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Efficacy of Botanical Plant Extracts on the Population Dynamics of Cotton Aphid, Aphis gossypii Glover (Hemiptera; Aphididae)

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Cover Page Footnote

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EFFICACY OF BOTANICAL PLANT EXTRACTS ON THE POPULATION DYNAMICS OF COTTON APHID, *APHIS GOSSYPII* GLOVER (HEMIPTERA; APHIDIDAE)

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ABSTARCT

Synthetic pesticides are excessively consumed to control crop pests but abundant use of chemicals may implicate the whole ecosystem badly in the end. Despite the growing concern, few natural products are commercialized for pest control whilst on-farm use of existing botanically-based pesticides remains a small, but growing, component of crop protection practice. The experiment was conducted to assess the potential trade-offs of using botanical extracts (Neem leaf extract, NLE, and Moringa leaf extract, MLE) along with synthetic insecticide, Confidor 200 SL, against *Aphis gossypii* Glover. Meanwhile, impact of these insecticides on natural enemies were also determined in the field experiment. Data were recorded 12h before, as well as 1, 3, and 7 days after the application (DPA) of insecticides. Results revealed that chemical insecticide after 1DPA were showed higher mortality (%) of aphid's population at leaf (33%) and boll stage (41%), whereas, the botanical treated plots showed lower mortality used alone as well combined application but lower numbers were observed on the negative controls. The same trend of insecticidal activity was observed from all treatments after 3DPA, but interestingly, after 7DPA, the resurgence of beneficial insects were only recorded in botanical extract-treated plots. The Confidor presented an adverse effect on natural enemies whereas no or few natural enemies were observed compared to herbal extracts. Overall, for long-term control, the combined use of botanical insecticides is proved to be more efficient in the management of the aphids than Confidor and caused no or little adverse impact on the beneficial insects.

Keywords: Plant extracts; beneficial insects; insect resurgence; environment-friendly.

INTRODUCTION

Cotton, *Gossypium hirsutum* (L.), well-known as "white gold" is an essential cash crop of Pakistan for upholding the economy and is conventionally grown in agricultural plains of Punjab and Sindh territories. The value-added service of cotton contributes 8.2 percent to

Agriculture sector continue to play a critical role in Pakistan economy and contribute about 3.2% of gross domestic product (GDP). Approximately 60% of the foreign exchange come from textile products which have boosted the national economy by over $2.5 billion mostly in ginning factories and textile mills in Pakistan that depend on cotton (Naheed and Rasul, 2010). Moreover, Pakistan is the world's fourth-largest cotton-producing country, while the third-largest exporter of raw cotton and a leading exporter of yarn in the world as yield per acre ranks 13th in the world. On the other hand, the cotton yield is declined due to several biotic and abiotic factors, and insect pests are the major limiting factors among biotic factors, which severely affect the cotton crop (Morgan, 1984).

Major devastating pests of cotton crop include sucking and chewing pests. Sucking pests include *Dysdercus koenigii*, *Thrips tabaci*, *Tetranychus macfarlanei*, *Amrasca biguttula biguttula*, *Bemisia tabaci*, as well as *Aphis gossypii*, *Sylepta derogata*, *Myllocerus undecimpustulatus maculosus* while chewing insect pests are termites, *Earias insulana*, *Pectinophora gossypiella*, and *Helicoverpa armigera* (Ahmed and Qasim, 2011; Qasim et al., 2018; Qasim et al., 2015). Deterioration in lint quality of cotton crop due to insect pest infestation resultantly 10-40% losses occur in the cotton crop (Gahukar, 2006).

Among the major pests, *A. gossypii* Glover is considered to be a risky pest to almost all crops as well as a vector of many viral diseases (Sharma and Joshi, 2010) and known as a polyphagous insect pest (Arif et al., 2009). *A. gossypii* attacks a variety of plants, infesting leaves, stems, roots, and fruit (Prishanthini and Laxmi, 2009) as well as caused indirect damage by secreting honeydew which leads to the development of sooty mold. Aforetime, it was reported that *A. gossypii* caused losses of the cotton crop, up to 40% but after soon, losses were reached up to 100% in Pakistan and India (Attle et al., 1987).

Bulk pesticidal usage against insect pests leads towards resistance against pesticides in insect pests (Brown, 1986; Panhwar, 2005; Qasim and Hussian, 2015), and caused adverse effects on non-target organisms, along with specific environmental hazards. To overcome the problems of synthetic chemical hazards, bio-pesticides are being exploited due to their biodegradability, least persistence and least toxic to non-target organisms, economical, and easy availability. Currently, about two hundred plant species have been described for insecticidal activities (Singh, 1996).

