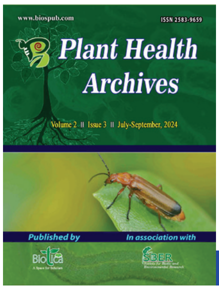

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Abundance of Major Pests of Okra in Relation to Crop Phenology and Cropping Systems

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Abstract

The prevalence of the important okra pests (cv. AO-1), which include the red spider mite (*Tetranychus urticae*), leaf hopper (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*), and shoot & fruit borer (*Earias vitella*), was investigated in both conventional and organic okra farming systems at Navsari Agricultural University in Gujarat from 2018 to 2020. Fruit damage has observed peak at the fruiting stage (23.57 & 20.44%), as evidenced by the highest populations of shoot and fruit borer (2.29 & 1.93). Significant and positive correlations between pest population and fruit damage with crop stage were found (r' = 0.722 & 0.750 and r'' = 0.793 & 0.746), suggesting advancement in crop stage (vegetative to flowering to fruiting stage) led to increased pest population and damage. Highest leafhopper population was noticed at flowering stage (9.24 & 9.98 leaf^{-1}) in both the farming methods. Correlation of leafhopper with crop stages in farming systems was non-significant and positive (r' = 0.002 and 0.041). Highest whitefly population was noticed at fruiting stage (1.63 & 2.03 leaf^{-1}) in both the farming systems. Correlation of whitefly population with crop stages was significant (r' = 0.710 & 0.732) implying advancement in crop growth increased whitefly population. Lastly, the highest Red spider mite population was noticed at fruiting stage (13.42 & 15.54 per 2 cm^2 leaf area) in both the farming systems. Correlation of mite population with crop stages was positive and significant (r' = 0.646 & 0.642) implying advancement in crop stage led to an increase in mite population in both the farming systems.

Keywords: Crop phenology, Farming practice, Okra, Pests

Introduction

In Gujarat, India okra is cultivated in 76,029 ha, yielding 908,676 MT and 11.95 t ha^{-1} of productivity (Anonymous, 2017). Heavy infestations of various pests are one of the main obstacles to the production of okra, since they not only cause quantitative loss, but also qualitative loss to the crop.

Okra has been found to support 72 insect species (Rao and Rajendran, 2002; Chauhan *et al.*, 2021). Sucking insect pest invasions not only harm the crop, but also compromise its health by spreading harmful illnesses (Sheedi, 1980; Daniel *et al.*, 2018). Twenty-nine (29) insect pest species were found in okra by Amin *et al.* (2019). Maqbool *et al.* (2024) reported a total of 19 species and 6 orders. The order Hemiptera contains the majority of species (9), followed by Lepidoptera with four species, Coleoptera with three, and Diptera, Orthoptera and Thysanoptera with one species each. According to Kanwar and Ameta (2007), the attack of insect pests resulted in a 48.97% decrease in pod production.

A comprehensive understanding of pest abundance in connection to crop phenological stages serves as a crucial foundation for the development of effective pest management techniques, particularly when it comes to managing the pest in various farming systems (Srinivas and Kumar, 2022). With particular reference to okra, no systematic attempts were undertaken to observe the pests diversity in connection to crop phenological stages under conventional and organic farming practices. In Gujarat,

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there wasn't enough such knowledge about okra. In order to determine the quantity of pests in connection to crop phenology, a study comparing the prevalence of pests in conventional and organic farming systems was conducted.

Materials and Methods

A study on the prevalence of the major okra pests, *viz*., the red spider mite (*Tetranychus urticae*), the whitefly (*Bemisia tabaci*), the leaf hopper (*Amrasca biguttula biguttula*) and the shoot and fruit borer (*Earias vitella*), was carried out in both conventional and organic farming systems at the Vegetable Research Unit and Certified Organic Farming Unit of Navsari Agricultural University in Gujarat (20.9248° N, 72.9079° E) during 2018-20. In both agricultural systems, the okra variety AO-1 was cultivated in accordance with the suggested package of practices.

