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A critical study on field efficacy of insecticides and biopesticides against major insect pests in Okra

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Abstract
Monitoring insect activity through routine surveys is one of the pathologist's key goals. Since the pest management system cannot function without precise estimates of pests and natural enemies or without accurate assessments of plant damage and its impact on yield, the knowledge about insect activity acquired through these surveys is essential. Insect resistance, insect resurgence, toxicity, and environmental pollution are only a few of the issues that have been brought on by the indiscriminate use of chemical pesticides without consideration for the financial harm to the crops. In order to determine whether to implement control measures, it is important to regularly check on the number of pests and their state in the crop. Laboratory tests were performed to assess the effectiveness of various botanicals and to determine the development threshold and duration against okra pest insects. Field studies were conducted to examine the succession of pests, seasonal incidence of various insect pests in relation to weather variables, spatial distribution, sequential sampling, and the effectiveness of various insecticides and biopesticides against the most significant insect pests of okra.

Keywords: Field efficacy, insecticides and biopesticides, Okra

Introduction
In order to deliver an adequate number of free radicals, antioxidants, and micronutrients to the body, vegetables serve a crucial role in human nutrition. This is because they are a rich source of carbs, proteins, lipids, minerals, vitamins, and dietary fiber. India, which accounts for 10% of global vegetable production, is the second-largest producer after China. According to the Indian Horticulture Database Board, India produced 162.19 Mt of vegetables in 2013–14. Given that a fairly big portion of the population practices vegetarianism and that common vegetables are less expensive than meat, fish, eggs, and dairy products, it is not unexpected that India has a much higher per capita intake of veggies than Western nations. When comparing vegetables to other crops, it should be noted that many of them can be grown all year long, some of them are ready for consumption in a short amount of time, and some of them can even be grown profitably twice a year. These factors have caused focus to be redirected toward intensive vegetable farming close to metropolitan areas in order to meet the rising demand.
Okra (*Abelmoschus esculentus* L. Moench), a crop grown primarily in tropical and subtropical countries, is one of the most economically significant vegetables. The geographical distribution of cultivated species (Figure 1) shows that it is present all over the world, from Mediterranean to tropical regions. In South-East Asia, which is regarded as the center of diversity, wild and domesticated species overlap, and out of the eight species of Abelmoschus, A. esculentus is the primary cultivar in India. Due to its excellent nutritious content, flavor, and long post-harvest life, it has taken a significant place among vegetables grown for export in India. It has tremendous potential to be one of the crops that generates foreign exchange and contributes significantly to world production.

Fig 1: fruit damage by *E. vitella* on okra in the experimental field

Out of an estimated 5-10 million insect species, less than 1 million have been identified so far, and about 60,000 species have been reported from India. Even Nevertheless, one of the biggest obstacles to increasing the yield potential of many vegetables, including okra, is the presence of insect-pests. It has been noted that different pests attack this crop at different growth stages. Noted nine insect species as significant global pests of this crop. On the other hand, according to the okra crop is devastated during its growing phase by up to 45 species of insect pests. These include the shoot and fruit borer (*Earias vitella*), cotton jassid (*Amrasca devastans*), red cotton bug (*Dysdercus cingulatus*), and cotton jassid (*Amrasca devastans*), all of which are quite serious and major barriers to its cultivation. These significantly reduce yield by infesting the crop both during the vegetative and reproductive phases. Along with these, other significant pests observed on okra at different growth stages include the cotton aphid, *Aphis gossypii; whitefly, Bemisia tabaci; mite, Tetranychus telarius; blister beetle, Mylabris pustulata*.

It takes a lot of time and careful field and lab data collection to forecast pest incidence. However, because of the sudden changes in environmental factors, particularly the temperature, rainfall, and humidity, as well as keeping topography in mind, it has become desirable to conduct short-term quantitative studies to forecast weather in a timely manner. This is because better weather predictions are now available, and changes in these factors have a significant impact on pest infestations within a season. Insect population dynamics have been shown to be strongly influenced by environmental variability and erratic resources.

Development of early prediction models that aid in forecasting pest occurrence in any location is facilitated by the connection between pests and climatic conditions. In addition to being crop- and location-specific, the pest occurrence and damage vary from year to year due to variations in the prevailing environmental conditions, as was also seen over the course of this study. Therefore, it is important to regularly monitor local insect pests and their natural enemies in the field in order to forecast epidemic outbreaks in a timely manner, prevent them, and recommend the most effective pest management strategy.