Plant extracts contain a lot of natural compounds which are helpful to manage various pests worldwide (Islam et al., 2018a; Islam et al., 2018b). The Azadirachtin is one of the natural compounds extracted from *Azadirachta indica* A. Juss, having insecticidal properties as well as antibacterial, antifungal, and antiviral for several years. Azadirachtin compound is useful for almost 400 pest species (Walter, 1999, Erler et al., 2010). Moreover, insect pests were unable to develop resistance against the botanical compound mixture of active ingredients in *A. indica.*

Moringa oleifera (Moringa) is also a multifunctional plant and has extensively been cultivated in many countries (Fahey, 2005). This plant is not merely responsible for nutrition to animals but correspondingly serves as an excellent alternative for the treatment of several diseases (Makkar and Becker, 1996). Moreover, this plant is also being used for the management of several insect pests (Ali et al., 2015; Ohia et al., 2014). The present study was designed to assess the performance of botanical extracts against cotton aphids in the field conditions, and also to test the survival of natural enemies after exposure to various insecticides to scrutinize more secure insecticides.

MATERIAL AND METHODS

Botanical extracts and chemical insecticides were excessively evaluated against *A. gossypii* and entomophagous insects with different concentrations. An experiment was carried out under a complete randomized block design (RCBD) with three replications, at the research center of the Department of Entomology, University of Agriculture Faisalabad, Pakistan. A total of 24 plots (8×3=24) with the size of 5×5 m^2 was randomly selected for the experiment. In each treatment (Table 1) cotton cultivar, NIAB-111 with recommended R ×R (0.4m), P×P (0.8m) distance was sown for cultivation. To reduce the inter-plot interference of insecticide on the population dynamics of cotton aphid and natural organisms, a relatively large inter-plot distance of 6 m was used (Qasim et al., 2018).

Collection of Plant Material and Preparation of Insecticides

Fresh and healthy leaves of *M. oleifera* (Moringa; MLE) and *A. indica* (Neem; NLE) were collected from near regimes of the University of Agriculture Faisalabad, Pakistan, and other surrounding territories. Selected botanical plants were chosen due to their availability, pesticidal, medicinal value, and insect repelling properties. All plant materials were brought into Integrated Pest Management Laboratory, Department of Agricultural Entomology, and University of Agriculture Faisalabad, Pakistan. Plant leaves were washed thoroughly before use and soaked in sterilized distilled water for one night. After washing, the leaves were grinded thoroughly with a rotary shaker for extraction. The extract was filtered through a double-layered muslin cloth followed by Whatman No. 1 filter paper and made two different concentrations (25% (1/4,v/v, extract: H2O) and 50% (2/4 v/v, extract: H_2O) for sole and mix plant extracts and used it in the further experiment immediately (Idrees et al., 2016), while the concentration of synthetic insecticide, Confidor (Imidacloprid) 200 SL, were prepared with concentrations of 250 $ml.acre^{-1}$.

Application and Observations Recorded

Confidor and aqueous leaf extract (Moringa and Neem) with different concentrations (25% and 50%) were used against cotton aphid and natural enemies. Insecticides were applied at the leaf stage of 30 days (2-6 plant leaves), and the boll stage of 90 days with the help of a knap sap sprayer. There were eight treatments of different pesticides and concentrations, along with one treatment as a controlled plot (Table 2). The patchy population of aphids was recorded at two times (leaf stage and boll stage), and natural enemies were observed at the mature stage only by a scoring system based on some aphids/leaf close to the plant terminal, 12 h before application and 1, 3, 7days post-application (days of post-application, DPA) (Hussain et al., 2015).

Statistical Analysis

Collected data were analyzed using SPSS and graphs were prepared through Microsoft Excel 2016.

Table 1: Effects of *Azadirachta indica* against various pest orders along with their insecticidal actions

