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INTERCROPPING AS SUSTAINABLE APPROACH AGAINST OKRA SHOOT AND FRUIT BORER *EARIAS* SPP.

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ABSTRACT

This study evaluates the effect of maize, sorghum and cowpea as intercrops with okra (at ratio of main: intercrop- of 1:1 and 2:1) against okra shoot and fruit borer *Earias* spp. incidence. The results revealed that the least shoot damage (5.00%) was observed with okra + cowpea (1:1) intercropping followed by okra + cowpea (2:1) and okra + sorghum (1:1). Maximum shoot damage (6.65%) was registered in okra + maize (2:1) as against mono-cropping (7.69%). Similarly, the least fruit damage (12.25%) was in okra + cowpea (1:1) crop statistically on par with that of okra + cowpea (2:1), okra + sorghum (1:1) and okra + sorghum (2:1); maximum (16.41%) was observed with okra + maize (2:1) and okra as a sole crop (18.42%). The okra + cowpea (1:1) recorded the maximum land equivalent ratio (1.31) followed by okra + cowpea 1.20 at 2:1 and okra+ sorghum 1.19 at 1:1 crop ratio. Okra intercropped with maize (2:1) was found less effective (0.99) than the okra sole. The maximum okra equivalent yield (111.4 q/ ha) was obtained with okra + cowpea intercropping (1:1), while the least (100.9 q/ ha) was in okra + maize (2:1).

Key words: Okra, *Earias* spp. intercrop, incidence, shoot and fruit damage, cowpea, sorghum, maize, monocropping, yield, okra equivalent yield, land equivalent ratio

Okra is an important green vegetable crop and its yield is affected by several biotic and abiotic factors, of which, insect pests are the major ones. The crop harbours to a large number of insect pests and vectors (Showkat et al., 2010), and 72 insect species are known (Srinivasa and Rajendran, 2003). Among them, okra shoot and fruit borer *Earias* spp., pose a major threat during kharif. Mohanasundaram et al. (2012) and Anand et al. (2014) observed that it causes 5.33 to 39.6% damage, while Radake and Undirwade (1981) reported it as 88 to 100% fruit damage in cotton. The farmers solely depend on synthetic insecticides for its control, which leads to many hazards like residues, insecticide resistance, pest resurgence, and secondary pest outbreaks. Use of intercropping can be an ecofriendly tool in IPM. The resource concentration hypothesis, evinced that intercropping system have more diverse habitat and thus creates barrier for insect pest movement and colonization. However, in monocropping there is no such implication (Andow, 1991). This study evaluates intercropping as an IPM strategy against okra shoot and fruit borer *Earias* spp.

MATERIALS AND METHODS

The field experiment was carried out at the Research Farm, TCA Dholi, Muzaffarpur (Bihar) during kharif 2018-19 and 2019-20. Okra (sole crop) was raised and with intercrops viz. maize, sorghum and cowpea, at the ratio of 1:1 and 2:1 (main and intercrop) each. The variety was Kashi Pragati of okra while Kashi Kanchan, Suwan and Multicut Sweet Sorghum were the varieties of cowpea, maize and sorghum. The randomized block design (RBD) was used with seven treatments, each replicated thrice. The plot size, inter and intra row spacing for the main crop were 3x2 m, 50 cm and 20 cm, respectively. All the cultural practices, recommended for the main crop were uniformly adopted with the seed rate being according to recommendation for a particular crop. Throughout the cropping period, pesticide application in any form was avoided and crop was harvested only after attaining the crop maturity by the respective crop. Starting from 30 days after sowing, the incidence of *Earias* spp., was observed. Shoot damage was counted randomly on 10 selected tagged plants in each replication at weekly interval and % shoot damage was computed. Mature fruits along with damage fruits were picked at an interval of two to three days and % damage was computed after each picking. Healthy and infested fruits were sorted out and weighed separately to work out the damage on weight basis. Observations with respect to fruit and grain yield of main as well as intercrops were also recorded plot wise. Suitability of different intercrops in okra was finally adjudged from

productivity and economic return points of view, by using the parameters like okra equivalent yield (EY) and land equivalent ratio (LER). The yield of different intercrops was converted into EY of okra crop based on price of the produce. The crop equivalent yield (CEY) was calculated as follows: Crop Equivalent Yield (CEY) = $\sum_{i=1}^{n}(Yi.ei)$, where, Y_i is yield of i^{th} component and e_i is equivalent factor of i^{th} component or price of i^{th} crop. Land equivalent ratio was calculated by using following formula: Land Equivalent Ratio (LER) = $\sum_{i=1}^{m}\frac{Yi}{Yij}$

where, Yi is the yield of i^{th} component from a unit area grown as intercrop and Yij is the yield of i^{th} component grown as sole crop over the same area. The data in respect of incidence and yield were subjected to statistical analysis by using OPSTAT online software.

RESULTS AND DISCUSSION

The data on the shoot and fruit damage in okra under different intercrops presented in Table 1 reveal that the shoot damage in all the crop combination started from 30 days after sowing -DAS and continued till 60 DAS while it attained its peak at 45 DAS. Among all the intercropping okra + cowpea (1:1) intercropping was observed with the least values of 2.85, 7.98 and 2.18% as against 4.58, 12.27 and 3.18% in sole crop at 30, 45 and 60 DAS. On the contrary, intercropping of okra with maize (2:1) led to maximum damage of 4.19, 10.35 and 2.76% at 30, 45 and 60 DAS, respectively. Similarly, on cumulative mean basis also, the least damage (5.00%) was in okra + cowpea (1:1) intercropping followed by okra + cowpea (2:1) (5.43%). The fruit damage varied remarkably among different crop combinations, the incidence started at 45 DAS and then increased continuously to it's a peak at 75 DAS, and then declined. The fruit infestation at 45, 60, 75 and 90 DAS ranged from 3.55 to 4.84, 13.17 to 18.26, 19.64 to 25.34 and 12.63 to 17.19%, respectively. However, on cumulative mean basis the least fruit damage (12.25%) was in okra + cowpea (1:1) which was statistically on par with okra + cowpea (2:1) of 13.31%, okra + sorghum (1:1) of 13.96%, and okra + sorghum (2:1) at 15.00%. The maximum fruit damage (16.41%) was recorded in okra + maize (2:1). Thus, okra intercropped with cowpea (1:1) was the best combination, which was statistically on par with okra + cowpea (2:1), okra + sorghum (1:1) and okra + sorghum (2:1). These results agree with those of Abro et al. (2004) on *Earias* spp. in cotton that okra can be used as a trap crop. Mohanasundaram et al. (2012) observed that intercropping of okra and cluster bean with Neembaan and spinosad spray led to the least fruit damage due to *E. vitella*. Sujayanand et al. (2016) observed that marigold intercropped with okra is the best followed by okra and coriander. In contrast, Mansour (2017) and Zakka et al. (2018) concluded that okra, intercropped with maize harbored maximum infestation of various pests.

Table 1. Effect of intercropping on shoot and fruit damage by *Earias* spp., in okra (pooled data, kharif, 2018, 2019)

