{Light transmission ratio (\%)} = \frac{\text{Light intensity on bottom surface}}{\text{Light intensity on top surface}} \times 100$$

Post harvest observations

Land equivalent ratio, okra equivalent yield and Yield

The land equivalent ratio was calculated with the help of following formula.

$$\text{LER} = \frac{\text{Yield of crop 'A' in intercrop}}{\text{Yield of crop 'A' in pure crop}} + \frac{\text{Yield of crop 'B' in intercrop}}{\text{Yield of crop 'B' in intercrop}}$$

Okra equivalent yield was calculated with the help of following formula:

$$\text{OEY (t ha}^{-1}\text{)} = \frac{\text{[Yield of intercrop (t ha}^{-1}\text{) x Price of intercrop (Rs q}^{-1}\text{)] + yield of main crop (t ha}^{-1}\text{)}}{\text{Price of okra (Rs q}^{-1}\text{)}}$$

Yield was calculating in terms of tone per ha.

Cost of cultivation, Gross return and Net returns

Cost of cultivation is calculated by sums of fixed cost and variable costs (seed, fertilizer, labour etc.)

In each treatment for calculating gross returns, yield was multiplied by the price per unit weight. For this calculation farm gate price was taken in an account.

Net returns were calculated by subtracting cost of cultivation from gross return.

Results & discussion

On field observations

Growth parameters (Plant height and Dry matter accumulation)

It is evident from the table-1 that higher growth parameters were recorded under sole cropping of okra than rest of the intercropping system. Among intercropping system, 1:2 ratio recorded higher growth parameters than 2:3 paired intercropping system over respective crops. After critical examination of data, revealed that okra: fenugreek and okra: greengram at the 1:2 row ratio, recorded higher growth parameters than other treatments. Whereas these were recorded minimum under intercropping of okra: radish at 2:3 row ratio.

It might be due to less competition for light, nutrients, moisture and due to the fact that sole crop enjoyed a competition free environment, which resulted in better development of growth parameters and more photo synthetically active leaf area. It in turn led to greater translocation of assimilates from source to sink which ultimately increased the yield. Similar results were also reported by Singh and Shrivastava (1987) [20]. The positive role of nitrogen, phosphorous and potassium for cell division and enlargement has been already established. The higher value of dry matter accumulation might be due to higher availability and translocation of nutrients during growth and development stages. The dry matter accumulation depends upon the photosynthesis and respiration rate, which finally increase the plant growth with respect to increased plant height, branches and fruit yield.

Table 1: Effect of intercropping system on growth parameters of okra.

Treatments	Plant height 90 DAS (cm)	DMA 90 DAS (g plant^{-1})
Okra sole	65.13	35.63
Okra: Palak (1:2)	58.20	28.10
Okra: Fenugreek (1:2)	63.60	32.13
Okra: Greengram (1:2)	62.23	32.03
Okra: Radish (1:2)	60.84	26.27
Okra: Palak (2:3)	60.64	25.83
Okra: Fenugreek (2:3)	60.97	31.27
Okra: Greengram (2:3)	61.26	31.63
Okra: Radish (2:3)	57.46	25.47
CD (P=0.05)	2.48	3.02

DMA- Dry matter accumulation

However, among intercropping system, the different growth parameters of okra were higher when intercropped with either fenugreek or greengram (leguminous crop) than the palak or radish crop (non leguminous crop). It is well known fact that the growth of crop (non leguminous) increased when grown in association with leguminous crops. Further, after critical analysis of data revealed that, 1:2 row ratio gave better growth behaviour of okra plant than the 2:3 row combination (paired) might be due to more congenial atmosphere was provided due to more space become available for all the crops. Similar results were also demonstrated by Kumar *et al.* (2006) [22].

Light intensity and Light transmission ratio

Light intensity and light transmission ratio are presented in table-2. Both the parameters were found to be higher in sole cropping of okra. It might be due to sole crop got better space, light and other resources and grow in competition free environment resulting better growth and development. Among the intercropping system light intensity and light transmission ratio were higher under Okra: Fenugreek (1:2) intercropping system. It might be due to less spacing of crops absorb maximum sunlight and got better competition free environment than paired row. Radke and Hagstrom (1976) reported that light use efficiency could be an important factor for the yield advantages under intercropping system such as millet with groundnut and potato with corn intercropping. Elsayed and Kandeel (2003) [4] showed that low density of trees, (Casurina glauca and Eucalyptus camaldulensis), modify the microclimate for okra, cowpeas and squash and offers a beneficial effect on their physiological processes. Kuruppuarachchi, (1990) [13] found that the benefit of shading on intercropped potato yields was variable and this variability might be related to the degree of shading. Batugal *et al.* (1990) [3] reported that intercropping maize with potato could be beneficial in providing partial shade for potato and reduce both air and soil temperatures.

Table 2: Effect of intercropping system on light intensity and light transmission ratio on okra.

Treatments	LI (%)	LTR (%)
Okra sole	81.56	27.80
Okra: Palak (1:2)	73.87	20.76
Okra: Fenugreek (1:2)	79.96	27.17
Okra: Greengram (1:2)	78.23	24.43
Okra: Radish (1:2)	72.73	19.97
Okra: Palak (2:3)	70.70	18.40
Okra: Fenugreek (2:3)	75.46	21.63
Okra: Greengram (2:3)	76.10	23.83
Okra: Radish (2:3)	68.43	17.02
CD (P=0.05)	4.29	3.60

* LI- Light intensity, LTR- Light transmission ratio

Post harvest observations

Land equivalent ratio, Okra equivalent yield and Yield

The data on land equivalent ratio under different treatments are presented in table-3. Data indicated that land equivalent ratio was significantly higher under intercropping of okra: greengram at 1:2 row ratio (1.96), followed by okra: greengram at 2:3 row ratio and okra: fenugreek at 1:2 row ratio, which were at par to each other than the rest of the treatments. The lowest land equivalent ratio was recorded under intercropping of okra: palak at 2:3 row ratios. This may be as a result of less competition for light and other resources between the plants, and greater utilization of land space and time. An LER greater than 1.0 usually shows that intercropping is advantageous whereas an LER less than 1.0 shows a yield disadvantage (Gliessman, 1998) [10].

Higher okra equivalent yield was recorded under intercropping of okra: radish at 1:2 row ratio (15.65 t ha^{-1}) table-3. Okra equivalent yield are the function of crop yield and their per unit price of the produce. Thus a crop yielding less may surpass other higher yielder if its unit is relatively quite high. It was also indicated that higher biomass production per unit of land area and efficient use of available resources under intercropping than sole cropping. Similar results also reported by Mandal *et al* (1996) [14].

Table 3: Land equivalent ratio, okra equivalent yield and yield influenced by intercropping system.

Treatments	LER	OEY (t ha^{-1})	Fruit Yield (t ha^{-1})
Okra sole	1.00	8.67	8.67
Okra: Palak (1:2)	1.78	13.39	8.16
Okra: Fenugreek (1:2)	1.86	10.76	8.56
Okra: Greengram (1:2)	1.96	11.43	8.43
Okra: Radish (1:2)	1.58	15.65	7.90
Okra: Palak (2:3)- paired	1.50	11.59	7.86
Okra: Fenugreek (2:3)- paired	1.59	9.85	8.23
Okra: Greengram (2:3)- paired	1.88	11.18	8.26
Okra: Radish (2:3)- paired	1.70	14.92	7.56
CD (P = 0.05)	0.15	1.12	0.25

