Saudi Journal of Biological Sciences 29 (2022) 3114–3121

Contents lists available at ScienceDirect

Saudi Journal of Biological Sciences

journal homepage: www.sciencedirect.com

Original article

Comparative conventional preventive strategies for insect pest of okra

Qasim Jan [a], Imtiaz Ali Khan [a], Laila A. Al-Shuraym [b], Mohammed Ali Alshehri [c], Nazeer Ahmed PhD [d,*], Muhammad Saeed [d], Mohamed El-Sharnouby [e], Samy Sayed [f]

[a] Department of Entomology, Faculty of Plant Protection, The University of Agriculture, Peshawar, 25130, Pakistan
[b] Biology Department, Faculty of Science, Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia
[c] Biology Department, College of science, University of Tabuk, Tabuk 71491, Saudi Arabia
[d] Department of Agriculture, University of Swabi, Anbar, 23561, Pakistan
[e] Department of Biotechnology, College of Science, Taif University, P.O. Box 11099, Taif 21944, Saudi Arabia
[f] Department of Science and Technology, University College-Ranyah, Taif University, B.O. Box 11099, Taif 21944, Saudi Arabia

ARTICLE INFO

Article history:
Received 2 December 2021
Revised 11 January 2022
Accepted 17 March 2022
Available online 21 March 2022

Keywords:
Clove
Hing
Eucalyptus globulas
Aphids
Thrips
Whiteflies

ABSTRACT

The use of natural substances for pest control in agriculture is economically viable. It benefits both the human being and the environment due to its low persistence and toxicity. Therefore, the biopesticidal potential of three- plants-derived extracts (clove [*Syzygium aromaticum*], Hing [Hing (*Asafetida*)], and Wood Ash [*Eucalyptus globulas*]) was evaluated against different ' 'insect's pests on five okra varieties. All the treatments were sprayed at two stages, 1st before flowering and 2nd at the fruit-bearing stage. The results of the 24 h pre-spray revealed that the mean density of *Aphis gossypii*, *Erias insulana*, and *Bemisia tabaci* were significantly lower on a Shehzadi variety. However, among the treatments mean density of the *A. gossypii* and *E. insulana* after 1st and 2nd treatments were substantially more bass with *E. globulas*. Moreover, the Mean density of aphids was significantly lower after 72 h and 1-week time intervals. Furthermore, after 1st and 2nd treatments, the *B. tabaci* was considerably lower with hing on Shehzadi variety. It was found in the present study that the yield of five okra varieties was affected significantly by the application of the three treatments-pesticides. Among the various treatments, the application with *E. globulas* recorded a considerably higher crop yield. Therefore, clove, hing and *E. globulas* could be effective as alternative pest management methods. Furthermore, biopesticides generally are encouraged since they can proffer the solution of controlling insect pests without any environmental concern.

1. Introduction

Okra is most nutritious and concluded as an essential component of the human diet. Okra fruit is rich in vitamins (e.g., vitamin A, vitamin C, vitamin B6, folic acid, riboflavin, etc.), minerals (e.g., calcium, magnesium, potassium, iron, zinc, phosphorus, and β carotene), carbohydrates, proteins, fats and fiber (Varmudy, 2011). The fully ripened okra seed is an excellent source of oil, protein, unsaturated fatty acids (e.g., linoleic acid) necessary for human nutrition. Its ripened fruit and stem have crude fiber used in the paper industry (Kumar et al., 2013). Okra yield in Pakistan is much lower than that would lead okra producing country for many reasons, mainly because of insect pests (Rahman et al., 2012). Seventy-two types of insects have been observed on okra vegetables (Rahman et al., 2013) from vegetative to reproductive stage, which causes considerable damage. The major okra sucking pests are aphids (*Aphis gossypii* G.), thrips (*Thrips tabaci* L), and whiteflies (*Bemisia tabaci* G.). On the other hand, most pests are shooting borers (*Earias* spp.) and fruit borers (*Helicoverpa armigera* H.). Insect pest infestations reduce growth and lower growth and reduce the development and transmission of pathogens into okra (Sheedi, 1980; Dhaliwal et al., 1981).

Various methods used to control the different insect pest population. These methods include, chemical insecticides, biological control, synthetic insecticides, resistance varieties and semiochemicals which affect the growth of insect, development and population (Ahmed et al., 2013; Ahmed et al., 2016; Fu et al., 2017;

* Corresponding author.
E-mail address: drnazeerento@gmail.com (

Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.sjbs.2022.03.022
1319-562X/© 2022 The Author(s). Published by Elsevier B.V. on behalf of King Saud University.

Ahmed et al., 2018; Ahmed et al., 2019). However, some studies also indicated that the entomopathogenic fungi alone or/and plant extracts are effective to control the populations of insect pests (Saif-Ur-Rehman et al., 2019a; Saif-Ur-Rehman et al., 2019b; Mastoi et al., 2020, Sayed et al., 2021a, Sayed et al. 2021b). The best way of controlling insect pests at present is through synthetic insecticides that have traditionally been widely used (Ilyas et al., 2015; Ahmed et al., 2021; Iqbal et al., 2021; Ullah et al. 2021). Nonetheless, they have negative effect for humans, animals, and beneficial insects. (parasitic wasps, bees, and lady beetles). The field workers are highly vulnerable due to their frequent exposure to pesticides. Two million people have been reported affected by insecticide toxicity, and 40,000 have died (Pingali et al., 1994; Rajput, 2004; Solangi and Lohar, 2007). Furthermore, genetically engineered pesticides have been used in commercial agriculture and horticulture for a long time to prevent indiscriminate pesticides.. Biopesticides are effective in lower doses and allowed in organic farming. They are safer for providing an appropriate alternative for humans, animals, non-target organisms, plants, and bacteria. (Kumar et al., 2003; Patel et al., 2009; Ahmed et al., 2016; Ahmed et al., 2021; Iqbal et al., 2021).

Due to their potential insecticide effects, botanicals can be an approach to managing insect pests. The advantage of these bioinsecticides is that, unlike other poisons, these are readily available and cheaper. These are relatively easy available, less harmful to natural enemies, mammalian pollinators, and environmentally friendly. Misuse and -high insecticidal costs have forced the quest for alternatives, particularly for developing countries. Another approach is to research traditional methods of pesticide control. While they are mostly not widely employed in developed countries, they play essential roles in developing countries ' pesticide control programs. Plant parts and derivatives have been a traditional practice for many years (Owusu 2001; Arannilewa et al., 2006; Adedire et al., 2011; Qari et al., 2020; Iqbal et al., 2021). Alternative solutions that are environmentally sustainable, affordable, and user-friendly (such as locally grown insecticide-powered plants) are required to combat this problem. Sand, dry pepper, and herbal extracts are just a few ancient ways discovered. Natural plant products such as volatile organic compounds and other products have been utilized to protect agricultural products against pests in several world regions for many years; Insecticide impacts on plant products against a wide range of pesticides have been discovered by a number of researchers (Tiroesele et al., 2015; Darshanee et al., 2017; Ahmed et al., 2018; Ahmed et al., 2019; Sharaby et al., 2020; Iqbal et al., 2021). The use of clove, *Eucalyptus globulas*, and hing are methods to be discussed. An approach based on plant products (without synthetic pesticides) in the present situation would seem to have tremendous potential for increasing okra production in the traditional crop system in all tropical and subtropical countries.