The experimental plots in each farming system measured 20 m × 20 m (400 m^2) wherein five spots (1 m × 1 m) were randomly selected in "W" shape to observe the pests. Five plants were selected in each spot at a random, thus total 25 plants of okra (AO-1) were tagged for recording pest observations in each plot.

The shoot and fruit borer (*E. vitella*) larvae were counted on 25 tagged plants at standard week wise interval in both the farming systems from germination to flowering stage of the crop. Fruit damage (%) was calculated by counting the number of healthy and infested fruits at each picking during the fruiting stage in order to document fruit borer-oriented fruit spoilage.

$$\text{Fruit damage (\%)} = \frac{\text{Number of infested fruits}}{\text{Total no. of healthy fruits}} \times 100$$

Leafhopper, *A. biguttula biguttula* and whitefly, *B. tabaci* were counted from three (top, middle and bottom) leaves of each selected plant whereas, red spider mite, *T. urticae* was recorded on the same leaves in 2 cm^2 leaf area.

In each farming system, the relationship between pest abundance and crop phenology was examined. For correlation, the SPSS 21.0 package was utilised. Tables 1 and 2 provide information on the standard week and crop phenological stages of okra in both the farming practices.

Results and Discussion

Okra that are grown in conventional and organic farming practices were examined for the prevalence of significant pests and the harm they caused in connection to crop phenology and cropping strategies. The findings of the current investigation are represented as follows.

Overall Assessment (Pooled Results of 2018-2020)

Shoot and Fruit Borer (E. vitella)

The fruit and shoot borer population peaked at fruiting stage of the crop (2.29±0.89 & 1.93±0.75 larva $plant^{-1}$) followed by in flowering (1.82 & 1.42) and vegetative (0.55 & 0.40) stages of the crop (overall average, 1.73±1.08 & 1.42±0.92 larvae $plant^{-1}$) under organic and conventional farming practices, respectively. In comparison to conventional farming, a higher population of fruit and shoot borer was observed throughout the crop's fruiting stage in organic farming, which is due to lack of use of sufficient quick knockdown chemicals in organic

Table 1: Abundance of shoot and fruit borer population and fruit damage on okra in relation to crop phenology and farming system

SMW	Crop Stage	2018-19		2019-20		Pooled (2018-20)	
		ORG	CNV	ORG	CNV	ORG	CNV
E. vitella larva $plant^{-1}$							
10-13	Vegetative Avg.±SD	0.59±0.74	0.38±0.45	0.51±0.59	0.43±0.50	0.55±0.66	0.40±0.47
14-15	Flowering Avg.±SD	1.76±0.17	1.27±0.03	1.88±0.34	1.56±0.17	1.82±0.25	1.42±0.15
16-23	Fruiting stage Avg.±SD	2.24±0.88	1.84±0.66	2.34±0.93	2.03±0.91	2.29±0.89	1.93±0.75
Overall average		1.70±1.05	1.34±0.85	1.75±1.12	1.51±1.02	1.73±1.08	1.42±0.92
Correlation coefficient (r) v/s crop phenology		0.702**	0.776**	0.730**	0.706**	0.722**	0.750**
Fruit damage (%)							
10-13	Vegetative Avg.±SD	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
14-15	Flowering Avg.±SD	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
16-23	Fruiting stage Avg.±SD	22.62±10.31	19.67±11.05	24.53±10.59	21.21±10.86	23.57±10.39	20.44±10.84
Overall average		12.93±13.86	11.24±12.95	14.01±14.80	12.12±13.50	13.47±14.31	11.68±13.17
Correlation coefficient (r) v/s crop phenology		0.785**	0.730**	0.797**	0.756**	0.793**	0.746**

[SMW: Standard meteorological week; ORG: Organic farming system; CNV: Conventional farming system; **Significant at 1% level] farming system. So, it may be inferred that the fruiting stage is the most favorable period for this pest in both the farming systems (Table 1).