Targeted Organisms	Order	Mode of actions	References
Amrasca biguttula biguttula	Homo ptera	INS	(Singh, 1996)
Aphis gossypii		GI, INS	(Nboyine et al., 2013)
Bemisia tabaci		INS	(Singh, 1996)
Asymmetrasca decedens		IGR	(Ascher et al., 1996)
Dysdercus fasciatus	Heteroptera	IGR	(Ruscoe, 1972)
D. koenigii		INS	(Guddewar et al., 1991)
D. cingulatus		ANT	(Olaifa et al., 1987)
Earias insulana	Lepidoptera	IGR, ANT	(Ascher et al., 1996)
E. vittella		INS,IGR	(Khan Khattak and Rashid, 2006)
Helicoverpa armigera		OPD	
H. armigera		ANT, GDI	(Wondafrash et al., 2012)
H. virescens		ANT,IGR	(Barnby and Klocke, 1990)
Pectinophora gossypiella		INS, RP	(Rafiq et al., 2012)
Spodoptera exempta		INS,IGR	(Tanzubil and McCaffery, 1990)
S. exigua		INS,IGR	(Prabhaker et al., 1986)
S. frugiperda		OPD	(Hellpap and Leupolz, 1999)
S. littoralis		ANT	(Simmonds et al., 1990)
S. litura		INS	(Behera and Satapathy, 1996)
Thrips tabaci	Thysanoptera	INS	(Ahmad et al., 1995)
Frankliniella occidentalis		IGR	(Ascher et al., 1996)
Tetranychus cinnabarinus	Acari	AC	(Tadas et al., 1994)
Pempherulus affinis	Coleoptera	INS	(Tadas et al., 1994)
Myllocerus undecimpustulatus		INS,OPD	(Agrawal, 1990)
Aedes aegypti	Diptera	INS	(Coelho et al., 2009)

OPD: Ovipositional deterrent, IGR, Insect growth regulator, GI: Growth inhibitor, ANT: Antifidant. INS: insecticide, GDI, growth development inhibitor, RP, repellent behavior, AC: Acricidal

Table 2: Treatments plot^{-1} with concentrations

Treatment	Confidor/ bio-pesticide	Concentration
T1	MLE	25% (1/4 v/v, extract: H_2O)
T2	NLE	25% (1/4 v/v, extract: H_2O)
T3	MLE+NLE	25% (1/4 v/v, extract: H_2O)
T4	MLE	50% (2/4 v/v, extract: H_2O)
T5	NLE	50% (2/4 v/v, extract: H_2O)
T6	MLE+NLE	50% (2/4 v/v, extract: H_2O)
T7	Confidor 200SL	250 ml acre^{-1}
T8	Control	

***MLE**= Moringa leaves extract**, NLE**= Neem leaves extract*

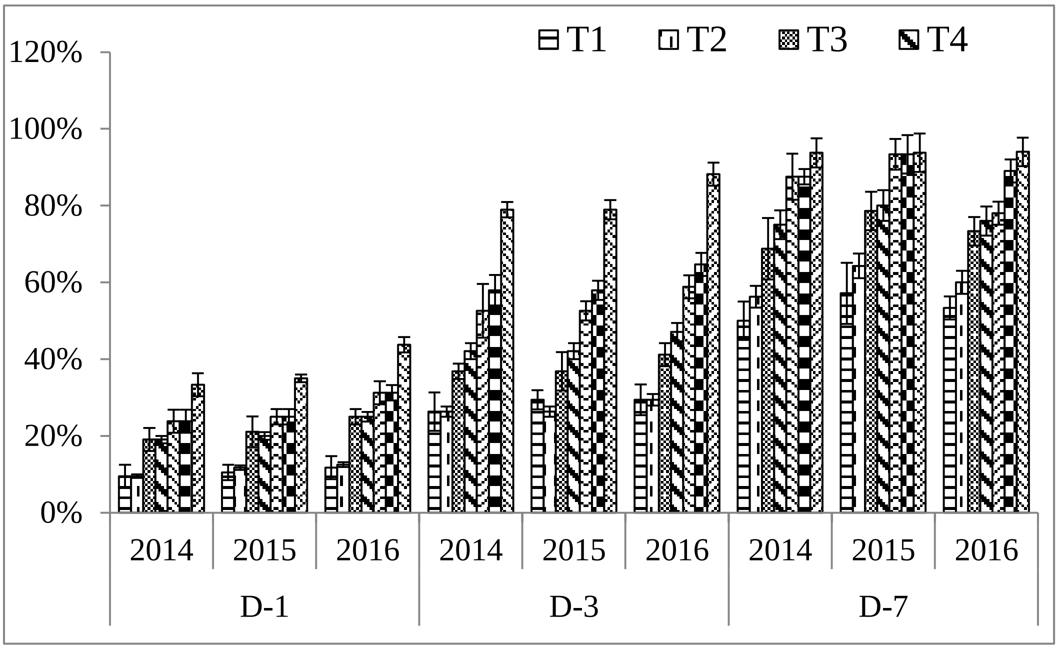

Figure 1: Mean ± SE (Mortality at leaf stage) of a number of aphids on day-1, day-3 and day-7 after application of different treatments of biopesticides and synthetic insecticides at leaf stage of cotton. All treatments with respect to time were significantly different (df: 120, P< 0.05). Results represent the data regarding application of treatments after Day-1, Day-3 and Day- 7