Research methodology

A. Esculentus (L.) Moench was the subject of the current research, which was conducted on it in controlled settings at the Department of Plant Protection in an experimental field during the summer (*kharif*) seasons. A laboratory investigation of various plant extracts' effectiveness against okra insect pests was done. In order to identify highly effective products against specific insect pests and prevent sole dependence on chemicals, the best botanical in terms of causing mortality in the insect pests obtained in the study was further evaluated in the field alongside the other chemical insecticides and biopesticides throughout the year. The most successful pesticides were also those with the fewest negative side effects after testing a variety of pesticides from various chemical families. Additionally, a backup pesticide was tried in case one ran into issues with resistance or pesticide residue. There have recently been problems all around the country with people not knowing enough about label claims and usage. The registration committee of India approved the use of all pesticides in this study. The safe handling of pesticides as well as the crucial national problem of "label claim" have been addressed in the hopes that this study will promote norms for the responsible use of pesticides in agriculture with the least possible negative effects on the environment.

Okra is referred to by a variety of regional names throughout the world. In addition to being known as lady's finger in India and England, this dish is also known as gumbo in the United States, guino-gombo in Spain, and guibeiro in Portugal. Different names have been given in various regional languages even within India. Due to its simple cultivation, consistent yield, adaptability to varying moisture conditions, and potential as a source of income for marginal and small farmers in the local market, it is quite well-liked in India.

The green, non-fibrous, mucilaginous fruits or pods of okra are grown for their seeds. The fruits are picked before they fully ripen and cooked in a variety of ways before being consumed as vegetables. When making gur or brown sugar from sugarcane juice, the roots and stems are used to clarify the juice. While mature fruits and stems containing crude fiber are used in the paper industry, its ripe seeds are roasted, ground, and used as a substitute for coffee in some nations. An alternative source of edible oil is extracts from okra seeds. Unsaturated fats like oleic acid and linoleic acid are abundant in the greenish-yellow edible oil, which also has a good flavor and aroma. Vitamins, calcium, potassium, and other minerals that are frequently missing in the diets of underdeveloped nations are found in significant quantities in okra. The "*Arka Anamica*" cultivar of okra was used in the current investigations. It was created at the Indian Institute of Horticultural Research in Bengaluru as a backcross between *A. esculentus* and *A. Tetraphyllus*. Around Aligarh, this variety is quite popular. The plant is robust, annual, upright, and well-branched, standing around 100 cm tall. Both sides of the petal base have purple pigment. Fruit is a long, fragile, dark green pod with five noticeable ridges.

Field efficacy of insecticides and biopesticides against major insect pests

Field tests were carried out to evaluate various insecticides and biopesticides on insect pests that were identified as important pests throughout the cropping season in my study. The experiment was triple-replicated and set up using a randomized block design.

In order to record the incidence of *E. Vitella*, damaged and undamaged fruits from three randomly selected plants were counted and per cent fruit damage was calculated.

Results and Discussion

Based on their relative abundance, these were classified as major, minor, and infrequent. Insects that appeared frequently over a long period of time and caused noticeable damage were classified as major pests, whereas those that appeared briefly and in relatively small numbers were regarded as minor pests and those that were occasionally noted were classified as occasional pests. The leaves, branches, shoots, flowers, and pods were all affected by the insect pests. Some of the species attacked the crop and bit and chewed it, while others pierced it and drank the sap from the parts they attacked.

Shoot and fruit borer, *E. Vitella*

Table provides information on the growth in shoot and fruit borer larval populations during the course of the year. On May 27, the bug first started to appear. Later, it grew and peaked on July 8 with a population of 0.78 larvae for every five picked fruits/plot. When the pest population was at its highest, the corresponding means of maximum temperature, minimum temperature, and humidity were 33.50 °C, 27.02 °C, and 75.35%, respectively, with 1.80 mm of precipitation. The population then started to fall and continued to work the harvest until the 12th of August. The month of July saw the greatest pest infestation, whereas August and September's second half saw no insect activity.

Emamectin benzoate (22.70%) and Ozoneem Trishul (26.23%) both showed minimal damage percentages one day after treatment, demonstrating the applicability of biopesticides. It was followed by equally potent compounds such as permethrin, chlorpyriphos, alphacypermethrin, fipronil, spinosad, dimethoate, monocrotophos, and acephate. At this point, the remaining pesticides were comparable, demonstrating the applicability of biopesticides once more.

Cypermethrin, carbaryl, permethrin, alphacypermethrin, fipronil, Emamectin benzoate, Spinosad, and monocrotophos all reduced the percentage of fruit damage by the borer three days after treatment. Surprisingly, Ozoneem Trishul and Neemazal 5% both showed equal results. Comparing indika and neem excel against dichlorvas, deltamethrin, quinalphos, chlorpyriphos, dimethoate, acephate, and pyridalyl did not affect indika and neem excel's ability to minimize damage to okra fruits.

The effectiveness of the pesticides varied slightly seven days after treatment; only Ozoneem Trishul, cypermethrin, carbaryl, permethrin, Emamectin benzoate, Spinosad, and monocrotophos had statistically equivalent effects. It should be highlighted that all insecticides, with the exception of the control, had an equivalent effect, along with neem excel, indika, and neemazal 5%, demonstrating the value of biopesticides in managing pest control.

After fourteen days of treatment, the pattern altered as chemical pesticides began to outperform biopesticides in terms of effectiveness. In this context, it can be seen that spinosad, carbaryl, and Cypermethrin were comparable to one another and showed the least amount of fruit damage from the borer. Permethrin, chlorpyriphos, alpha-Cypermethrin, fipronil, Emamectin benzoate, monocrotophos, and neemazal 5% and Ozoneem Trishul, which provided par values, followed the first three.

It should be noted that over time (1 DAT to 14 DAT), the percentage of fruit damage decreased at a maximum rate in cypermethrin (59.00%), followed by carbaryl (52.32%), Spinosad (42.25%), and pyridalyl (35.67%), as well as quinalphos (32.32%), deltamethrin (24.71%), and neemazal 5% (23.69%), demonstrating the pesticides' longevity. However, damage increased over time in the cases of dichlorvas, permethrin, chlorpyriphos, alphacypermethrin, fipronil, Emamectin benzoate, dimethoate, monocrotophos, acephate, neem excel, indika, and Ozoneem Trishul, which showed a decline in effectiveness due to an increase in fruit damage percentage.

Table 1: Effect of chemical pesticides and biopesticides on shoot and fruit borer, *E. Vitella* fruit damage during kharif (summer) season

Treatments	1 DAT	3 DAT	7 DAT	14 DAT
Cypermethrin	$42.20^{a} \pm 1.35$	$30.10^{bc} \pm 2.16$	$26.23^{c} \pm 3.13$	$26.60^{d} \pm 3.26$
Dichlorvas	$33.53^{a} \pm 4.53$	$32.80^{b} \pm 4.63$	$34.57^{b} \pm 4.82$	$37.63^{b} \pm 6.20$
Carbaryl	$37.80^{a} \pm 2.69$	$28.53^{c} \pm 1.63$	$22.43^{c} \pm 3.03$	$22.63^{d} \pm 1.25$
Deltamethrin	$35.80^{a} \pm 4.69$	$35.80^{b} \pm 4.69$	$34.37^{b} \pm 4.19$	$37.53^{b} \pm 3.81$
Permethrin	$26.70^{b} \pm 3.02$	$23.50^{c} \pm 2.30$	$28.03^{c} \pm 2.92$	$30.90^{c} \pm 4.29$
Quinalphos	$38.33^{a} \pm 3.07$	$34.13^{b} \pm 2.38$	$33.07^{b} \pm 2.04$	$36.55^{b} \pm 1.19$
Chlorpyriphos	$31.30^{b} \pm 2.51$	$33.60^{b} \pm 2.92$	$31.00^{b} \pm 2.57$	$34.47^{c} \pm 2.30$
Aphacypermethrin	$33.50^{ab} \pm 4.53$	$29.27^{c} \pm 7.51$	$31.50^{b} \pm 7.86$	$35.23^{c} \pm 7.48$
Fipronil	$29.93^{b} \pm 7.47$	$27.87^{c} \pm 8.49$	$31.17^{b} \pm 9.26$	$34.90^{c} \pm 8.25$
Emamectin benzoate	$22.70^{c} \pm 4.52$	$25.27^{c} \pm 4.98$	$30.60^{bc} \pm 3.74$	$36.10^{bc} \pm 4.54$
Spinosad	$32.63^{b} \pm 4.63$	$23.20^{c} \pm 2.45$	$23.60^{c} \pm 0.49$	$21.90^{d} \pm 2.37$
Dimethoate	$31.30^{b} \pm 2.51$	$34.57^{b} \pm 2.37$	$37.07^{b} \pm 3.59$	$41.47^{b} \pm 2.37$
Monocrotophos	$27.23^{b} \pm 4.35$	$26.33^{c} \pm 4.70$	$28.20^{c} \pm 4.40$	$32.90^{c} \pm 3.64$
Acephate	$26.30^{b} \pm 3.40$	$30.13^{b} \pm 4.28$	$35.70^{b} \pm 4.05$	$40.57^{b} \pm 4.40$
Pyridalyl	$41.10^{a} \pm 1.35$	$35.83^{b} \pm 2.61$	$34.97^{b} \pm 3.28$	$38.53^{b} \pm 2.95$
Azadirachtin (Neem excel)	$35.60^{a} \pm 2.69$	$32.73^{b} \pm 0.82$	$39.17^{b} \pm 0.79$	$39.63^{b} \pm 1.06$
Azadirachtin T/S	$33.53^{a} \pm 4.53$	$29.53^{c} \pm 2.91$	$32.03^{b} \pm 2.96$	$34.83^{c} \pm 4.70$
1% EC (Neemazal) Azadirachtin1500	$38.90^{a} \pm 3.56$	$38.50^{b} \pm 3.94$	$40.17^{b} \pm 3.49$	$45.13^{b} \pm 3.39$
ppm (Indika) Azadirachtin 5%	$26.23^{bc} \pm 5.44$	$25.97^{c} \pm 5.18$	$29.70^{c} \pm 5.29$	$35.50^{c} \pm 3.04$
EC (Ozoneem Trishul) Control	$42.20^{a} \pm 1.35$	$49.20^{a} \pm 0.98$	$55.20^{a} \pm 0.53$	$62.43^{a} \pm 1.77$
LSD (p<0.05)	9.04	9.44	9.66	9.36

