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Assessment of Crop Loss in Okra (*Abelmoschus esculentus* L.) Due to Damage by the Major Insect Pests

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ABSTRACT

A field experiment on the yield loss assessment in Okra due to insect-pest was carried out at the research farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during *pre-kharif* (15th February–14th May), *kharif* (15th May–14th August) and *post-kharif* (15th August–14th November) seasons in 2 years, 2015 and 2016. The experiment was laid out in Randomized Block Design and replicated 6 times. The treatments were T_1 (protected by chemical insecticide), T_2 (protected by organic insecticide), T_3 (unprotected). The chemical protection significantly suppressed the jassid and % damage by fruit borer in contrast to organic protection and unprotected in all the 3 seasons. However, the't' test analysis revealed non-significant relation between yield of organically and chemically managed plots and significant relation was found between the yield of untreated with organically and chemically managed plots which is directly related with the abundance of insect population. From chemically management 30.52%, 25.16% and 33.26% and from organically managed plots 29.37%, 20.68% and 32.38% gain in yield was recorded in pre-*kharif*, *kharif* and *post-kharif* seasons, respectively. The avoidable losses from chemically protected plots were 23.39%, 20.00% and 24.88% in 3 seasons, respectively. The same from organically managed plots were 22.73%, 16.98% and 24.39% in 3 cropping seasons respectively as mention above. Since, non-significant different in losses of yield lies between chemically and organically protected plots, organic management for pest management may be opted considering all aspects like health, environment and export earnings.

KEYWORDS: Assessment, crop loss, fruit borer, jassid, okra, pest

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Ladies finger, *Abelmoschus esculentus* L. is an important vegetable crop grown in tropical and sub-tropical parts of the world (Meganha et al., 2010). In the plains of West Bengal, it can be grown from late January–November. It has tremendous export potential accounting for 60% of fresh vegetable export (Sharma et al., 1993) and earns 30% exchange earning from export of vegetables, next to onion. This is due to its high nutritive valueand prolonged shelf life (Sindhu and Puri, 2016).

Insect-pests are the major constraints of its production. Pest of okra are either polyphagous or oligophagous which gets good number of alternate host round the year is main reasons of high pest incidence. More than 72 number of insect-pest species attack the okra crop of which, the sucking pests like jassid (*Amrasca biguttula biguttula* Ishida), aphid (*Aphis gossypii* Glover), whitefly (*Bemesia tabaci* Genn.) and mite (*Tetranychus cinnabarinus* Boisd.), fruit borers like *Earias vittella* (Fab.), *Earias insulana* (Bois) and *Helicoverpa armigera* (Hub) are known to cause economic damage to the crop (Chandra and Subhag, 2012, Birah et al., 2012, Karthik et al., 2015, Kumar and Sing, 2021, Mohammad et al., 2018, Das et al., 2011). The infestation occurs throughout the vegetative as well as reproductive stages of the crop causing ample reduction in yield (Satpathy and Rai, 1999). The fruit borers alone reported to cause damage to okra in an extent of 3.5–90% in different parts of the country (Ghosh et al., 1999, Mandal et al., 2006). It is reported that about 40–56% loss in okra due to the leafhopper infestation (Satpathy et al., 2007, Sharma and Sharma 2001). Losses caused by leaf hopper in plant height, number of fruits and weight of fruits per plant were recorded up to 47.6, 50.0 and 57.2%, respectively (Chauhan et al., 2021).