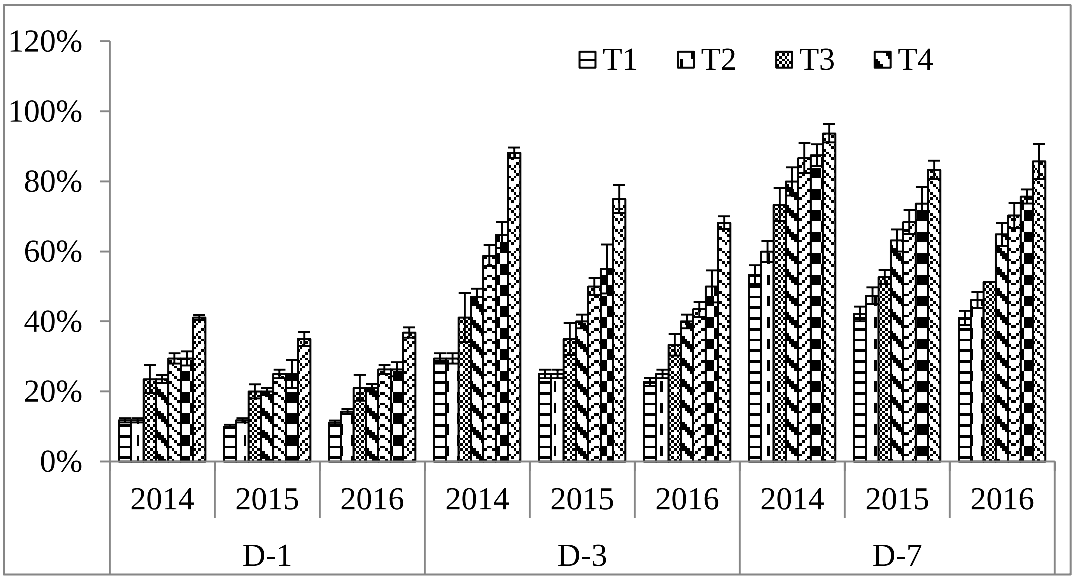

Figure 2: Mean ± SE (Mortality at boll stage) of a number of aphids on day-1, day-3 and day-7 after application of different treatments of biopesticides and synthetic insecticides at boll stage of cotton. All treatments with respect to time were significantly different (df: 120, P< 0.05). Results represent the data regarding application of treatments after Day-1, Day-3 and Day-7.

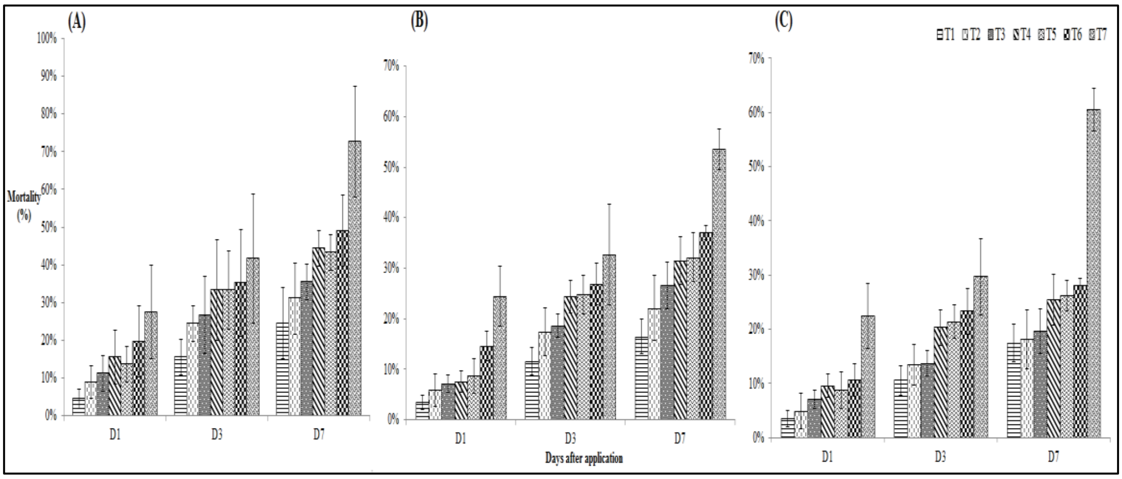

Figure 3: Mean ± SE (Mortality) of the population of the natural enemy at day-1, day-3 and day-7 after application of different treatments of biopesticides and synthetic insecticides at leaf stage of cotton. All treatments with respect to time were significantly different (df: 120, P< 0.05). (A) Indicate represents the number of days after treatment application and (B) represent to hours after treatment applications (C) indicates the control treatment after Day-1, Day-3 and Day-7.