Likewise, the fruiting stage of the crop showed the most fruit damage from shoot and fruit borer infestations (23.57±10.39 & 20.44±10.84%) (overall average, 13.47±14.31 & 11.68±13.17%), which is later considered as most preferable stage. Because organic farming does not employ harmful pesticides, comparatively more fruit damage was observed in organic farms than in conventional farms. There was a positive and significant correlation between the population of shoot and fruit borer and its fruit damage with crop stage (r' = 0.722 & 0.750 and 'r' = 0.793 & 0.746), suggesting that as crop stage advanced from vegetative to flowering to fruiting, there was a corresponding increase in the populations of shoot and fruit borer and fruit damage in both farming systems (Table 1).

Leaf hopper (Amrasca biguttula biguttula)

Highest leafhoppers population was noticed at a flowering stage of the crop (9.24±3.43 and 9.98±3.84 leaf^{-1}), followed by 5.00 & 6.03 and 4.52 & 5.24 leafhopper leaf^{-1} (overall average, 5.47±3.52 and 6.37±3.80 leafhopper leaf^{-1}) at fruiting and vegetative stages of the crop in the organic farming practices and conventional practices, respectively. Higher population of leaf hopper was noticed in conventional farming practices than organic production of okra crop at flowering stage which might be due to colourful stage of the crop attracting the leaf hopper. This could be also due to application of higher doses of nitrogen fertilizers in conventional farming system which led to increased plant succulence. Thus, it may be established that flowering stage is the most favourable period for leafhopper in both farming systems. Correlation of leafhopper population with crop stages in both the farming systems was non-significant and positive (r' = 0.002 and 0.041) implying that advancement in crop stage (vegetative to flowering stage fruiting stage) correspondingly may lead to increase in leafhopper population on okra in both the farming systems (Table 2).

Whitefly (Bemisia tabaci)

There were no population noticed at vegetative stage; while the whitefly population for fruiting stage (1.63±1.22 & 2.03±1.18 leaf^{-1}) was found significantly ($p<0.05$) higher than flowering stage (0.74±0.13 & 0.93±0.08 leaf^{-1}). Overall average was 1.03±1.05 & 1.29±1.27 leaf^{-1} in both the farming systems. Higher whitefly population was noticed at fruiting stage in conventional farming system could be due to excessive application of nitrogenous fertilizers leading to higher vegetative growth and succulence than organically

Table 2: Abundance of sucking pest populations on okra in relation to crop phenology and farming system

SMW	Crop Stage	2018-19		2019-20		Pooled (2018-20)	
		ORG	CNV	ORG	CNV	ORG	CNV
Leafhopper leaf^{-1}							
10-13	Vegetative Avg.±SD	4.80±5.37	5.45±5.62	4.23±4.46	5.02±5.03	4.52±4.91	5.24±5.33
14-15	Flowering Avg.±SD	9.15±1.81	9.80±1.99	9.33±5.04	10.16±5.69	9.24±3.43	9.98±3.84
16-23	Fruiting stage Avg.±SD	4.76±2.41	5.80±2.34	5.25±2.74	6.27±3.62	5.00±2.47	6.03±2.83
Overall average		5.40±3.54	6.27±3.58	5.54±3.66	6.47±4.26	5.47±3.52	6.37±3.80
Correlation coefficient (r) v/s crop phenology		-0.065	-0.012	0.067	0.083	0.002	0.041
Whitefly leaf^{-1}							
10-13	Vegetative Avg.±SD	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
14-15	Flowering Avg.±SD	0.79±0.49	1.03±0.36	0.69±0.22	0.82±0.21	0.74±0.13	0.93±0.08
16-23	Fruiting stage Avg.±SD	1.70±1.04	2.06±1.19	1.15±1.02	1.99±1.22	1.63±1.22	2.03±1.18
Overall average		1.09±1.10	1.32±1.29	0.98±1.04	1.26±1.29	1.03±1.05	1.29±1.27
Correlation coefficient (r) v/s crop phenology		0.708**	0.730**	0.687**	0.713**	0.710**	0.732**
Red spider mite leaf^{-1}							
10-13	Vegetative Avg.±SD	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
14-15	Flowering Avg.±SD	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
16-23	Fruiting stage Avg.±SD	11.38±8.45	14.38±10.71	15.47±11.65	16.69±12.85	13.42±9.86	15.54±11.54
Overall average		6.50±7.95	8.22±10.06	8.84±10.88	9.54±11.87	7.67±9.33	8.88±10.86
Correlation coefficient (r) v/s crop phenology		0.642*	0.641*	0.638*	0.630*	0.646*	0.642*