In order to manage the pests all sort of efforts have been madeby the researchers (Suman et al., 2021, Chandran et al., 2020, Jan et al., 2022). However, till date management practices are pesticide biased and that too with synthetic pesticides. Due to heavy pest-load, tremendous volumes of insecticides areused to manage the insect-pest of okra. It is a matter of deep concern that fruits are plucked and marketed even after a day of spraying. Since the tender fruits of okra are taken after a little cooking, there is every possibility of retaining toxic residue in food stuff (Amjad et al., 2020). Frequent use of synthetic pesticides indiscriminately leads into disturbance in delicate balance between insect-pests and their natural enemies and enhance resistance to insecticides in the pests (Cothran et al., 2013, Anonymous, 2013, Zhao et al., 2015). To combat with challenges arising from the chemical dependent farming, organic farming is gaining popularity during last decades (Tscharntke et al., 2012, Lobley et al., 2005, Dangour et al., 2010, Willer and Lernoud, 2019). The organic farming supports lower insect-pest infestation than the conventional farming (Torok et al., 2021). Moreover, the demand of organic products is high as organic farming yields more nutritious and safer than conventional farming (Loureino et al., 2001). During 2002, the organic production was 14,000 t in India of which 85% was exported. Keeping in view present investigation was therefore carried out to assess the effects of organics on damage caused by pests and its impact on yield.

2. MATERIALS AND METHODS

The field experiment was conducted at the research farm of the Uttar Banga Krishi Viswavidyalaya located at Pundibari, Cooch Behar, West Bengal, India during the *pre-kharif* (15th February–14th May), *kharif* (15th May–14th August) and *post-kharif* (15th August–14th November)seasons in 2 years, 2015 and 2016. The experimental domain is situated inbetween 26°19'86''N latitude and 89°23'53''E longitude at an elevation of 43.0 m above mean sea level. The variety Arka Anamika was grown directly in three seasons in the plot size 5×3 maintaining spacing of 60×30 cm^2 in consisting of 3 treatments and replicated 6 times. NPK in the ratio of 80:60:40 were applied in treatments T_1 and T_2, while in treatment T_3 diluted crude microbial culture was applied after final tilth of land at afternoon hours and applied repeatedly at 15 days interval. The treatment T_1 was kept unprotected, which was allowed to pest infestation without application of insecticide. Whereas the protected plots in treatment T_1 and T_2, chemical insecticides imidacloprid @ 25 g *a.i.* ha^{-1} and organic insecticides 25 ml l^{-1} were applied respectively. In treatment T_1 and T_2, 3 rounds of sprays in pre and *post-kharif* and 4 rounds of spray in *kharif* at 14 days interval were given. Observations were made at weekly interval from 5 randomly selected plants. T-test analysis was workout for each pair of pest population and their corresponding yield in all the treatments using SPSS software.

2.1. Preparation and application of indigenous microbial culture

The indigenous microbial culture, jeewamrita was prepared as the method followed by Palekar (2005).The components of indigenous microbial culture were fresh 5 kg cow-dung, 5 l cow urine, 1 kg molasses, 1 kg chickpea dust (Gram), one hand full soil (from bund), 100 l Water. Fresh cow dung was kept and hanged in mosquito net in the drum containing 100 l of water in such a way that it may dip in. After 24 h, mosquito net containing cow dung was squeeze by hands within drum as much as possible and then cow urine, molasses, chickpea dust, handful of virgin soil were added. For next 3 days, the same is stirred thrice by a wooden or bamboo stick daily. The indigenous material was prepared after 4–5 days and was ready to use.

2.2. Preparation of organic pesticides

Organic pesticide was prepared by following the methods as designated agniastra by Palekar (2005). The ingredients used for the preparation of organic pesticides were 3.5 kg neem leaves, 350 g garlic paste 350 g green chilli 350 g tobacco powder and 10 l of cow urine. All the ingredients were mixed in a bowl and boiled for 45 m to 1 h. After boiling it was kept for 48 h. The mixture was strained by cloth poured in the bottle which can be kept in bottle for 3 months in cool and dry place and became ready for use.

3. RESULTS AND DISCUSSION

3.1. Pest population level

3.1.1. Jassid (Amrasca biguttula biguttula Ishida)

A moderate population of jassid was recorded in *pre-kharif* seasons in both the year of studies. The analysis of pooled mean data of two years revealed that chemical protection reduced the jassid population significantly with 5.10 leaf^{-1} as compared to 8.05 leaf^{-1} in organically managed plots and 23.53 leaf^{-1} in untreated control (Table 1). The t'-test value showed significant variation in jassid population among all the treatments.