Pre and post-treatment results were subsequently subjected to analysis of variance, and the average values were compared using Tukey's HSD test at a 0.05 significance level.

RESULTS

Mortality (%) of A. gossypi at Leaf Stage

Significant results were observed with the application of plant extracts and Confidor to determine the mortality effects on population dynamics of cotton aphid and beneficial insects.

Pretreatment data were also observed before one day of application. The collected data revealed that the aphid population varied significantly with a concentration of insecticides. All treatments performed better against cotton aphids. Meanwhile, negative impacts were also observed on the population of beneficial insects, particularly on Confidor treated plots.

During 2014, at 1 DPA on leaf stage, Confidor gave excellent results regarding the mortality of cotton aphids compared to all other treatments applied either single (Moringa leaf extract or Neem leaf extract) or double bio-pesticides (Moringa leaf extract + Neem leaf extract) at both concentrations. The highest mortality% of aphids at single pesticide was observed from Confidor: 33% followed by NLE (50% Conc): 24%, MLE (50% Conc): 19%, NLE (25% Conc): 10% and MLE (25% Conc): 10%, whereas with the combination of bio-pesticides, the higher mortality was recorded in NLE+MLE (50% Conc): 24% followed by NLE+MLE (25% Conc): 19%,respectively (Figure 1). According to 3 DPA, Confidor produced excellent regarding the mortality% of cotton aphid as compared to other treatments. According this, the highest mortality% of aphids at single pesticide was observed from Confidor: 79% followed by NLE (50% Conc): 53%, MLE (50% Conc): 42%, NLE (25% Conc): 26% and MLE (25% Conc): 26%, whereas with the combination of bio-pesticides the higher morality was recorded in NLE+MLE (50% Conc): 58% followed by NLE+MLE (25% Conc): 37%, respectively (Figure 1). Likewise, at 7 DPA, Confidor showed 94% of aphid mortality followed by NLE (50% Conc): 88%, MLE (50% Conc): 75%, NLE (25% Conc): 56% and MLE (25% Conc): 50%, whereas with the combination of bio-pesticides the higher morality was recorded in NLE+MLE (50% Conc): 88% followed by NLE+MLE (25% Conc): 69%, respectively (Figure 1). During 2015 and 2016, the same trend of insecticidal impacts was recorded, as shown in Figure 1.

Mortality (%) of A. gossypi at Boll Stage

During the year 2014, results revealed that application of Confidor performed better control as compared to another insecticide on the boll stage of the cotton crop. According this, at 1 DPA, Confidor: 41% followed by NLE (50% Conc): 29%, MLE (50% Conc): 24%, NLE (25% Conc): 12% and MLE (25% Conc): 12%, whereas with the combination of bio-pesticides the higher morality was recorded in NLE+MLE (50% Conc): 29% followed by NLE+MLE (25% Conc): 24%, respectively (Figure 2). According to 3 DPA, Confidor: 88% followed by NLE (50% Conc): 59%, MLE (50% Conc): 47%, NLE (25% Conc): 29% and MLE (25% Conc): 29%, whereas with the combination of bio-pesticides the higher morality was recorded in NLE+MLE (50% Conc): 65% followed by NLE+MLE (25% Conc): 41% respectively (Figure 2). Likewise, at 7 DPA, Confidor showed 94% of aphid mortality followed by NLE (50% Conc): 87%, MLE (50% Conc): 80%, NLE (25% Conc): 60% and MLE (25% Conc): 88%, whereas with the combination of bio-pesticides the higher morality was recorded in NLE+MLE (50% Conc): 73% followed by NLE+MLE (25% Conc): 69%, respectively (Figure 2). Furthermore analysis data showed the similar trend of insecticide efficacy during 2015 and 2016.

Effect of Insecticides on the Population Dynamics of Beneficial Insects at the Mature Stage

Data recorded after the spraying of insecticides on beneficial insects revealed that all the treatments concerning different time intervals were significantly different, overall little or no negative impact on beneficial insects was observed except Confidor insecticide-treated plots. Figure 3 showed that the highest population mortality of beneficial insects was observed at Confidor: 22% application, whereas the significant minimum mortality was recorded among the botanical treated plots such as NLE+MLE (50% Conc): 11%, MLE (50% Conc): 10%, NLE (50% Conc): 9%, NLE+MLE (25% Conc): 7%, NLE (25% Conc): 5% and MLE (25% Conc): 3%. Accordingly, the same trend of aphid mortality was observed on 3 and 7 DPA of insecticides. Overall the results of this study indicated that insecticidal impacts of all treatments between different time intervals profoundly influence the population dynamics of cotton aphids.