In previous studies with different purposes, okra and herbal extracts were used against various insect pests (Abdel et al., 2014; Iqbal et al., 2015; Sarkar et al., 2016). However, okra types and plant extracts were ineffective against aphids, whiteflies, or spotted bollworms (cloves, hing, and *E. globulas*). In this study, the potential utility for the control of insect pests on okra (aphid, bowls, and spotted bollworms) was evaluated with Hing, locally known as the Anja (Ana), clove (*Syzygium aromaticum*), locally known as Lowang ash, and clove, popularly known as the Lowang ash (*E. globulas*). This information would allow farmers in Pakistan to use readily available plant components to control insect pests and increase Okra yield.

2. Materials and methods

The experiment was conducted at the Agronomy Research Farm of the University of Agriculture, Peshawar, Pakistan. The experiment was laid out in Randomized Complete Block Design (RCBD) with a split-plot arrangement having 3 replications. Hing, clove, and *E. globulas* were used to test three conventional management techniques against okra insect pests on five varieties: Super green, Pusashawani, Tulsi, Shehzadi, and Green gold. Seeds were acquired from a local bazaar in Peshawar's Guru Mandi. The plot was confined to 5 $\times$ 4 m2, with a length of 5 m and a width of 4 m. Row to row distance was kept 25 cm, and plant to plant space was12 cm. A buffer zone of 1.5 m was marked between each replication and 1 m among the plots.

2.1. Preparation of extracts

Extracts of hing, clove, and *E. globulas* were prepared using the methodology of Munir (2006). Plant products were converted into powder form of approximately 3 mm in size with grinder help, locally controlled *E. globulas* (a traditionally made fireplace for cooking food). *E. globulas* (1 kg) was obtained from burnt fire wood use for cooking; sieved to remove particles/stone and were stored in plastic container properly until needed for bioassay. Two hundred fifty grams of each clove and hing were wrapped in Muslin fabric and steeped for 10 to 15 min in 5 L of water before boiling. After boiling, the solutions were kept for 24 h to get 5% (w/v) stock solution.

2.2. Data collection

Insect pest data were collected randomly in each sub-plot by selecting 5 plants (35 days old). Aphid data was collected by selecting each leaf from the plant's top, middle, and bottom based on the leaf base. Data were recorded per plant for whiteflies and borers. Twenty-four hours pre-spray and 24 h, 48 h, 72 h, and one-week post spray data were collected on 5 randomly selected plants in each subplot of each treatment. Spray application was repeated at two 'weeks' intervals.

2.3. Yield

Data of okra yield was obtained from each plot that was weighed through electrical balance and later converted into kg ha^{-1} by using the following formula:.

$$Yield(kgha^{-1}) = Yieldofplotinkgx10,000m^2$$

$$Areaofsubplot(m^2)$$

2.4. Data Analysis

The collected data were subjected to Analysis of Variance, and means were compared using DMRT (1% probability level) using Originpro software version 2018. Figures were also obtained by Originpro software.

3. Results

Mean density of insect pests showed significant difference ($F_{4,1}$ = 4.16, P = 0.041) in between five okra varieties. Results reveal that the mean density of *A. gossypii* was significantly higher (4.73 *A.*

gossypii leaf^{-1}) on Green gold followed by Super Green (4.43 *A. gossypii* leaf^{-1}) and Pussashawani (4.17 *A. gossypii* leaf^{-1}) while lower (2.73 *A. gossypii* leaf^{-1}) density was observed on Shehzadi which were significantly different from rest of the varieties. However, the mean density of bollworm was significantly higher (6.03 *E. insulana* plant^{-1}) on Pussa-shawani, followed by Green Gold (5.30 *E. insulana* plant^{-1}) and lower (3.53 *E. insulana* plant^{-1}) on Shehzadi. Furthermore, the mean density of *B. tabaci* was significantly higher (4.43*B. tabaci* plant^{-1}) on Green gold followed by Pussashawani (3.63*B. tabaci* plant^{-1}) and lower (2.73*B. tabaci* plant^{-1}) on Shehzadi similar to Tulsi (3.17*B. tabaci* plant^{-1}) and Super Green (3.43*B. tabaci* plant^{-1}). **(**Fig. 1**)**.

Number of aphid's leaf^{-1} showed significant difference ($F_{4,1}$ = 154.15, P = 0.00) on different okra varieties when treated with plant extracts after first spray. Among the treatments mean density of the aphids was significantly lower (1.3 aphids leaf^{-1}) on Shahzadi (0.4 aphids) with *E. globulas*, which is followed by hing (0.9 aphids leaf^{-1}) and clove (1.9 aphids leaf^{-1}), while it was significantly higher in control (7.5 aphids leaf^{-1}) **(**Fig. 2**a)**. However, the mean density of aphids was significantly lower after 72 h of treatment and higher after 24 h. In varieties, x time interval interaction plots in which shehzadi variety was practiced and sprayed interval of 48 h, 72 h and one week yielded a significantly lower mean density of aphids (1.6 aphids leaf^{-1}) on Shahzadi and higher on Super Green (4.5 aphids leaf^{-1}) **(**Fig. 2**b)**. Furthermore, Moreover, Treatment and varieties interaction showed significant difference ($F_{4,1}$ = 8.71, P = 0.000) after second spray. Among the treatments mean density of the aphids was significantly lower (0.0 aphids leaf^{-1}) with *E. globulas* on Shehzadi, which was followed by hing (0.6 aphids leaf^{-1}) **(**Fig. 2**c)**. However, higher *A. gossypii* (7.7 aphids leaf^{-1}) was observed in the control. Furthermore, the Mean density of aphids was significantly lower after 1 week of treatment (0.6aphids leaf^{-1}) and higher (5.9 aphids leaf^{-1}) after 24 h on Green Gold **(**Fig. 2**d)**. Moreover, Mean density of *Bemisia tabaci* after first spray-on five varieties of okra showed significantly difference ($F_{4,1}$ = 9.10, P = 0.001) at 5% level. The treatments mean density of the *B. tabaci* was significantly lower (0.6*B. tabaci* plant^{-1}) with hing on Shehzadi while it was significantly higher in control (7.7*B. tabaci* plant^{-1}) on Pussa-Shawani (Fig. 3**a**). Meanwhile, there was no significant difference among the spraying intervals (24 h, 48 h, 72 h and 1 week) (Fig. 3**b)**. Among the treatments mean density of the *B. tabaci* was significantly lower (0.1*B. tabaci* plant^{-1}) with hing on Shehzadi, which was followed by Tulsi and Green Gold (0.6*B. tabaci* plant^{-1}) while it was significantly higher in control (6.1*B. tabaci* plant^{-1}) on Super Green (Fig. 3**C**). In varieties, x time interval interaction plots in which Shehzadi variety was practiced and spray 1 week yielded significantly lower mean density of aphids (1.4*B. tabaci* plant^{-1}) (Fig. 3**d**). Mean density of *E. insulana* after first spray-on five varieties of okra showed significantly difference ($F_{4,1}$ = 8.10, P = 0.004) at 5% level. Among the treatments density of the *E. insulana* was significantly lower (0.6 *E. insulana* plant^{-1}) on Shehzadi with *E. globulas*, while it was significantly higher in control (7.7 *E. insulana* plant^{-1}) on Pussa-Shawani **(**Fig. 4**a)**. However, in varieties, x time interval interaction plots in which Shehzadi variety was practiced and all the spray intervals yielded a significantly lower density of *E. insulana* (1.9 *E. insulana* plant^{-1}) **(**Fig. 4**b)**. Nevertheless, The results reveal that the mean density of *E. insulana* after 2nd spray was significant difference. Among the varieties mean density of *E. insulana* was significantly lower on Shehzadi (0.8 *E. insulana* plant^{-1}) with hing and higher (7.1 *E. insulana* plant^{-1}) with Control on PussaShawani **(**Fig. 4**C)**. In varieties, x time interval interaction plots in which Shehzadi variety was grown and 1 week after treatment resulted in a significantly lower mean density of *E. insulana* (0.7 *E. insulana* plant^{-1}) **(**Fig. 4**d)**.