[SMW: Standard meteorological week; ORG: Organic farming system; CNV: Conventional farming system; *Significant at 5% level; **Significant at 5% level] grown crop. Whitefly population exhibited significant and positive (r' = 0.710 & 0.732) correlation with crop phenology, which suggests an increase in the number of whiteflies in both farming systems as crop stages advanced (Table 2).

Red Spider Mite (Tetranychus urticae)

Red spider mite population have observed peak at fruiting stage of the crop (13.42±9.86 & 15.54±11.54 per 2 cm^2 leaf area) (overall average: 7.67±9.33 & 8.88±10.86 per 2 cm^2 leaf area) in both the farming systems; whereas, no population was noticed at the vegetative and flowering stages of the crop. This indicated that vegetative and flowering stages of okra crop were not preferred by red spider mite in both the farming systems. Correlation of mite population with crop stages was positive and significant (r' = 0.646 & 0.642) suggesting that progression of crop growth stages correspondingly led to an increase in mite population across both the farming practices (Table 2).

According to Siddartha *et al.* (2017), sucking pests such as leafhoppers, *A. biguttula biguttula*, aphids, *A. gossypii* and whiteflies, *B. tabaci* attacked okra plants in the early stages of crop growth, while two-spotted spider mites, *T. urticae*, predominated in the mid and later stages, causing significant yield losses, which is also reported in the present investigation indicating the conformation of the present findings. From the 3rd week of July until the crop reached maturity, or until the final week of October, Kadam (2003) noted the presence of various insect pests and the pattern of their succession on okra cv. Parbhani Kranti. The current findings are supported by the observation that aphid and fruit and shoot borer populations were found from the late vegetative stages to the crop's maturity; whereas jassid and whitefly populations were linked from the early vegetative to late blooming cum fruiting stage of the crop. The population of the sucking pest whitefly, *Bemisia tabaci* (Gennadius) on okra was examined by Lal and Singh (2019) over the course of two seasons. In both years, the whitefly invasion peaked on the 18th SMWS, after beginning in the fourth week of March (the 13th SMWS). Rita *et al.* (2000) documented mite activity on okra in Punjab, which is consistent with the current findings. The findings of the study showed that mites emerged later in the crop's growth and found peak in the final two weeks of August.

Conclusion

The highest number of shoot and fruit borer and associated damage were observed in both conventional and organic farming systems, during the crop's fruiting stage. There was a significant and positive correlation between crop stage and the number of shoot and fruit borer pests and the damage they caused to the fruit. This suggests that as crop stages advanced, the pest population and damage also increased. Leafhopper population peaked at crop's flowering stage in both the farming methods. However, its correlation with crop stages in both the farming systems was non-significant and positive. Whitefly population was considerably higher at crop's fruiting stage in both the farming methods. It showed a strong and positive link with crop stages, suggesting that development in crop stage resulted in a higher population of whiteflies in both agricultural systems. Finally, in both farming methods, the largest Red spider mite population was noticed during the crop's fruiting stage. The mite population and crop stages showed a substantial and positive correlation, suggesting that as crop stages advanced, the mite population grew in both agricultural systems.

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