The analysis of pooled mean data of two years (Table 1) during *kharif* season exhibited significant suppression of the population from the application of chemical (0.02 leaf^{-1}) followed by organically managed plot (0.33 leaf^{-1}). The 't' test analysis revealed significant difference in jassid population level among all the treatments.

Chemical management in *post-kharif* season significantly suppressed the jassid population to 1.19 leaf^{-1} over other treatments (Table 1). The organic management also provided excellent results (1.31 leaf^{-1}) and in untreated control plots it was 2.65 leaf^{-1}. The significant differences of jassid population were observed between untreated control with organically and chemically managed plots; and between organically and chemically protected plots upon't' test analysis. A critical analysis of the result showed that jassid population varied over the seasons both the years. A relatively moderate level of jassid population was observed during *pre-kharif* season, but it was lowest in *kharif* crop Ghosh et al. (1999) recorded 21.58 leaf^{-1} of aphid and 14.44 leaf^{-1} of jassid population in the untreated plots during *kharif* with the variety Arka Anamika. The result in the present investigation was not in conformity with Ghosh et al. (1999) might be due to variation in crop growing period and under the present investigation were the 1.66 leaf^{-1} and 1.06 leaf^{-1}, respectively. However, in the present study the jassid population of 23.53 leaf^{-1} was recorded in *pre-kharif* i.e February sown crop. Though chemical management effectively controlled the pest population but 5.10leaf^{-1} jassid till remained during pre-*khari f*season. In organically managed plots the population level was next to that of chemical one. It is apparent that the okra crops in terai region suffer much from jassid. The control measure through chemical means though suppressed the pest population but failed to bring down the population of jassid below ETL (approximately 2 per leaf) in *pre-kharif*.

3.1.2. Fruit borer (Earias vittella Fabricius) in terms of % damaged fruit

The pooled mean data of 2 years in *pre-kharif* season showed that the damage was highest in untreated control (14.11% in number and 13.83% in weight) (Table 1). Chemical management effectively suppressed fruit borer infestation and registered lowest % of damaged fruits (3.27% in number and 3.13% in weight). Significant suppression of fruit borer damage (5.56% in number and 5.39% in weight) was also recorded in plots managed organically. When cross comparison was done, the t'-test analysis clearly showed significant differences in % damage of fruits (both in number and weight) among all the treatments *viz.*, untreated, chemical and organically controlled plots.

During *kharif* season, highest % of fruit damage was recorded in unprotected plots (19.63% in number and 18.89% in weight) (Table 1). Chemical management significantly reduced the fruit damage and recorded 4.84% and 4.58% bored fruit in number and weight. Organic management also showed excellent efficacy over untreated control by suppressing the fruit borer damage (6.97% and 6.73% in number and weight respectively). The 't' test analysis of data exhibited,variation in % damage of fruit (in number and weight) by borer in untreated control and protected plots (chemical and organic) was significant.

Damage of fruit due to borer was higher in untreated control in *post-kharif* season (23.39% and 22.25% in number and weight) as compared to protected plots (Table 1). Suppression of fruit borer damage was maximum from chemically treated plots (6.99% and 6.75% in number and wt.) followed by organically managed plots (7.23% and 7.11% in number and weight). A significant difference in respect to % damaged fruit was found among untreated control with organically and chemically managed plots and between untreated controls with protected plots as per 't' test value.