Furthermore, it was found in the present study that the yield of five okra varieties was significantly affected by the application of the three treatments. Among the varieties, Shehzadi yielded significantly ($F_{4,1}$ = 5.95, P = 0.000) higher with 11826 kg ha^{-1} significantly different from other varieties. However, Among the various treatments, *E. globulas* application gave a significantly ($F_{4,1}$ = 48.52, P = 0.000) higher yield of 12021 kg ha$^{-1,}$ significantly

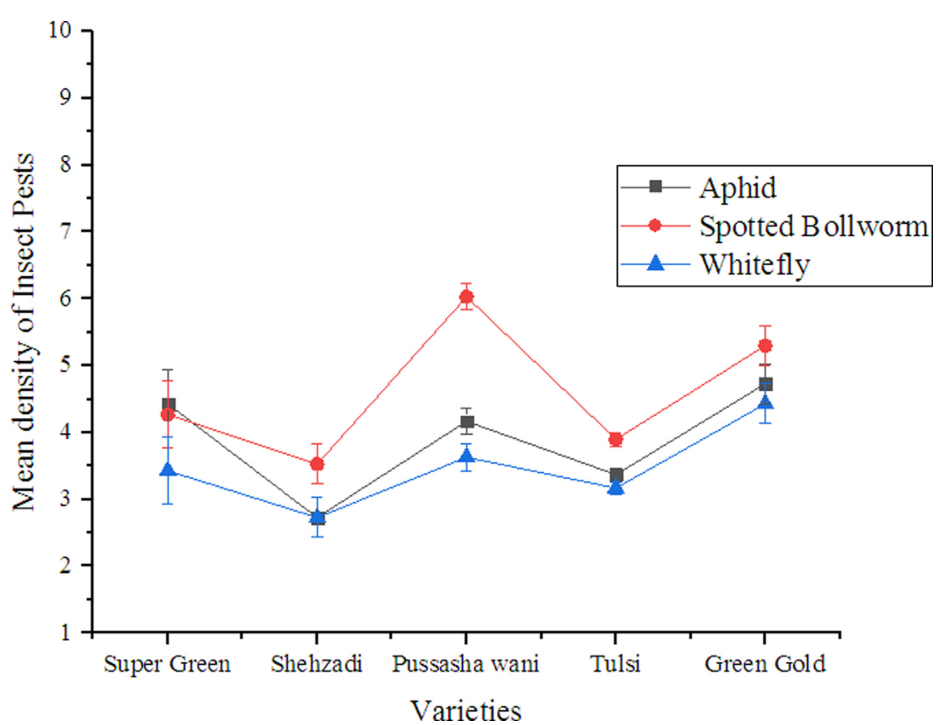

Fig. 1. Mean density of insect pests on five okra varieties before 24 h oftreatments.

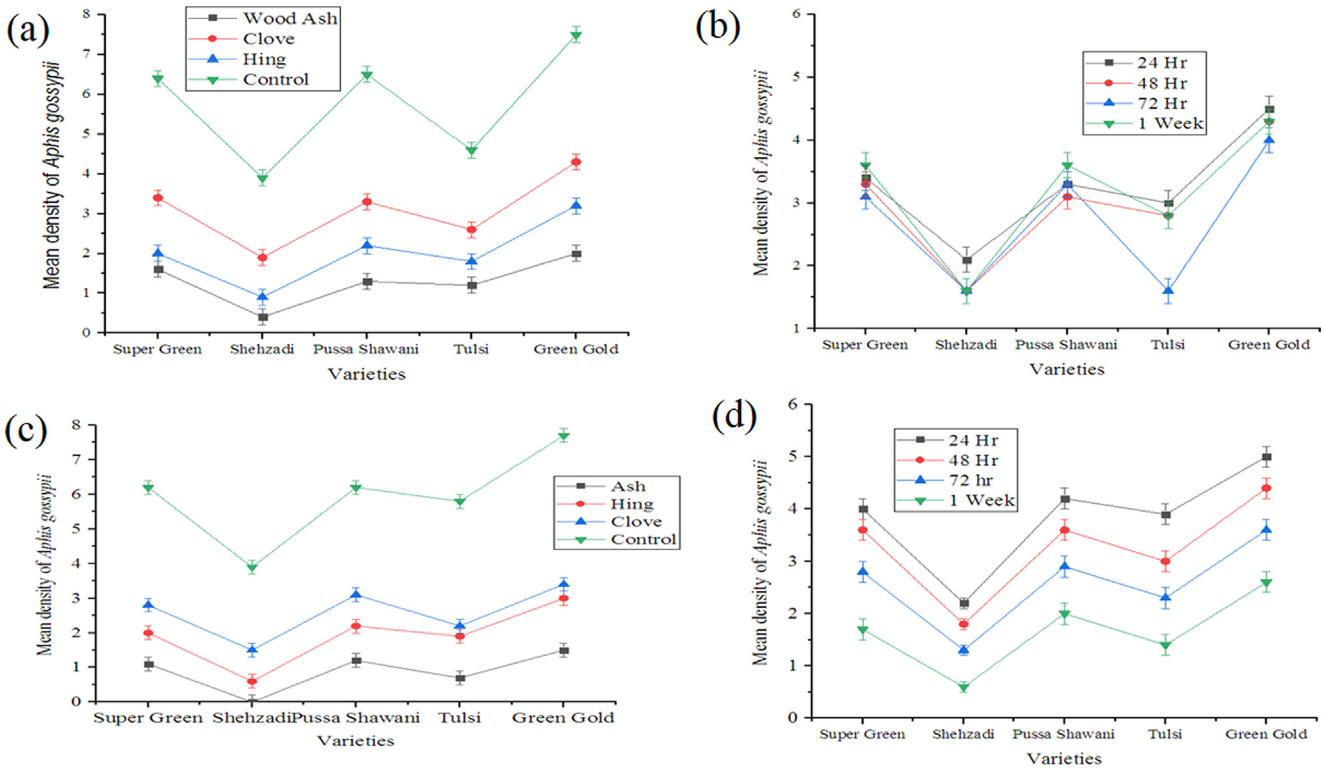

Fig. 2. Mean Density of *Aphis gossypii* after first (a) and second spray (b)on five varieties of okra, (c)the interaction between varieties and plant extracts and (d) the interaction between time intervals and okra varieties.