DISCUSSION

In this present study, we attempt to explore the effects of Confidor pesticide compared with botanical extract against entomophagous insects and cotton aphids by using the RCBD design. Field observations revealed that Confidor was most effective against cotton aphids. No of aphid's mortality after day-1 of spraying were observed Confidor 33% and 41% applied plots at both leaf and boll stage of the cotton crop respectively. Similar trends of results were observed by Nawaz et al. (2019) and Ali et al. (2016) on the effectiveness of imidacloprid against cotton aphids. Many pest species are affected by imidacloprid just because of the dual-mode of action, such as contact, and systemic effects. Yi et al. (2012) experimented to determine the efficacy of imidacloprid and observed 100% aphids' mortality. The same trend of results was found by Sun et al. (2002) that the seed treatment of imidacloprid increased the grain yield in Russian wheat aphid resistant as well as susceptible wheat cultivars. Gray et al. (1996) found that imidacloprid-treated oat or wheat plants reduced adult longevity and fecundity of three cereal aphid species as compared to non-treated plants.

The results show that the effectiveness of Confidor treated plots may significantly reduce the population builds up of *A. gossypi* over time. At 7 DPA application, all botanical treated plots performed excellently as compared to chemical insecticide applied plots. Meanwhile, the negative effect on the population dynamics of beneficial insects was also observed in Confidor treated plots. The total number of beneficial insect mortality (1.06 % and 1.53 %) was recorded at the leaf and boll stage after day-1 spraying of observation.

Despite the negative effect of Confidor insecticide on the Populations of natural enemies, beneficial insects were significantly higher in the plots treated with botanical pesticides at both concentrations (*M.oleifera* and *A. indica*) 5.06, 17.96 at leaf and boll stage of the cotton crop.

The decrease of the natural enemies in Confidor insecticides shows that this strategy is harmful to natural enemies, while the bio-insecticides safeguard natural enemies (Mancini et al., 2008; Hohmann et al., 2010). The high mobility of the natural foraging enemies makes them more susceptible to pesticides than pests, in particular when pests have a cryptic behavior, like bollworms. Neem extract reaches mainly pests but not natural enemies because the active ingredients in the extracts react only after ingestion. (Sabbahi, 2008) showed that *Beauveria bassiana* is highly pathogenic on sucking bugs (*Lygus lineolaris*) but does not harm certain natural enemies such as Coccinellids.

CONCLUSION

Results of the experiment revealed that all the tested plant extracts have potential value to substitute synthetic insecticides within the framework of long-term sustainable pest management. Further research is needed to test the extracts on another crop, which has a similar pest complex to verify the result obtained in this study and also to determine the efficacy levels of the extracts. The present study recommended that bio-pesticides should be used effectively against *A. gossypii* and subsequently increase the population of natural enemies. Therefore, this study results interpret that these bio-extracts are environmentally friendly and less toxic to natural enemies as compared to other synthetic pesticides and can provide a significant role in the future for controlling pests and reducing the usage of highly toxic pesticides

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable for this section

CONFLICT OF INTEREST

All authors declare no conflict of interests

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REFERENCES

Agrawal I (1990). Ovicidal activity of some phytochemicals on Myllocerus undecimpustulatus Faust (Coleoptera: Curculionidae). Indian. J. Entomol. 52:35-38.

Ahmad F, Khan F, Khan M (1995). Comparative efficacy of some traditional and non-traditional insecticides against sucking insect pests of cotton. Sarhad J. of Agric.24:1-10.

Ahmed S, Qasim M (2011). Foraging and chemical control of subterranean termites in a farm building at Faisalabad, Pakistan. Pak. J. Life Soc. Sci. 9:58-62.

Ali H, Qasim M, Saqib HSA, Arif M, Islam SU (2015). Synergetic effects of various plant extracts as bio-pesticide against wheat aphid (Diurophous noxia L.)(Hemiptera: Aphididae). Afr. J. Agric. Res. 3:310-315.

Ali A, Desneux N, Lu Y, Liu B, Wu K (2016). Characterization of the natural enemy community attacking cotton aphid in the Bt cotton ecosystem in Northern China. Sci. Rep. 6:24273.