Mean followed by the same letters within the same column are not significantly (p<.05) different from each other using LSD test.

Cypermethrin, carbaryl, deltamethrin, and Spinosad recorded the least amount of fruit damage fourteen days after treatment, followed by permethrin, quinalphos, and chlorpyriphos. Neemazal 5%, in contrast, was as efficacious as acephate, dimethoate, Emamectin benzoate, and fipronil at a later stage (7 DAT). The effects of the remaining treatments were roughly equal.

Cypermethrin, carbaryl, deltamethrin, permethrin, quinalphos, chlorpyriphos, and spinosad were found to be more effective even up to 14 days after treatment when pesticide effectiveness and longevity were examined. Contrarily, when fruit damage increased over time (1 DAT to 14 DAT), the remaining pesticides and biopesticides comparatively decreased their efficacy.

Conclusion

The research conducted for this thesis started with an examination and identification of several insect pests that affect okra. After that, studies on their seasonal incidence, life cycles at various temperature regimes, distribution, and management using chemical and non-chemical methods were conducted. I have made an effort to go through the fundamentals of integrated pest control, such as monitoring, forecasting, and decision-making. Therefore, my thesis can be seen as an effort to develop an IPM module, specifically to control the insect pests of okra.

Any insecticide's effectiveness is largely dependent on how it is applied, which is determined by the insecticide's characteristics, the type of pest or pest complex that needs to be controlled, and the time or stage at which the application is to be made. However, a number of issues, such as bioaccumulation and biological magnification, are connected to their use. Their negative effects were foreseen as early as 1962 by Rachel Carson in her facts-revealing book "The Silent Spring". She tried to speak, but no one could hear her. It's imperative that we use pesticides sparingly and strive to reduce the number of times we apply them. In my opinion, these chemical pesticides should be supplemented with plant-based botanicals or biopesticides, much as how Indian farmers employ organic manures in addition to inorganic fertilizers to maintain the fertility of the land. It might be a supplement to existing techniques like mechanical, physical, cultural, biological, hormonal, pheromonal, and even sterilization control.

The same group of pesticides will probably control pests in the same manner. Pesticide resistance is more likely to develop when pesticides that control pests in the same way are used repeatedly. Therefore, the chemical group to which a specific pesticide belongs must be known to pesticide applicators. Utilizing these from multiple chemical classes lowers the possibility of developing resistance to them. When using pesticides in an integrated pest management program, it's important to rotate between pesticides from various chemical families.

- Research on the succession of pests in okra provided the best opportunity to identify a new pest shortly after it arrived, to determine the number of pests present in the crop and their status, and to choose the appropriate time to implement control measures.
- In addition to affecting the status of the insect pests, weather variations also had an impact on their dynamics, dispersion, and abundance.

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