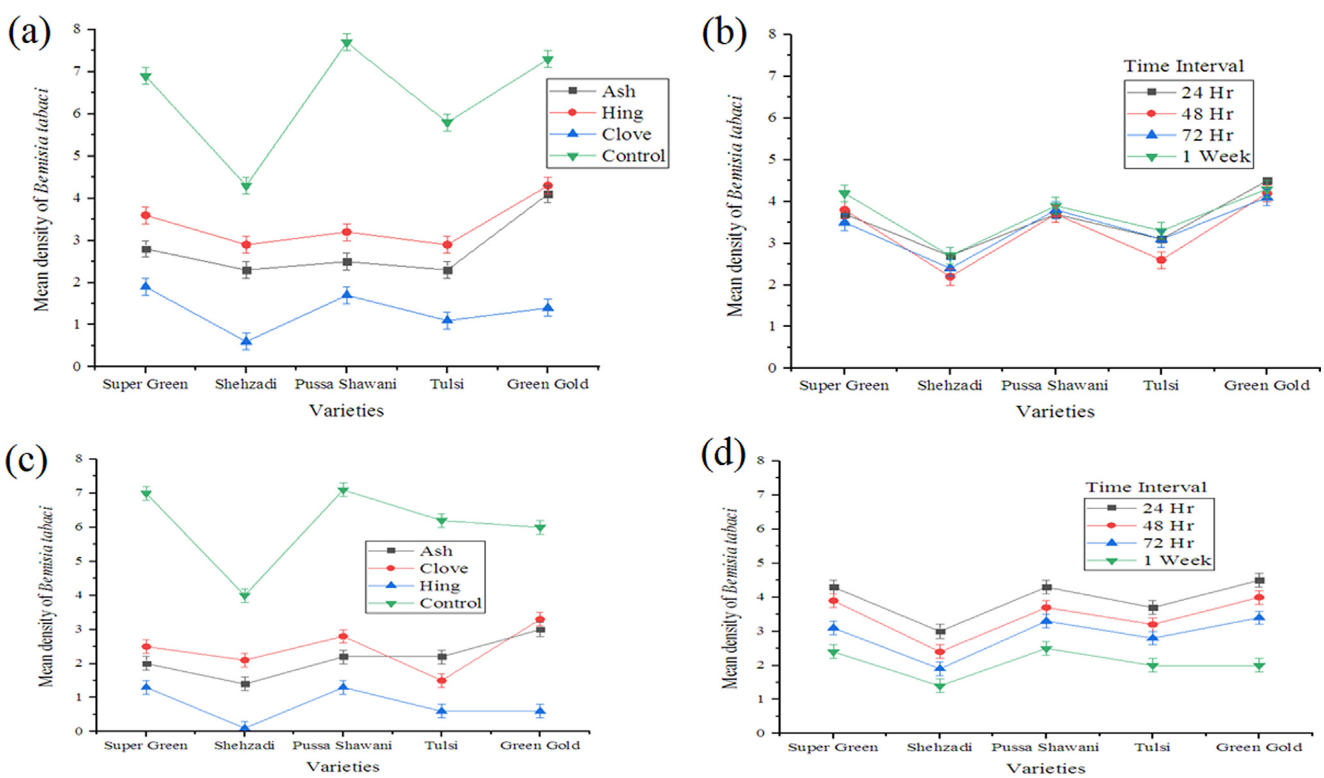

Fig. 3. Mean density of *Bemisia tabaci* after first (a) and second spray (b)on five varieties of okra, (c) the interaction between varieties and plant extracts and (d) the interaction between time intervals and okra varieties.

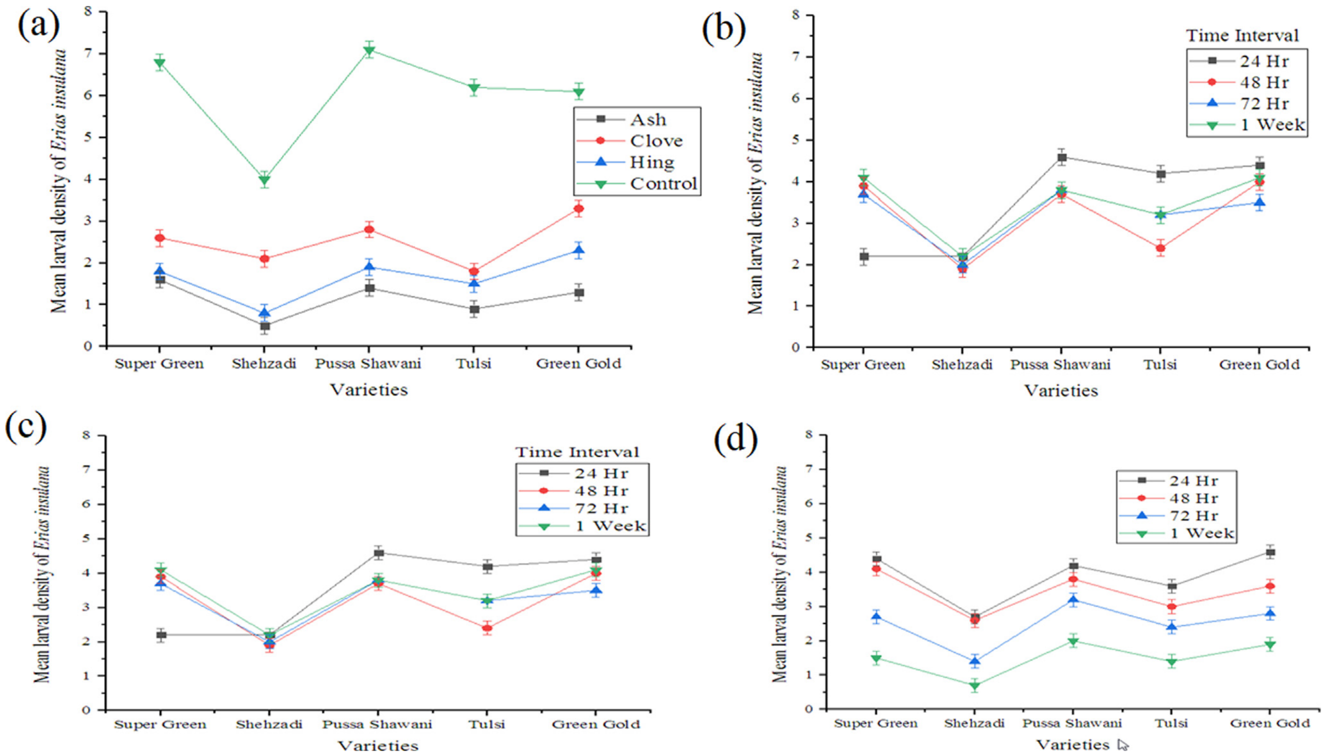

Fig. 4. Mean larval density of *Erias insulana* after first (a) and second spray (b)on five varieties of okra, (c) theinteraction between varieties and plant extracts and (d) the interaction between time intervals and okra varieties.

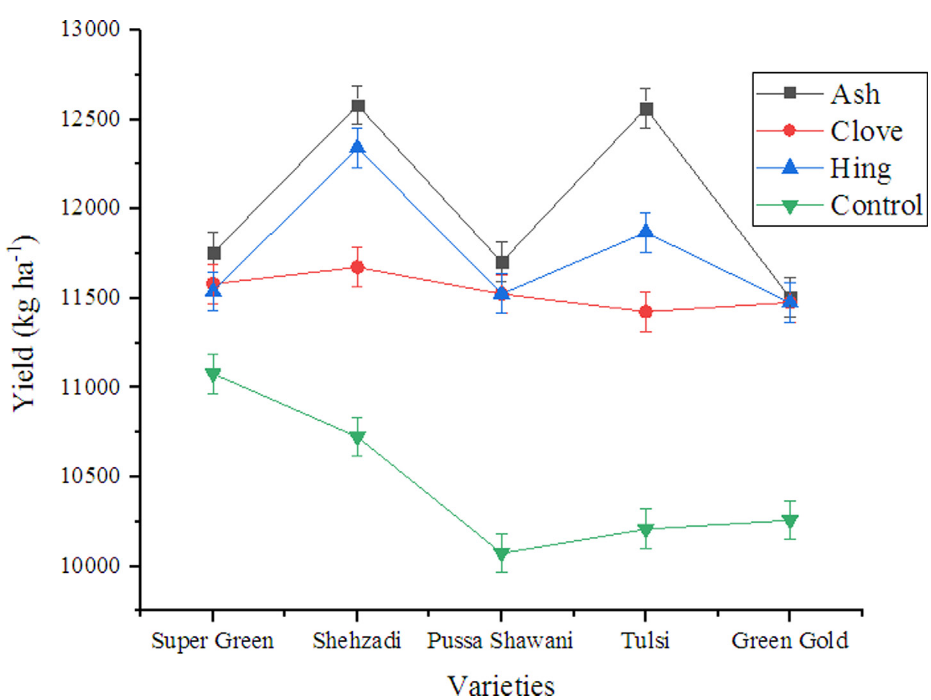

Fig. 5. Mean yield (kg ha^{-1}) of five okra varieties after treatments.