Intercropping system	% shoot damage				% fruit damage (weight basis)				
	30 DAS	45 DAS	60 DAS	Cumulative mean	45 DAS	60 DAS	75 DAS	90 DAS	Cumulative mean
T_1 - Okra + Maize (1:1)	3.93 (11.42)#	10.00 (18.42)	2.58 (9.23)	6.35 (14.58)	4.52 (12.25)	16.65 (24.06)	24.20 (29.43)	16.13 (23.65)	15.37 (23.06)
T_2 - Okra + Maize (2:1)	4.19 (11.81)	10.35 (18.75)	2.76 (9.56)	6.65 (14.94)	4.84 (12.69)	18.26 (25.27)	25.34 (30.18)	17.19 (24.47)	16.41 (23.87)
T_3 - Okra + Sorghum (1:1)	3.46 (10.72)	9.26 (17.71)	2.45 (9.00)	5.85 (13.99)	4.25 (11.88)	15.37 (23.05)	21.88 (27.86)	14.32 (22.20)	13.96 (21.91)
T_4 - Okra + Sorghum (2:1)	3.58 (10.90)	9.59 (18.03)	2.64 (9.33)	6.08 (14.27)	4.45 (12.17)	16.24 (23.73)	23.62 (29.03)	15.70 (23.32)	15.00 (22.76)
T_5 - Okra + Cowpea (1:1)	2.85 (9.71)	7.98 (16.39)	2.18 (8.47)	5.00 (12.92)	3.55 (10.84)	13.17 (21.24)	19.64 (26.29)	12.63 (20.80)	12.25 (20.47)
T_6 - Okra + Cowpea (2:1)	3.06 (10.06)	8.69 (17.14)	2.34 (8.78)	5.43 (13.46)	4.03 (11.57)	14.09 (22.00)	20.85 (27.15)	14.27 (22.17)	13.31 (21.37)
T_7 - Okra (sole crop)	4.58 (12.34)	12.27 (20.49)	3.18 (10.26)	7.69 (16.09)	5.77 (13.88)	20.50 (26.89)	28.74 (32.40)	18.66 (25.58)	18.42 (25.39)
SEm(±)	(0.21)	(0.28)	(0.26)	(0.13)	(0.35)	(0.84)	(0.89)	(0.77)	(0.69)
CD (p=0.05)	(0.65)	(0.88)	(0.80)	(0.42)	(1.10)	(2.63)	(2.77)	(2.39)	(2.51)
CV	6.41	5.16	9.55	3.32	9.71	11.42	9.80	10.71	9.98

DAS - Days after sowing; #Figures in parentheses values angular transformation.

Table 2. Competition functions and economics of intercropping (pooled data, kharif, 2018, 2019)

Intercropping system	Yield (q ha^{-1})			Gross return (Rs ha^{-1})	Profit/ loss over okra sole crop (Rs ha^{-1})	Land Equivalent Ratio (LER)
	Main crop	Intercrop	Okra equivalent			
T_1 - Okra + Maize (1:1)	64.5	32.8	110.0	137326.0	821.0	1.12
T_2 - Okra + Maize (2:1)	73.5	19.7	100.9	125980.0	- 10525.0	0.99
T_3 - Okra + Sorghum (1:1)	71.5	19.5	110.4	137825.0	1320.0	1.19
T_4 - Okra + Sorghum (2:1)	79.5	13.5	106.4	132845.0	- 3660.0	1.10
T_5 - Okra + Cowpea (1:1)	79.0	8.9	111.4	139140.0	2635.0	1.31
T_6 - Okra + Cowpea (2:1)	89.0	5.8	111.2	137710.0	1205.0	1.20
T_7 - Okra (sole crop)	109.3		109.3	136505.0		
SEm(±)	3.39		4.06			
CD (p=0.05)	10.57		12.20			
CV	7.26		6.49			

The intercropping with okra as main component differed in productivity as per seasons (Table 2). Consistently, intercropping of cowpea with okra (2:1) was found superior with maximum yield (89.0 q/ ha) over sole crop (109.35 q/ ha), while the least (64.5 q/ ha) was obtained in maize intercropped with okra (1:1). Thus, okra + cowpea (1:1) resulted in the maximum LER (1.31) followed by okra + cowpea 1.20 at 2:1 and okra + sorghum 1.19 at 1:1 crop ratio, and it is more efficient over sole okra. On the contrary, okra intercropped with maize (2:1) was found less efficient (0.99) than the okra sole. The maximum okra equivalent yield (111.4 q/ ha) was in okra + cowpea intercropping (1:1) while it was minimum (100.9 q ha) in okra + maize (2:1). Thus, intercropping of cowpea with okra (1:1) and (2:1) worked efficiently with respect to LER and okra equivalent yield while the okra + maize (2:1) crop combination was found least effective. Mohamed et al. (2007) studied the impact of cucumber and cowpea as against okra monocropping and reported that okra and cucumber had the maximum LER. Further, Das et al. (2017) evaluated chickpea and rapeseed as intercrops in different proportions and sole crop too, and maximum LER was with intercrop.

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