Among the different pests attacking okra, fruit borer can be considered as key one as it attacks the cashable part i.e., fruit of the plant and thereby directly reflected to the yield. Any loss at this stage cannot be replenished by any means. Thus damage of fruits caused by the borer had direct bearing

Table 1: Effect of different treatments on pest population of okra in three seasons (*Pooled mean data of 2015–2016)

T	Jassid (leaf^{-1})			Fruit borer (%)						Yield (t ha^{-1})		
	Pre-kharif	*Kharif*	*Post-kharif*	*Pre-kharif*		*Kharif*		*Post-kharif*		*Pre-kharif*	*Kharif*	*Post-kharif*
				DF (N)	DF (W)	DF (N)	DF (W)	DF (N)	DF (W)			
U	*23.53 **(4.90)	1.06 (1.25)	2.65 (1.77)	14.11 (22.06)	13.83 (21.83)	19.63 (26.30)	18.89 (25.76)	23.39 (28.92)	22.55 (28.35)	8.94	8.80	8.00
C	5.10 (2.37)	0.20 (0.84)	0.80 (1.14)	3.27 (10.42)	3.13 (10.18)	4.84 (12.71)	4.58 (12.35)	6.99 (15.32)	6.75 (15.06)	11.67	11.00	10.65
O	8.05 (2.92)	0.33 (0.91)	1.31 (1.35)	5.56 (13.63)	5.39 (13.42)	6.97 (15.31)	6.73 (15.04)	7.23 (15.60)	7.11 (14.46)	11.57	10.60	10.58
Figure in parenthesis indicates square root transformed value												
t value (Pr>t)												
U Vs C	43.47 (.0001)	57.51 (<.0001)	101.00 (<.0001)	42.99 (<.0001)	80.74 (<.0001)	79.22 (<.0001)	85.15 (<.0001)	212.82 (<.0001)	9.93 (<.0001)	11.04 (<.0001)	10.25 (<.0001)	31.63 (<.0001)
U Vs O	31.26 (.0001)	43.48 (.0001)	65.00 (.0001)	32.13 (.0001)	63.47 (<.0001)	64.21 (.0001)	258.98 (<.0001)	115.80 (.0001)	9.62 (<.0001)	8.04 (<.0001)	21.88 (<.0001)	11.53 (<.0001)
C Vs O	9.14 (<.0001)	12.65 (<.0001)	25.46 (<.0001)	12.56 (<.0001)	23.31 (<.0001)	39.16 (<.0001)	17.55 (<.0001)	2.73 (0.0213)	4.95 (0.0006)	0.26 (0.7989)	1.81 (0.1004)	0.30 -0.7691

DF (N): % Damaged fruit (in No.); DF (W): % Damaged fruit (in weight); T: Organic; U: Untreated; C: Chemical; O: Organic

on yield of the crop. Higher level of fruit damage caused by borer was recorded in *post-kharif* followed by the *kharif* and *pre-kharif* seasons.

Even with full chemical protection 3.27%, 4.58% and 6.99% fruit was damaged in three seasons respectively. The maximum fruit damage was recorded in untreated control (14.11%, 19.63% and 23.39%) in *pre-kharif, kharif* and *post-kharif* respectively seasons. However, Ghosh et al. (1999) recorded 9.05% bored fruit during *kharif* season. On the contrary Rawat and Sahu (1973) recorded 69% loss in weight of healthy fruits. Further Dhawan and Sidhu1984) observed maximum damage of 67.75% to fruit and 25.04% to buds due to *Earias* sp. in late October. However, Srinivasan and Krishnakumar (1983) reported 9.3% of fruit infestation by *Earias vittella*. Whereas it was 36% of harvestable fruit damage due to *Earias sp.* infestation as reported by Krishnaiah et al. (1980). Variation of loss in yield might be due to influence of agro ecological situation over different areas they studied. Patil et al. (2002) reported that okra (Arka Anamika) grown during summer season could be effectively control by the combined treatment of NSKE+cypermethrin against fruit borers and recorded the lowest fruit damage (14.48%) and highest pod yield (6.722 t ha^{-1}) that supports present results. Though the chemical control measure suppressed fruit borer infestation but did not reduce borer infestation below ETL (approximately 12% bored fruit) during *kharif* and *post-kharif*.

3.2. Yield of okra fruits

Results on incidence of different pest species, their relative abundance under different management practices played highly significant role in variation in yield of okra fruit (Table 1). The average fruit yield in *pre-kharif* season was lowest in unprotected plot (8.94 t ha^{-1}). The data on average fruit yield indicated that the higher yield was obtained from the chemically managed plots (11.67 t ha^{-1}) followed by organic one (11.57 t ha^{-1}). The differences in yield of untreated control over chemical and organic control were found significant. But, non-significant relation in respect to yield was found in between chemically and organically managed plots as per t-test value.

In *kharif* season chemical management not only suppressed the pests very effectively but also increase the yield (11.00 t ha^{-1}) followed by organically managed plot (10.60 t ha^{-1}) and significantly lowest in untreated control (8.80 t ha^{-1}) plots (Table 1). The differences in yield of untreated control over chemical and organic control were found significant. However, non-significant relation was recorded between chemically and organically managed plots when cross comparison was done with the 't' test value.

Analysis of pooled data of 2 years in *post-kharif* season revealed that application of chemical management was resulted better yield to the tune of 10.65 t ha^{-1}; closely followed by organic management 10.58 t ha^{-1} and the lowest being achieved from untreated control plot (8.00 t ha^{-1}). The 't' test revealed significant relation between the yield of untreated with organically and chemically managed plots but non-significant relation between plots managed organically and chemically.

The data on fruit yield clearly reveals significant variations between protected and unprotected plots which also shows that the yield is directly related with abundance of insect pests. The yield was recorded higher in chemically treated plots 11.67, 11.00 and 10.65 t ha^{-1} in *pre-kharif, kharif* and *post-kharif* respectively. The organic management gave 11.57, 10.60 and 10.58 t ha^{-1} yields in *pre-kharif, kharif* and *post-kharif*, respectively which bear non-significant relation with the chemical protection. The untreated control plot recorded lowest yield (8.94, 8.80 and 8.00 t ha^{-1} in *pre-kharif, kharif* and *post-kharif* respectively). The results under present investigation is in accordance with Ghosh et al. (1999) where they obtained 8.57 t ha^{-1} yield in untreated plots and 12.40 t ha^{-1} fruit yield in insecticidal treated plots. On the contrary Kumar et al. (2016) recorded only 5.792 t ha^{-1} from plots treated with imidacloprid 17.8 SL. Similarly, Patil et al. (2002) recorded 6.722 t ha^{-1} yield of okra variety (Arka Anamika) from insecticidal treated plots during summer season. The difference might be due to regional climatological variations which influenced the relative abundance of the pest population that ultimately reflected on yield.

3.3. *Increase in yield over untreated control and avoidable losses*

Analysis of pooled mean data of two years during *pre-kharif* season showed that under the different management practices highest (30.54%) increase in yield was achieved through chemical protection (Figure 1). The increase in yield over untreated control through organic management was 29.36%. It can be said that 30% and 29% of yield can be saved with chemical and organic protection respectively. In respect to avoidable losses in yield it was found that 23.38% yield can be avoided by chemical protection and the corresponding value for organic protection was 22.70%. Therefore, it is clear that insect pest is major constraint in okra production in Terai zone of West Bengal. However, the avoidable losses in yield as well as increase in yield in chemically and organically protected plots had no significant difference when subjected to t-test analysis.

In *kharif* significantly higher rate of increase in yield over untreated control (25.00%) and avoidable loss in yield (20.00%) was obtained from chemically managed plots (Figure 1). It is also important to note that organic management also resulted in good gain in yield over untreated control and avoidable loss in yield with the % value of 20.68% and 16.98% respectively. However, avoidable losses in yield as well as increase in yield in chemically and organically protected plots had no significant difference when subjected to t-test analysis.

In *post-kharif* season an increase in yield was recorded 33.26% from chemically protected plots over control (Figure 1) and it was 32.38% from organically protected plots. In respect to avoidable losses in yield it was found that 24.88% yield can be avoided by chemical protection and 24.39% from organically protected plots. The avoidable losses in yield as well as increase in yield in chemically and organically protected plots had no significant difference when subjected to t-test analysis. Under chemical management 30.52%, 25.16% and 33.26% increase in yield was obtained from chemically protected plots over control in *pre-kharif, kharif* and *post-kharif*, respectively. According to Rawat and Sahu (1973) during *kharif* season the average loss in the weight of healthy fruits was 69% due to combined effect of jassid and borer. Kanwar and Ameta (2007) reported that insect pests in okra caused 49.30% reduction in fruit yield. The difference might be due to variation in variety taken and the agro-climatic conditions. In organically managed plots 29.37%, 20.68% and 32.38% gain in yield was recorded in *pre-kharif, kharif* and *post-kharif*, respectively. On the other hand, Misra (2002) found that okra shoot and fruit borer, *Earias vittella* (Fab.) caused 36–90% loss in the fruit yield of okra. Patel et al. (2012) recorded the highest avoidable loss in okra fruit yield of 29.59% by seed treatment+need based application of insecticides throughout the crop season in Gujarat. In the present study the avoidable losses in yield in chemically protected plots were 23.39%, 20.00% and 24.88% in three respective seasons. The avoidable losses in yield were 22.73%, 16.98% and 24.39% in organically managed plots in three cropping seasons respectively. The

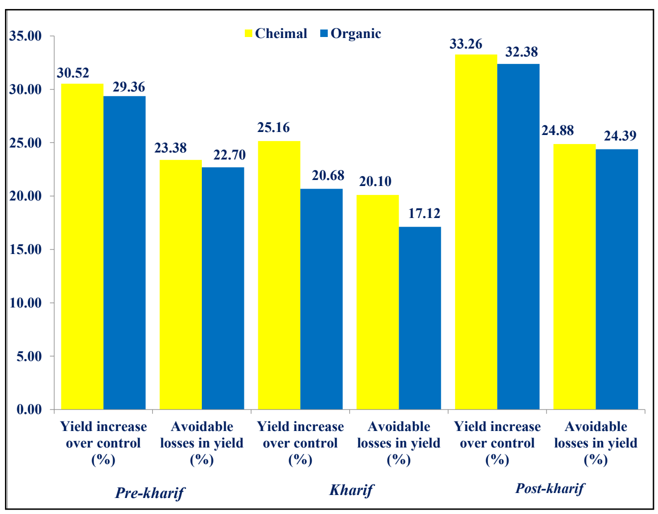

Figure 1: Increase in yield over untreated control and avoidable losses in yield

net available loss was 54.04% in summer crop if not grown under insecticidal protection. In Terai region of West Bengal earlier report by Ghosh et al. (1999) depicted that the loss of okra fruit yield due to insect-pest was relatively higher and 30.81% loss in fruit yield could be considered as avoidable loss which supports the results under present investigations. The organic protection though lies behind the chemical one so far as suppression of pest population is concerned but they showed non-significant relation in respect to yield. Increase in yield over untreated control and avoidable losses in yield in pre and *post-kharif* crop are notable. Where, the chemical protection was found best for *kharif* crop.

4. CONCLUSION

Organic management may be opted to minimize the loss of okra despite higher protection was obtained from chemical management because there were no significant yield differences between chemically and organically protected plots. Increase in yield and avoidable loss of chemically and organically managed plot over untreated control was found non-significant in *pre-kharif* and *post-kharif* and significant in *kharif* but with little difference. Moreover, okra is a perishable vegetable; needs frequent plucking of fruit. It requires a little cooking for consumption. Hence, there is every possibility of retaining toxic residue in food. Therefore, organic production system including organic pest management is the best way for okra.

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