different from others. Among the interactions (treatment × varieties), *E. globulas*, when sprinkled on the Shehzadi variety, gave a higher yield (12582kgha^{-1}) of okra (Fig. 5).

4. Discussion

Natural pesticides are an excellent alternative to synthetic pesticides because they are safe for the environment, natural enemies, humans, and other animals (Sayed et al., 2020; Ahmed et al., 2021; Iqbal et al., 2021). The okra is one of the vegetables frequently picked from the field and probably picked daily; hence highly toxic chemicals might leave residual effects in consumable pods. This research indicated that clove, hing, and *E. globulas* could reduce the infestation of ' 'insect pests and improve the yield of the okra plant. Furthermore, the research suggested that *E. globulas* and hing based biopesticides were adequately effective in controlling *Aphis gossypii* and *E. insulana* whereas, hing was more effective, especially against *B. tabaci* infesting okra.

Aphids and Spotted Bollworms population decreased after 72 hrs. But their toxicity was close to peaks of reduction percent up to one week during the second spray. After 72 h of spraying, the botanical pesticides began to detox, and the maximum effect on the population of Aphides and Spotted Bollworms was lowered until one week after the rush. It is generally observed that synthetic pesticides reduce insect infestation immediately, but develops resistance against these pesticides. However, biopesticides are natural substances, and insects never tolerate the efficacy of biopesticides. Our results are similar to that of Rani and Jyothsna (2010). They had observed that plants produce some morphological advances and protein that have toxic, repellent or anti-nutritional effects on the herbivores. In the present study, the mean density of *A. gossypii* and *E. insulana* was significantly lower on the Shehzadi variety, which might be attributed to morphological features or the production of secondary metabolites. Such components are responsible for reducing insect pest preferences for a variety. The present study presents study's results supported by Siva-Kumar (2004), who reported that *Meranoplus bicolor* was found useful to control insect feeding on the flowers and at the base of immature bolls of cotton. Ali et al. (2005), also reported that bio-pesticides controlled sucking complex populations on cotton. The least values of the insect population, under the *E. globulas* extract compared to hing and clove extract, proved that it was most effective against aphids and spotted bollworms in the okra variety of Shehzadi. Because of this, it had the highest yield of the okra variety Shehzadi, which explained its high monetary value.

In agriculture systems where environmental protection and the conservation of beneficial organisms is essential, the application of bio-pesticides that provide desirable alternatives to synthetic chemicals is increased in recent years, with synthetic chemicals in agriculture systems to protect the environment and preserve beneficial microorganisms (Ahmed et al., 2021; Iqbal et al., 2021). However, there have been little or no attempts to control insect pests of Okra plants using these plant extracts, mostly *E. globulas*. Repellence or suppression by *E. globulas* of 'insect pests on Okra Shehzadi species could be an antimicrobial effect of alkanes in *E. globulas*. Nevertheless, Super Green, Pussasha Wani, and Green Gold were highly susceptible to aphids, whitefly and spotted bollworms. This highest number of these insect populations may be due to hosts and favorable environmental conditions. Another important reason for the abundance may be the season of the pest. Our results are supported by Sohail et al. (2015).

Likewise, the *E. globulas* application gave lower *E. insulana* density, which might be due to bollworms' feeding behavior. As a result, our findings matched those of Lal and Verma. (2006), who found that *E. globulas* could successfully reduce sucking and chewing insects. They observed that lupron and *E. globulas* dusting was best in managing the pest population long-term. Similarly, Aderolu et al. (2012) reported that neem and *E. globulas* had affected insect pests and the number of damaged leaves per plant of amaranths plant. *E. insulana* was significantly lower on Shezadi and with *E. globulas* treatment. Shehzadi variety was non-preferred by the *E. insulana* due to some plant characters like trichome. Similar results were also reported by Mohamed (2012). The chewing type behavior of bollworms might be the main reason for its control. Further, in our study, the pest attack was reduced in the Shehzadi variety due to physical characteristics like setae, trichome, etc. Similar results were also reported by Hanley et al. (2007). They had studied plant defenses against insect pests due to physical properties, either forming waxy cuticles or developing spines or setae. Our study based on reducing the mean population of whitefly with hing is partially favored by Kaleri et al. (2011) and Khan et al. (2014). They reported the efficacy of different plant extracts regarding percentage reduction of the whitefly population after hing application. Our results also aligned with that of Noonari et al. (2016). They had stated that maximum removal of the whitefly population occurs with hing application (60.18%).

Among the varieties mean density of *B. tabaci* after the 1st and 2nd treatments was significantly lower on Shehzadi and higher on Green gold. There was no significant difference among the spraying intervals (24 h, 48 h, 72 h, and 1 week) after the 1st treatment. Still, the time interval of 1 week after the 2nd treatment yielded significantly lower (2.2*B. tabaci* plant^{-1}), while 24 h after treatment gave substantially higher (4.0*B. tabaci* plant^{-1}). Similarly, Mahmood et al. (2014) found a significant reduction in the whiteflies population after 24 hrs, 48 hrs,72 hrs when treated with hing application. Ali et al. (2011) also reported similar results. The present study revealed that *B. tabaci* density was significantly reduced with the application of hing. The current investigation's present findings showed that the botanical pesticides effectively reducing the whitefly population up to one week with maximum reduction after one week of spray.

With an increasing awareness of environmental pollution, the natural-products concept has returned to the global arena as a proposed alternative for pest control. Natural products reportedly have reduced environmental consequences, leading to several studies' emergence (Ahmed et al., 2021; Iqbal et al., 2021). Before synthetic insecticides' development and commercial success beginning in the 1940 s, botanical insecticides were effective weapons in the ' 'farmer's arsenal against crop pests (Isman, 2008). Plant extracts have been found to take comparatively more days to combat sucking insects. However, previous studies have documented that while synthetic insecticides are quicker than botanicals in their regulation, they negatively affect biocontrol agents (Khan and Atta, 2007; Oladimeji and Kannike, 2010; Khaliq et al., 2014; Ursani et al., 2014). The extracts of the plant contain many substances which have been toxic to sucking and chewing insects. Hing will disrupt the chemoreceptors, which prevent insects from feeding. It also acts like a repellent, larvicidal egg, stimulates the hatching of eggs, and reduces insect pests' reproduction. (Iqbal et al., 2015). The Hing contains the biodegradable, insecticidal liminoid, a botanical insect inhibitor (Walter et al., 1999), which interacts with some cellular proteins that contribute to developmental harms such as insect growth and premature death (Upadhyay and Singh, 2012).