Arif MI, Rafiq M, Ghaffar A (2009). Host plants of cotton mealybug (Phenacoccus solenopsis): a new menace to cotton agroecosystem of Punjab, Pakistan. Int. J. Agric. Biol. 11:163-167.

Ascher K, Meisner J, Klein M (1996). Efficacy of commercial neem products against lepidopteran pests, leafhoppers and thrips, and improving homemade preparations by adjuvant. In "A paper presented at the Fifth International Neem Conference", pp. 4-9.

Attle A, Eliheneidy A, El-Kady E (1987). Studies on the aphid, Aphis craccivora in Egypt. Bull. de la societe. Entomol. d'Egypte 66:319-324.

Barnby MA, Klocke JA (1990). Effects of azadirachtin on levels of ecdysteroids and prothoracicotropic hormone-like activity in Heliothis virescens (Fabr.) larvae. J. Insect Physiol. 36:125-131.

Behera U, Satapathy C (1996). Screening indigenous plants for their insecticidal properties against Spodoptera litura Fab. Insect Environ. **2**:43-44.

Brown A (1986). Insecticide resistance in mosquitoes: a pragmatic review. J. Am. Mosq. Control Assoc. **2**:123-140.

Coelho JS, Santos ND, Napoleão TH, Gomes FS, Ferreira RS, Zingali RB, Coelho LC, Leite SP, Navarro DM, Paiva PM (2009). Effect of Moringa oleifera lectin on development and mortality of Aedes aegypti larvae. Chemosphere 77:934-938.

Erler F, Cetin H, Saribasak H, Serttas A (2010). Laboratory and field evaluations of some botanical pesticides against the cedar leaf moth, Acleris undulana. J. pest sci. 83: 265-272.

Fahey JW (2005). Moringa oleifera: A Review of the Medical Evidence for Its Nutritional, Therapeutic, and Prophylactic Properties. Part 1. Trees for life Journal **1**.

Gahukar R (2006). Improving the conservation and effectiveness of arthropod parasitoids for cotton pest management. Outlook Agric. 35: 41-49.

Gray S, Bergstrom G, Vaughan R, Smith D, Kalb D (1996). Insecticidal control of cereal aphids and its impact on the epidemiology of the barley yellow dwarf luteoviruses. Crop Prot. 15: 687-697.

Guddewar M, Shukla A, Pandey S (1991). Assessment of insecticidal and ovicidal properties of Tabornaemontana coronaria against red cotton bug (Dysdercus koenigii). Indian J. entomol. 53: 311-315.

Hellpap C, Leupolz W (1999). Influence of socioeconomic factors on the use of neem insecticides by farmers. Azadirachta indica. 317-322.

Hohmann CL, Silva FA, De Novaes TG (2010). Selectivity of neem to Trichogramma pretiosum riley and Trichogrammatoidea annulata de Santis (Hymenoptera: Trichogrammatidae). Neotrop. Entomol. 39; 985-990.

Hussain D, Ali H, Qasim M, Khan J (2015). Insecticidal susceptibility and effectiveness of Trichogramma chilonis as parasitoids of tomato fruit borer, Helicoverpa armigera. Pak. J. Zool. 47:1427-1432.

Idrees A, Qasim M, Ali H, Qadir ZA, Idrees A, Bashir M, Qinge J (2016). Acaricidal potential of some botanicals against the stored grain mites, Rhizoglyphus tritici. J. Entomol. Zool. 4: 611-617.

Islam W, Qasim M, Noman A, Adnan M, Tayyab M, Farooq TH, Wei H, Wang L (2018a). Plant microRNAs: Front line players against invading pathogens. Microb. Pathog. 118: 9-17.

Islam W, Qasim M, Noman A, Tayyab M, Chen S, Wang L (2018b). Management of Tobacco Mosaic Virus through Natural Metabolites. Rec. of Nat. Prod. 12.

Khan Khattak M, Rashid M (2006). Evaluation of neem (Azadirachta indica Juss) oil, neem seed water extracts and baythroid TM against bollworms and egg parasitoid, Trichogramma chilonis. Pak. Entomol. 28: 5-10.

Makkar H, Becker K (1996). Nutritional value and antinutritional components of whole and ethanol extracted. Moringa oliefera.

Mancini F, Termorshuizen JL, van Bruggen AH (2008). Increasing the environmental and social sustainability of cotton farming through farmer education in Andhra Pradesh, India. Agric. Syst. 96: 16-25.

Morgan JM (1984). Osmoregulation and water stress in higher plants. Annu. Rev. Plant Physiol. 35: 299-319.

Naheed G, Rasul G (2010). Recent water requirement of cotton crop in Pakistan. Pak. J. Meteorol. 6.

Nawaz A, Ali H, Sufyan M, Gogi MD, Arif MJ, Ranjha MH, Arshid M, Waseem M, Mustafa T, Qasim M, Rizwan M (2019). Comparative bio-efficacy of nuclear polyhedrosis virus (NPV) and Spinosad against American bollworm, Helicoverpa armigera (Hubner). Rev. Bras. Entomol. 63(4): 277-282

Nboyine J, Abudulai M, Opare-Atakora D (2013). Field efficacy of neem (Azadirachta indica A. Juss) based biopesticides for the management of insect pests of cotton in Northern Ghana. J. Exp. Biol. Agric. Sci 1: 321-327.

Ohia C, Ana G, Bolaji O (2014). Larvicidal Activity of Aqeous Extract of Moringa oleifera Seeds on Anopheles gambiae and its Effects on Poecilia reticulata. Agrosearch **13**:176-185.

Olaifa JI, Erhun WO, Akingbohungbe A (1987). Insecticidal activity of some Nigerian plants. Int. J. Trop. Insect Sci. **8**:221-224.

Panhwar F (2005). Mediterranean fruit fly (Ceratitis capitata) attack on fruits and its control in Sindh, Pakistan. Digitalverlag GmbH, Germany. Available on World Wide Web at http://www.chemlinde/publications/documents/Mediterranean%5Ffruit% 5Ffly. pdf 24.

Prabhaker N, Coudriet D, Kishaba A, Meyerdirk D (1986). Laboratory evaluation of neem-seed extract against larvae of the cabbage looper and beet armyworm (Lepidoptera: Noctuidae). J. Econ. entomol. 79:39-41.

Prishanthini M, Laxmi V (2009). The Phenococcus solenopsis. Department of Zoology, Eastern University, Sri Lanka.

Qasim M, Husain D, Islam SU, Ali H, Islam W, Hussain M, Wang F, Wang L,Wang CL (2018). Effectiveness of Trichogramma chilonis Ishii against spiny bollworm in Okra and susceptibility to insecticides. J. Entomol. Zool. 6:1576-1581.

Qasim M, Hussian D (2015). Efficacy of insecticides against citrus psylla (Diaphorina citri Kuwayama) in field and laboratory conditions. Cercetari Agronomice in Moldova 48:91-97.

Qasim M, Lin Y, Fang D, Wang L (2015). Termites and microbial biological control strategies. South Asia J. Multidiscip. Stud. 1:1-27.

Rafiq M, Dahot MU, Naqvi SH, Mali M, Ali N (2012). Efficacy of neem (Azadirachta indica A. Juss) callus and cells suspension extracts against three lepidopteron insects of cotton. J. Med. Plants Res. 6: 5344-5349.

Ruscoe CN (1972). Growth disruption effects of an insect antifeedant. Nature 236:159-160.

Sabbahi R (2008). Utilisation du champignon entomopathogène Beauveria bassiana dans une stratégie de gestion phytosanitaire des principaux insectes ravageurs en fraiseraies, Université du Québec, Institut National de la Recherche Scientifique.

Sharma PK, Joshi PC (2010). Feeding potential of seven spotted ladybeetle, Coccinella septumpunctata (Linnaeus) on mustard aphid, Lipaphis erysimi (Kaltenbach) and cotton aphid, Aphis gossypii (Glover). Nat. Sci. 8:198-202.

Simmonds M, Blaney W, Ley S, Anderson J, Toogood P (1990). Azadirachtin: structural requirements for reducing growth and increasing mortality in lepidopterous larvae. Entomol. Exp. Appl. 55: 169-181.

Singh K (1996). Potential of neem for insect pest management. Pestology. **20**: 29-33.

Sun C, Zhang Q, Xu J, Wang Y, Liu J (2002). Effects of transgenic Bt cotton and transgenic Bt+CpTI cotton on population dynamics of main cotton pests and their natural enemies. Acta Entomol. Sin. 46: 705–712

Tadas P, Kene M, Deshmukh S (1994). Effect of raw cotton seed oil against sucking pests of cotton. Pak. Res. J. 18: 142-143.

Tanzubil PB, McCaffery AR (1990). Effects of azadirachtin and aqueous neem seed extracts on survival, growth and development of the African armyworm, Spodoptera exempta. Crop Prot. 9: 383-386.

Walter JF, (1999). Commercial experience with neem products. Biopesticides: use and delivery. 155-170.

Wondafrash M, Getu E, Terefe G (2012). Neem, Azadirachta indica (A. Juss) extracts negatively influenced growth and development of African Bollworm, