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Sustainable production and pest management of okra [*Abelmoschus esculentus* (L.) Moench] through inter cropping

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ABSTRACT

A field trial was conducted during pre-kharif season of 2022-23 at the Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India to assess the impact of intercropping on sustainable production and eco-friendly management of major insect pests of okra under maize border crop. The trial was laid out in a Randomized block design with seven different treatment combinations.Jassids and whitefly,specially the white flies,vector of Yellow Vein Mosiac Disease, have become one of the major challenges for the commercial okra growers of this area mainly in rainy season. The preswnt work has been carried out with an aim to manage these notorious pests of okra in a sustainable manner. The results showed that intercropping had a significant effect on various growth, yield, quality, economics and major pest complexes of okra.Trial result revealed that okra and cowpea combination recorded the highest okra equivalent yield (26.15 ton/ha), closely followed by okra and marigold (22.89 ton/ha). Regarding pest control, significant maximum reduction of jassid and whitefly were noticed in okra and marigold association (35.06% and 27.12 % respectively). intercropping also showed a notable effect on the quality parameter of the main crop. Intercropping okra with cowpea produced a significantly maximum concentration of ascorbic acid(22.5mg/100g) than other treatments. From an economic standpoint, the intercropping system of okra and cowpea system exhibited highest net return (Rs.2,35,038.50) and benefit-cost ratio (B:C ratio3.98). The intercropping system of okra and cowpea was an efficient user of biological resources showing maximum values for land equivalent ratio (1.50), relative crowding coefficient (2.22) and lowest aggressivity value (-0.12). Okra and Amaranthus combination recorded the lowest values for the above-mentioned parameters. So, it can be concluded that intercropping okra with cowpea might be a sustainable production system for farmers in the Gangetic plains of West Bengal.

Keywords: *Cowpea, economics, inter cropping, okra, pest incidence, quality, sustainable, yield.*

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench), a crop of malvaceae family, is a widely cultivated fruit vegetable around the globe. In verdant landscapes of West Bengal the cultivation of this prized vegetable finds its niche, primarily gracing the districts of Nadia, Bankura, South Paraganas, North Paraganas, Burdwan and Murshidabad.But there is wide gap between national productivity and average production of this crop in West Bengal.This disparity can be attributed to the widespread prevalence of two highly destructive virus diseases like bhindi yellow vein mosaic virus (BYVMV) disease and enation leaf curl virus (ELCV).which also pose a threat to okra cultivation in the gangetic plains of eastern India, i.e west Bengal. These malicious viruses are transmitted through cryptic whitefly species, persistently infecting the okra crop throughout its all stages of growth. The consequences of these infections are severe, leading to substantial yield losses ranging from 50% to a staggering 94% [1].

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On the other hand, Jassid is also a serious pest of okra for this zone. But unfortunately, the okra growers indiscriminately use synthetic pesticides for control of these notorious pests resulting in pesticide residue, insecticide resistance, pest resurgence, and outbreaks of minor pests[2].This type of crop production system is much more effective than a monocropping system because it increases crop diversity, the population of natural enemies, suppresses pest population vis a vis reduces the number of chemical spray and it offers a scope for ecofriendly production system [3]. Degradation of soil fertility, natural hazards, pest and disease incidences, market price fluctuation put to the farming families in insecurity of income generation for their livelihood [4]. On the other hand to address the crop failure, increment of farm productivity intercropping with vegetables might be a profitable venture as it generates more income of the farm through increased production per unit area through the inclusion of more crops per year [5] throughcomplete and economical use of natural resources like soil, water, space, nutrients and sunlight [6].So to tide over this alarming situation intercropping may be an eco-friendly and sustainable approach for integrated management of these notorious pests of okra.

MATERIALS AND METHODS

The present field trial was carried out during the pre-kharif

(Feb-June) season of 2022-23 in Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India following RandomizedBlock Design with seven treatment combinations andfour replications. The treatments combinations were T1– Sole Okra; T2–SoleAmaranthus; T3 – Sole Cowpea; T4 – SoleMarigold; T5–Okra+Amaranthus T6 –Okra + Cowpea; T7–Okra +Marigold.The recommended package of practices was followed for okra and the intercrops under study. The intercrop seeds were sown inbetween the rows of okra in a 1:1 ratio, following an additive series. The maize seeds were sown around the field as a border crop. The varieties okra hybrid OH-517 and the RangaJaba variety of amaranthus, KashiKanchan variety of cowpea, Bidhan Basanti of marigold and P-3396 variety of maize were used for the trial. Observations were recorded on different growth, yield, quality and pest infestation parameters. The economics of cultivation was calculated by computing the market price of okra and their intercrops and net returns and benefit-cost ratios were worked out where Net returns = Gross returns – Total production cost and Benefit: Cost = Gross returns / Total production cost[7].Ascorbicacidcontentofokrafruitswereanalyzed.[8].In association of crop yield, Okra equivalent yield was calculated [9]

$$\text{Okra equivalent yield(kg/ha)} = \frac{\text{Yield of okra(kg/ha)+yield of inter crop (kg/ha)} \times \text{sale price of inter crop(Rs/kg)}}{\text{Sale price of okra (Rs/kg)}}$$

competitive functions like land equivalent ratio (LER) was enumerated [10] using this equation.

$$LER = \sum yij/yii$$

Where,Yij=yield of crop in inter cropping system
Yii= yield of the crop in sole cropping system

Aggressivity (A) [11]value of the main crop and intercrops were analysed by following equation.

$$Aab = \frac{Yab}{Yaa \times Zab} - \frac{Yba}{Ybb \times Zba}$$

Where, Aab = Aggressivity value for the component crop "

Relative crowding coefficient (K) [12] of the system was measured with the following formula

$$Keb = \frac{Yab}{Yaa - Yab} \times \frac{Zba}{Zab}$$

After30,40, 50 and 60 days of planting, the population of white fly and jessed were counted from five top , middle and bottom leaves of each tagged plants per plot and their average was done. Percent increase or decrease of pests over control was calculated by this formula.

%increase or decrease over control=

$$\frac{\text{Mean value of untreated plot} - \text{Mean value of treated plot}}{\text{Mean value of untreated plot}} \times 100$$

The experimental data were subjected to statistical analysis by using OPSTAT online software.

Results and Discussion

Growth parameters

The results of the said investigation clearly pointed out that intercropping had a significant effect on most of the growth parameters of okra(Table 1). The intercropping combination like okra and cowpea recorded significant maximum values for plant height (95.30 cm), leaf number per plant (33.31), root length (11.40 cm), root volume (34.38 cc), shoot weight (395.29 g) over other treatment combinations except sole okra where it was *at par* for those characters. In all the cases okra and Amaranthus grown together recorded minimum values for the above- mentioned characters of okra. Intercropping okra with legume i.e. cowpea might have a positive and synergistic effect on performance component crops . A similar observation has been noted in the tomato + fenugreek intercropping system for better utilization of resources and less competition between both the component crops for different horizontal and vertical resources [4].

Yield parameter

Data pertaining to yield parameters (Table 2) clearly indicated okra, grown alone out yielded other combinations as it had a maximum productivity of 21.60 ton of fruits per hectare followed by okra and cowpea system (14.85 ton/ha) of intercropping association. But when okra equivalent yield data was computed maximum data for the same attributed was observed in okra + cowpea growing (26.15 ton/ha) which was closely pursued by okra +marigold (22.89 ton/ha) and lone bhindi (21.60 ton/ha) plots. The maximum okra equivalent yield recorded in okra + cowpea intercropping system might be due to higher yield of the main crop and greater market price of the component crop [13].

Quality parameter

Interpretation of quality parameter data (Table 2) i. e. ascorbic acid content of okra fruit exhibited similar trend as like of other parameters under study. Intercropping okra with cowpea produced a significantly maximum concentration of ascorbic acid(22.5mg/100g) which might be a case of lesser competition for resources between the two crops, resulting increased availability of nutrients for the synthesis of ascorbic acid within the okra fruits. Conversely intercropping of okra with Amaranthus displayed the significantly lowest ascorbic acid content of 17.25 mg/100 g in okra fruit. A similar type of findings was also observed in the capsicum + French bean intercropping system[14]. This could be attributed to the potential competition for resources between the two crops, resulting in a reduced availability of nutrients for the synthesis of ascorbic acid within the okra plants.

Competitive functions

Enumeration of competitive functions of the system (Table2) clearly indicated that okra and cowpea intercropping system, where the efficient biological nitrogen fixer legume like cowpea was taken, used biological resources judiciously, as it recorded maximum values for Land equivalent ratio (1.50) and Relative Crowding Coefficient (2.22).Okra and Amaranthus exhibited the highest level of aggressiveness among all treatments, with an observed value of (-0.22) for this character. On the contrary, the okra and cowpea combination displayed the lowest aggressiveness with a value of (-0.12), followed by okra and marigold with a value of (-0.18). Intercropping tomato with fenugreek also recorded similar results[4].

Pest build up

Thorough interception of pest infestation data (Table 3 and 4),

recorded on different dates(30,40,50 and 60 days after sowing), revealed that marigold had a remarkable and significantly suppressing effect of jassid and white fly populations of okra compared to sole cropping and other intercropping combinations as okra + marigold intercropping system recorded significantly minimum jassid and white fly population. Regarding the reduction percentage over control plot significant maximum reduction of jassid(35.06%) and white fly(27.12%) were noticed in okra and marigold association over sole okra plots. Minimum infestation of jassids in okra marigold plots might be due to the repulsive action of marigold plants which deterred the attack or visit of jassids.A similar type of investigation was observed where the lowest infestation was found in the okra + marigold combination, followed by the okra + cowpea combination [15].

Economics of production

Thedatapertainingto the economics of production (Table-5)indicated that the intercropping system of okra and cowpea was the most financially rewarding as this combination recorded the highest net return (Rs.2,35,038.50) and benefit-cost ratio (B:Cratio 3.98).On the other hand, the intercropping system of okra with amaranthus was the least economically viable, reflecting the lowest net return (Rs76,898.50.) and B:C ratio (2.08).Similar trend of higher B:C ratio was also found in okra + cowpea intercropping system [16]

Conclusion

The results of the said investigation clearly indicated intercropping had a remarkable and significant effect on growth, yield, quality parameters data and attack of relevant insect pests of okra. A thorough interpretation of the said data revealed that growing cowpea in inter spaces of okra recorded maximum values for growth, yield and quality parameters of okra. Maximum values for growth attributes and okra equivalent yield were obtained in in okra + cowpea growing closely followed by okra + marigold and lone bhindi plots. Regarding pest repellent data it was found that a remarkable suppressing effect of jassid and white fly of this valuable vegetable crop i.e. okra over other intercrops as it recorded minimum infestation of these devastating pests. Sole cultivation of okra showed maximum attack of jassids and whitefly. Intercropping okra with cowpea produced significantly maximum concentration of ascorbicacid over rest of the treatments under study.Okra and cowpea intercropping system also identified as the maximum user of biological resources as it recorded maximum values for the Land equivalent ratio and Relative Crowding Coefficient (2.22) and lowest value of aggressivity. The data pertaining to the economics of production indicated that the intercropping system of okra and cowpea was the most financially rewarding as this combination recorded the highest net return and benefit-cost ratio.Due to minimum values for Land equivalent ratio and Relative Crowding Coefficient and highest aggressivity okra and amaranthus system of intercropping was marked as minimum user of biological resources and in all the cases this combination recorded minimum values for the above-mentioned characters of okra.

Threadbare enumeration of trial results, an inference may be drawn that additional growing of cowpea in between rows of okra can be a sustainable approach as this cropping pattern gave the highest yield with quality fruits, managed the virulent pests of okra effectively and fetched the highest return per unit area through efficient utilization of land, water and light. Thus, considering the findings,it may be concluded that cowpea growing as intercrop with okra can be adopted as a sustainable productionsystem for the farmers of Gangetic plains of West Bengal.

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Future scope of the study

So, to make this kind of vegetable crop production system popular among the farmers or to popularize this type of intercropping system further research work may be carried out.some areas which need to be addressed in future related to this trial is to to repeat the present work in different okra growing locations or zones of West Bengal for formulation of a robust pest vis-a-vis disease management strategy alongwith initial and residual soil nutrient profile should be studied to maintain nutrient reserve of the soil which is a key and need of sustainable farm production.The presnt work also finds the gap where consorted effect of different botanicals or bio control agents and crop rotation or intercropping models on ecofriendly management of okra pests and diseases is to be evaluated further. chalking out a long-term planning for observing the effect of different organic amendments, crop residue ,etc. upon okra based intercropping system for sustainable farm production is also find its need for future study.

Conflict of interest

The authors declare no conflicts of interest related to the preparation of this research manuscript.

Table-1. Effect of intercropping on growth parameters of okra

Treatments	Plantheight (cm)	Noof leaves /plant	Rootlength (cm)	Rootweight (g)	Rootvolume(cc)	Shoot weight (g)
SoleOkra	86.31	31.06	10.29	22.01	31.13	334.32
Okra+Amaranthus	80.31	26.68	6.613	15.82	22.34	284.50
Okra + Cowpea	95.30	33.31	11.4	25.10	34.38	395.28
Okra +Marigold	83.75	30.12	8.62	19.07	28.18	309.28
C.D. 5%	10.37	4.43	1.47	3.36	3.18	36.86
S.E.	4.52	1.38	0.32	0.41	0.59	11.35

Table-2. Effect of intercropping on yield, quality and competitive functions of okra.

Treatments	Yield (ton/ha)	Okra equivalentyield (ton/ha)	Ascorbic acid (mg/100g)	LER	Aggressivity	RCC
SoleOkra	21.60	21.60	19.10	1.00	-	-
Okra+Amaranthus	8.69	12.33	17.35	1.3	-0.22	0.67
Okra + Cowpea	14.85	26.15	22.50	1.0	-0.12	2.20
Okra +Marigold	12.28	22.89	17.97	1.2	-0.18	1.31
C.D. 5%	3.27	3.15	1.96	-	-	-
S.E.	1.00	0.97	0.63	-	-	-

LER: Land equivalent ratio; RCC: Relative crowding ratio

Table- 3 Population build-up of whitefly in the intercropping system.

Treatments	30 DAS	40 DAS	50 DAS	60 DAS	ROC (%)
SoleOkra	12.76	15.62	17.7	12.39	0
Okra+Amaranthus	10.09	13.88	15.96	11.93	11.30
Okra + Cowpea	6.95	8.49	13.5	10.39	24.15
Okra +Marigold	3.77	5.56	11.59	7.74	27.12
C.D. 5%	1.09	0.84	0.7	0.96	1.49
S.E.	0.33	0.26	0.21	0.29	0.46

DAS: Days after sowing;ROC : Reduction over control

Table-4 Population build-up of jassid in the intercropping system

Treatments	30 DAS	40 DAS	50 DAS	60 DAS	ROC(%)
SoleOkra	10.89	12.86	15.11	9.68	0.00
Okra+Amaranthus	9.75	12.04	13.85	10.61	4.72
Okra + Cowpea	7.66	9.81	12.85	9.80	13.22
Okra +Marigold	5.81	6.86	8.55	4.83	35.06
C.D. 5%	0.61	0.98	0.62	0.52	1.65
S.E.	0.19	0.30	0.19	0.16	0.50

DAS: Days after sowing; ROC: Reduction over control

Table-5. Economics of okra based intercropping system.

Treatments	Cost of cultivation (Rs/ha)	Grossreturn (Rs/ha)	Netreturn (Rs/ha)	Benefit:Cost Ratio
SoleOkra	73,561.50	2,59,200.00	1,85,638.50	3.52
SoleAmaranthus	38,802.50	69,350.00	30,547.50	1.78
Sole Cowpea	65,370.00	1,54,800.00	89,430.00	2.36
SoleMarigold	97,821.00	1,68,030.00	70,209.00	1.71
Okra+Amaranthus	71,061.50	1,47,960.00	76,898.50	2.08
Okra + Cowpea	78,761.50	3,13,800.00	2,35,038.50	3.98
Okra +Marigold	1,00,761.50	2,74,680.00	1,73,918.50	2.72

Sale price of okra @Rs. 12/kg; amaranthus @RS 5/kg; cowpea @Rs 10/kg ; marigold@ Rs9/kg ;

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