Clove oil is being tested against several urban and agricultural pests, and some insecticides have been proven to be effective against some of them. Many other plant products have been tested and found to be effective against imported red Prevent workers, including mint oil and cinnamon oil (Kim et al., 2003, Yang et al., 2003; Chaieb et al., 2007; Chang et al. (2013)). Clove was successful against sucking insects in the current study. It may be because the insecticidal activity of different extracts of plants and different concentrations remained unchanged. In this respect, too, the time factor is essential. Plant extracts usually contain many metabolites that operate through different modes of action with sub-lethal effects on the target insect (Chiasson et al., 2004). The results are similar to Mahdi and Rahman (2008), who tested spices against stored beetles for toxicity. Zeng et al. (2010) assessed and evaluated the clove's chemical components utilizing GC–MS. There were

18 active compounds and 9 identified. The main element of 2-methoxy-4-(2-propenyl)-phenol was identified as 83 percent. Trans-Caryophyllene activity (12%) was also associated with insecticidal properties. Insects can also be used to control contact and fumigant actions of plant extracts due to their ability to influence various insect life stages (Han et al., 2008; Tripathi et al., 2009). Further research should also focus on active ingredients and identify the optimal application methods for natural plant extracts.

The highest yield was recorded in Shehzadi (12582 Kg/ha) treated with wood compared to other varieties treated with hing and clove. This increase in outcome might be associated with its resistance to different insect pests. Our results agree with that of some previous research, i.e., Shannag et al. (2007) had reported that the yield of okra was low with a high infestation of insect pests. Similarly, plots treated with *E. globulas* yielded significantly higher yields than control and other treatments (hing, clove). Our results conforming to Mahmood et al. (2010). Accordingly, the highest yield of cucumbers was achieved from plots treated with *E. globulas* + permethrin dust. Ukeh et al. (2007) also recorded the highest output from okra plots treated with *E. globulas*. The yields obtained from treated plots of plant extracts were considerably higher, in line with Fuglie (1998) and Panhwar (2002), who reported that the extract of the treated plants on the cowpea field increased flower production per plant. The main threat to crop production was the infestation of insect pests on the farm. These results align with previous researchers ' observations, which found that plant extract increases vegetable and pea crops' yield by protecting them from insect pests (Panhwar, 2002). Gaby (2000), likewise, showed a significant increase in plant yield when using plant extract in powder or solution. Field findings indicated no phototoxic effect on the okra leaves was generated by any of the extracts used in this study. The study findings conflicted with, who claimed that neem products induced yellowing and subsequent leaves to be discarded. If it is sprayed early morning or late evening, plant-based insecticide application effectiveness can be enhanced (Oparaeke et al., 2003).

5. Conclusion

These results showed a significant difference in efficiency of treatments with the plant extracts as compared to the control. The yield in plots dealing with plant extracts was relatively higher than that of in control plots. Reduced production in the Okra plant in the control group is related to high pest infestation. The more a farmer avoids using the insecticidal solution, the more the farm becomes exposed to high pests; this could result from non - application of either the hing and clove extract or the *E. globulas* extract. If botanicals are applied initially, the population could be kept below the economic injury level, an essential point of IPM. Therefore, this study promotes and developing local plants as protectants against insect pest infestations. It is also suggested to investigate the effect of these natural products in the farm environment on controlling the sucking insect pests under laboratory conditions.

6. Availability of data and material

All data related to this paper are available in the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This work was funded by Taif University Researches Supporting Project number (TURSP-2020/139), Taif University, Taif, Saudi Arabia.

References

Abdel-Razek, A.S., Abdel-Salam, A.E., Abd El-Ghany, N.M., 2014. Sustainable potato tuber moth, *Phthoremia operculella* (Zeller), control using biopesticides of natural and microbial origin. J. Agric. Sci. Technol. 2 (6), 125–130.

Adedire, C.O., Akinkurolere, R.O., Obembe, O.M., Oduleye, O.O., 2011. Response of *Callosobruchus maculatus* F. To extracts of Cashew kernel. J. Plant Dis. Prot. 118 (2), 75–79.

Aderolu, I.A., Omoloye, A.A., Ojo, J.A., 2012. Comparative Evaluation of Modified Neem Leaf, Wood Ash and Neem Leaf Extracts for *Hymenia recurvalis* control on Amaranthus spp. in Ibadan Southwest Nigeria. Int. J. Hort. Crop Sci. Res. 2 (1), 27–35.

Ahmed, N., Ahmad, S., Ahmad, S., Junaid, M., Mehmood, N., 2013. Population trend of aphid (*Lipaphis erysimi* Kalt) on canola (*Brassica* spp.) cultivar in Peshawar. Pak Entomol 35, 135–138.

Ahmed, N., Alam, M., Saeed, M., Ullah, H., Iqbal, T., Al-Mutairi, K.A., Shahjeer, K., Ullah, R., Ahmed, S., Ahmed, N.A.A.H., Khater, H.F., 2021. Botanical Insecticides Are a Non-Toxic Alternative to Conventional Pesticides in the Control of Insects and Pests.

Ahmed, N., Chamila Darshanee, H.L., Fu, W.Y., Hu, X.S., Fan, Y., Liu, T.X., 2018. Resistance of seven cabbage cultivars to green peach aphid (Hemiptera: Aphididae). J. Econ. Entomol. 111 (2), 909–916.

Ahmed, N., Darshanee, H.L.C., Khan, I.A., Zhang, Z.F., Liu, T.X., 2019. Host selection behavior of the green peach aphid, *Myzus persicae*, in response to volatile organic compounds and nitrogen contents of cabbage cultivars. Front. Plant Sci. 10, 79.

Ahmed, N., Huma, Z., Haq, M. u., Rehman, S. -., Ullah, M., Ahmed, S., 2016. Effect of Different Plant Extracts on Termite Species (*Heterotermis indicola*), J. bioresour. manag**.** 3 (2). DOI: https://doi.org/10.35691/JBM.6102.0049.

Ali, H., Ahmad, S., Hassan, G., Amin, A., Naeem, M., 2011. Efficacy of different botanicals against red pumkin beetle (*Aulacophora foveicollis*) in bitter gourd (*Momordica charantia* L.). Pak. J. Weed Sci. Res. 17 (1), 65–71.

Ali, S., Khan, M.A., Habib, A., Rasheed, S., Iftikhar, Y., 2005. Management of yellow vein mosaic disease of okra through pesticide/botanical pesticide and suitable cultivars. Int. J. Agric. Biol. 7 (1), 145–147.

Arannilewa, S.T., Ekrakene, T., Akinneye, J.O., 2006. Laboratory evaluation of four medicinal plants as protectants against the maize weevil, *Sitophilus zeamais* (Mots) African. J. Biotech. 5, 2032–2036.

Chaieb, K., Hajlaoui, H., Zmantar, T., Kahla-Nakbi, A.B., Rouabhia, M., Mahdouani, K., Bakhrouf, A., 2007. The Chemical Composition and Biological Activity of Clove Essential Oil, Eugenia caryophyllata *(Syzigium aromatic*um L. Myrtaceae): A Short Review. Phytother. Res. 21 (6), 501–506.

Chang, A.N., Khuhro, R.D., Yousufzai, B.Z., Dhiloo, K.H., Rajput, I.A., 2013. Efficacy of neem kernal powder and oil against cauliflower insect pests under field conditions. Life Sci. Int. J. 7 (1), 2848–2852.

Chiasson, H., Bostanian, N.J., Vincent, C., 2004. Acaricidal properties of a Chenopodium–based botanical. J. Econ. Entomol. 97 (4), 1373–1377.

Darshanee, H.L., Ren, H., Ahmed, N., Zhang, Z.F., Liu, Y.H., Liu, T.X., 2017. Volatile–mediated attraction of greenhouse whitefly Trialeurodes vaporariorum to tomato and eggplant. Front. Plant Sci. 8, 1285.

Dhaliwal, J.S., Sidhu, M.S., Singh, G., 1981. Effect of different dates of sowing on sorghum and the incidence of red leaf spot disease and major insect pests in Punjab. J. Res. Agric. Univ. Ludhiana. 18, 400–405.

Fu, W., Yu, X., Ahmed, N., Zhang, S., Liu, T., 2017. Intraguild predation on the aphid parasitoid *Aphelinus asychis* by the ladybird *Harmonia axyridis*. BioControl. 62 (1), 61–70.

Fuglie, S.L., 1998. Producing food without pesticides: Local solution to crop pest control I West Africa. Church–world service, Dakar Senegal. 140, (1998).

Gaby, S., 2000. Natural crop protection in the tropics. Margraf Verlag press, p. 502.

Han, R.-D., Parajulee, M., He, Z., Ge, F., 2008. Effects of environmental humidity on the survival and development of pine caterpillars, *Dendrolimus tabulaeformis* (Lepidoptera: Lasiocampidae). Insect. Sci. 15 (2), 147–152.

Hanley, M.E., Lamont, B.B., Fairbanks, M.M., Rafferty, C.M., 2007. Plant structural traits and their role in antiherbivore defense. Persp. Plant. Ecol. Evol. Sys. 8, 157–178.

Ilyas, M., Ahmed, N., Zada, A., Rahman, J., Maula, F., Khan, N.H., Umair, M., 2015. Impact of various insecticides and planting dates on the management of maize stem borer Chilo partellus. Adv. Life. Sci Technol., p. 35.

Iqbal, J., Ali, H., Hassan, M.W., Jamil, M., 2015. Evaluation of indigenous plant extracts against sucking insect pests of okra crop. Pak. Entomol. 37 (1), 39–44.

Iqbal, T., Ahmed, N., Shahjeer, K., Ahmed, S., Al–Mutairi, K. A., Khater, H. F., Ali, R. F., 2021. Botanical Insecticides and their Potential as Anti–Insect/Pests: Are they Successful against Insects and Pests?. Open intech.

Isman, M.B., 2008. Botanical insecticides: for richer, for poorer. Pest Manag. Sci. 64 (1), 8–11. https://doi.org/10.1002/ps.1470.

Kaleri, A.W., Lohar, M.K., Rustamani, M.A., Nahiyoon, A.A., 2011. Efficacy of different bio–pesticides against sucking insect pests on okra crop. Pak. J. Entomol. 26 (1), 67–72.
Khaliq, A., Khan, A.A., Afzal, M., Tahir, H.M., Raza, A.M., Khan, A.M., 2014. Field evaluation of selected botanicals and commercial synthetic insecticides against *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) populations and predators in onion field plots. Crop Prot. 62, 10–15.
Khan, M.A., Atta, S., 2007. Effect of imidacloprid and extracts of neem and dathura on white fly population and tomato yellow leaf curl virus disease incidence Proceeding of the International Symposium on Microbial Technologies for Sustainable Agriculture. Faisalabad, Pakistan.
Kim, S.-I., Park, C., Ohh, M.-H., Cho, H.-C., Ahn, Y.-J., 2003. Contact and fumigant activities of aromatic plant extracts and essential oils against *Lasioderma serricorne* (Coleoptera: Anobiidae). J. Stored Prod. Res. 39 (1), 11–19.
Kumar, D.S., Tony, D.E., Kumar, A.P., Kumar, K.A., Rao, D.B.S., Nadendla, R., 2013. A review on: *Abelmoschus esculentus* (okra). Int. Res. J. Pharm. App. Sci. 3 (4), 129–132.
Kumar, S., Kalidhar, S.B., 2003. A review of the chemistry and biological activity of *Pongamia pinnata*. J. Med. Arom. Plant Sci. 25, 441–465.
Lal, C., Verma, L.R., 2006. Use of certain bio–products for insect–pest control. Indian. J. Traditional Knowledge. 5 (1), 79–82.
Mahdi, S.H.A., Rahman, M.K., 2008. Insecticidal effect of some spices on *Callosobruchus maculatus* (Fabricius) in black gram seeds. Rajshahi. Univ. J. Sci. 27, 47–50.
Mahmood, K., Eijaz, S., Khan, M.A., Alamgir, A., Shaukat, S.S., Mehmood, Z., Sajjad, A., 2014. Effects of bio–pesticides against jassid *(Amrasca devastans* Dist.) and white fly *(Bemisia taba*ci Genn.) on okra. Int. J. Biol. Biotech. 11 (1), 161–165.
Mahmood, T., Tariq, M.S., Khokar, K.M., Hidayatullah, Hussain, S.I., 2010. Comparative effect of different plant extracts and insecticide application as dust to control the attack of red pumpkin beetle on cucumber. Pakistan J. Agric. Res. 23: 3–4.
Mastoi, A.H., Ahmed, N., Saif–Ur–Rehman, Khan, I.A., Jiang, J., Hu, X. S., Liu, T. X., 2020. Effect of heat stress on life history of pea aphid, (*Acyrthosiphon pisum* (HARRIS)(HEMIPTERA: APHIDIDAE) based on life table. Pak. J. Agri. Sci. 57(1), 325–332.
Mohamed, M.A., 2012. Impact of planting dates, spaces and varieties on infestation of cucumber plants with whitefly, *Bemisia tabaci* (Genn.). J. Basic Appl. Zool. 65 (1), 17–20.
Munir, K. 2006. Efficacy of different plant crude extracts for the control of insect pests of okra. M. Sc (Hons.) Thesis, The Univ. Agric. Peshawar, Pakistan. Pp. 1–50.
Noonari, A.M., Abro, G.H., Khuhro, R.D., Buriro, A.S., 2016. Efficacy of bio–pesticides for management of sucking insect pests of cotton, *Gossipium hirsutum* (L.). J. Basic Appl. Sci. 12, 306–313.
Oladimeji, A., Kannike, M.A., 2010. Comparative studies on the efficacy of neem, basil leaf extract and synthetic insecticides, lambda–cyhalothrin, against Podagrica spp. on okra. Afr. J. Microbiol. Res. 4 (1), 033–037.
Oparaeke, A.M., Dike, M.C., Amatobi, C.I., 2003. Preliminary study on clove, *Syzigium* aromatic Gaertun and *Eugenia caryophyllata* Thunb (Myrtaceae) as a source of insecticide. Nig. J. Agric. Ext. 13, 73–80.
Owusu, E.O., 2001. Effect of some Ghanaian plant components on control of two, stored–product insect pests of cereals. J. Stored Prod. Res. 37 (1), 85–91.
Panhwar, S.B., 2002. Farmers adoption of plant materials for insects control. International service for National Agricultural Research, Haque, Netherland, 4, 61 – 68.
Patel, P.S., Patel, G.M., Shukla, N.P., 2009. Evaluation of different modules for the management of pest complex of okra. Pestol. 33 (1), 31–37.
Pingali, C., Parbhu, L., Marquiz, B., Florencia, G.P., 1994. Pesticides and Philippine rice farmer health. Am. J. Agric. Econ. 76, 587–592.
Qari, S.H., Khalil, A.H., Abdelfattah, N.A.H., Shehawy, A.A., 2020. Effect of different plant extracts and nanoparticles on *Thrips tabaci* (Lind.) (Thysanoptera: Thripidae) under field conditions and their allelopathic potential on the onion, *Allium cepa* L. using bioassays and RAPD analysis. Egypt. J. Biol. Pest Control. 30, 13 (2020). https://doi.org/10.1186/s41938-020-00216-1.
Rahman, K., Waseem, K., Kashif, M., Jilani, M.S., Kiran, M., Ghazan, F., Mamoon–Ur–Rashid, M., 2012.Performance of different okra (*Abelmoschus esculentus* L.) cultivars under the agro–climatic conditions of Dera Ismail Khan. Pak. J. Sci. 64 (4), 316–319.
Rahman, M.M., Din, M.M.U., Shahjahan, M., 2013. Management of okra shoot and fruit borer, *Earias Vitella* using chemical and botanical insecticides for different okra varieties. Int. Res. J. Appl. Life Sci. 2 (1), 1–9.
Rajput, M.H., 2004. Effect of bio–pesticides against sucking insect complex on cauliflower *Brassica oleraceae* L. M.Sc. thesis submitted to Sindh Agriculture University. Tandojam., 53
Rani, P.U., Jyothsna, Y., 2010. Biochemical and enzymatic changes in rice as a mechanism of defense. Acta. Physiol. Plant. 32 (4), 695–701.
Saif–Ur–Rehman, Ahmed, N., Lahori, A. H., Feng, J. N., Wang, D. (2019). Use of indigenous isolates of Metarhizium, Isaria and Beauveria as potential bio–control agents against Sitophilus oryzae under laboratory conditions. Pak. J. Agric. Sci**.** 56(4).
Saif–Ur–Rehman, Jiyang, Z., Ahmed, N., Feng, J. N., Wang, D., 2019. Potential of four entomopathogenic fungi isolates as biological control agents against two aphid species under laboratory conditions. Pak. J. Agric. Sci**.** 56(2), 421–429.
Sarkar, S., Patra, S., Samanta, A., 2016. Efficacy of different bio–pesticides against sucking pests of okra (*Abelmoschus esculentus* L. Moench). J. Appl Nat. Sci. 8 (1), 333–339.
Sayed, S.M., Alotaibi, S.S., Gaber, N., Elarrnaouty, S.-A., 2020. Evaluation of five medicinal plant extracts on *Aphis craccivora* (Hemiptera: Aphididae) and its predator, *Chrysoperla carne*a (Neuroptera: Chrysopidae) under laboratory conditions. Insects. 11 (6), 398. https://doi.org/10.3390/insects11060398.
Sayed, S., Elarnaouty, S.A., Ali, E., 2021a. Suitability of five plant species extracts for their compatibility with indigenous *Beauveria bassiana* against *Aphis gossypii* Glov. (Hemiptera: Aphididae). Egypt. J. Biol Pest Control. 31, 11. https://doi.org/10.1186/s41938-020-00361-7.
Sayed, S., Elarnaouty, S.A., Al-Otaibi, S., Salah, M., 2021b. Pathogenicity and side effect of indigenous *Beauveria bassiana* on *Coccinella undecimpunctata* and *Hippodamia variegata* (Coleoptera: Coccinellidae). Insects. 12 (1), 42. https://doi.org/10.3390/insects12010042).
Shannag, H.K., Al–Qudah, J.M., Makhadmeh, I.M., Freihat, N.M., 2007. Differences in growth and yield responses to *Aphis gossypii* G. between different okra (*Abelmoschus esculentus* L. Moench) varieties. Pl. Prot. Sci. 43, 109–116.
Sharaby, A.M.F., Gesraha, M.A., Fallatah, S.A.B., 2020. Botanical extracts against the potato tuber moth, *Phthorimaea operculella* (Zeller 1873) (Lepidoptera: Gelechiidae), during storage conditions. Egypt. J. Biol. Pest Control**.** 30, 93. https://doi.org/10.1186/s41938-020-00294-1.
Sheedi, M.A., 1980. Arthropods associated with okra *Hibiscus Esculentus* L. crop. Sindh Agriculture University, Tandojam.Pp.58. M.Sc. thesis.
Siva-kumar, S., 2004. Effect of botanical pesticides on control of cotton insect pests in India state of Kerala. Insect. Environ. 2 (2), 142–145.
Sohail, K., Jan, S., Usman, A., Shah, S.F., Usman, M., Shah, M., Ahmad, M., 2015. Evaluation of some botanical and chemical insecticides against the insect pests of okra. J. Entomol. Zool. Stud. 3 (2), 20–24.
Solangi, B.K., Lohar, M.K., 2007. Effect of some insecticides on the population of insect pests and predators on okra. Asian J. Plant Sci. 6(6), 620–926.
Tiroesele, B., Thomas, K., Seketeme, S., 2015. Control of cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae), using natural plant products. Insects 6 (1), 77–84.
Tripathi, A.K., Singh, A.K., Upadhyay, S., 2009. Contact and fumigant toxicity of some common spices against the storage insects *Callosobruchus maculatus* (Coleoptera: Bruchidae) and *Tribolium castaneu*m (Coleoptera: Tenebrionidae). Int. J. Trop. Insect Sci. 29 (3), 151–157.
Ukeh, D.A., Umoetok, S.B.A., Iwejuo, P., Emosairue, S.O., 2007. Effects of Plantain inflorescence ash and neem seed extract on the yield and insect pests of eggplant (*Solanum Melongena* L.) in Calabar, Nigeria. Res. J. Agron. 1(2), 88–93.
Ullah, M., Ullah, F., Khan, M.A., Ahmad, S., Jamil, M., Sardar, S., Tariq, K., Ahmed, N., 2021. Efficacy of various natural plant extracts and the synthetic insecticide cypermethrin 25EC against Leucinodes orbonalis and their impact on natural enemies in brinjal crop. Int. J. Trop. Insect Sci. 42 (1), 173–182.
Upadhyay, S.K., Singh, P.K., 2012. Receptors of garlic (*Allium sativum*) lectins and their role in insecticidal action. Protein. J. 31 (6), 439–446.
Ursani, T.J., Malik, S., Chandio, J.I., Palh, Z.A., Soomro, N.M., Lashari, K.H., Baloch, M. A., Solangi, B.K., Solangi, M.N., Mastoi, G.M., 2014. Screening of biopesticides against insect pests of brinjal. Int. J. Emerging Trends Sci. Tech. 1 (6), 918–931.
Varmudy, V., 2011. Marking survey need to boost okra exports. Department of Economics, Vivekananda College, Puttur, Karnataka, India.
Walter, J.F., 1999. Commercial experience with Neem products. In Hall F.R., Menn, J. J., Eds., Botanical pesticides: use and delivery. Humana.
Yang, Y.-C., Lee, S.-H., Lee, W.-J., Choi, D.-H., Ahn, Y.-J., 2003. Ovicidal and adulticidal effects of *Eugenia caryophyllata* bud and leaf oil compounds on *Pediculus capitis*. **J**. Agric. Food Chem. 51 (17), 4884–4888.
Zeng, L., Lao, C.Z., Cen, Y.J., Liang, G.W., 2010. Study on the insecticidal activity compounds of the essential oil from *Syzygium aromaticum* against stored grain insect pests. Julius–Kühn–Archiv 425, 766.