LER- Land equivalent ratio, OEY- Okra equivalent yield

Yield was recorded higher under sole cropping of okra than rest of the intercropping system table-3. Padmavathi and Raghavaiah (2004) [15] reported that yields per plant of vegetable intercrops were greater in monoculture. Yadav *et al.* (2000) [26] reported that significant increase in seed and stover yield of fenugreek and mustard were observed under sole planting of both the crops over rest of the intercropping treatments. This was primarily due to higher plant population per unit area as the replacement type system of intercropping was followed. Reduction in yield in intercropping might be due to more competition for agro resources, allelopathic and shading effect of plants in intercropping. Similar findings were also reported by Singh (1993) [21]. Among intercropping system, these were recorded higher under 1:2 ratio than 2:3 paired intercropping system over respective crops. After critical examination of data, revealed that okra: fenugreek and okra: greengram at the 1:2 row ratio, recorded higher yield than other treatments. Whereas these were recorded minimum under intercropping of okra: radish at 2:3 row ratio. Increase in plant height, dry matter accumulation in successive growth stages helped in increasing the fruit yield ha^{-1}. This was mainly due to higher photosynthesis efficiency and net assimilation, which helped in increasing the overall growth of the plants.

Cost of cultivation, Gross return and Net returns

Data pertaining to economics of sole and intercropping system are presented in the table 4. The data indicated that intercropping of okra: radish at 1:2 row ratio gave maximum gross return (Rs 187800 ha^{-1}) followed by okra: radish at 2:3 row ratio, whereas intercropping of okra: radish at 1:2 row ratio gave maximum net return (Rs 165238 ha^{-1}) followed by okra: radish at 2:3 row ratio, okra: palak at 1:2 row ratio. Highest Benefit Cost ratio (Rs. 7.73) was observed under intercropping of okra: radish at 2:3 row ratio.

The profit (gain) of the farmers involved in the intercrops may be increased by reduction in the cost of labour. The man-days in weeding of intercrops may be reduced as a result of ability of the companion crops to suppress the obnoxious weeds. The cost of fertilizer will also be reduced in inter-cropping because of the ability of companion crops to reduce the impact of rainfall and erosion, thereby reducing the nutrient depletion of the soil. The ability of companion crops in restoring soil fertility has been highlighted by many workers. Similar results were also given by Alabi and Esobhawan (2006) [1].

Table 4. Effect of sole and intercropping on economics of okra

Treatments	Total cost (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B: C ratio (Rs)
Okra (sole) 45cm	16683	104000	87317	1: 5.23
Okra: Palak (1:2) 45:25cm	23592	160800	137208	1: 5.81
Okra: Fenugreek (1:2) 45:25cm	21723	129200	107277	1: 4.94
Okra: Greengram (1:2) 45:25cm	19641	137653	118012	1: 6.00
Okra: Radish (1:2) 45:25cm	22562	187800	165238	1: 7.33
Okra: Palak (2:3) paired (30:75)	21197	139200	118003	1: 5.56
Okra: Fenugreek (2:3) paired (30:75)	19947	118300	98353	1: 4.93
Okra: Greengram (2:3) paired (30:75)	18366	134627	116261	1: 6.32
Okra: Radish (2:3) paired (30:75)	20506	179200	158694	1: 7.73

* Yield of okra measured in terms of fruit yield, yield of palak, fenugreek and greengram measured in terms of seed yield and yield of radish measured in terms of root yield.
* B: C ratio- Benefit: Cost ratio.

Summury and Conclusion

Based on the finding of this experiment, it may be concluded that sole crop of okra recorded higher growth parameters and yield as compare to rest of the intercropping treatments which is due to more free space for growth and development then intercropping systems. Whereas among intercropping with various crops, growth parameters and fruit yield of okra recorded higher under leguminous crops it is due to synergistic effect of leguminous crops on main crop.

Acknowledgements

I am grateful to the Department of Agronomy, Indira Gandhi Agriculture University, Raipur, Chhattisgarh, India for providing financial and logistical support towards this research and manuscript.

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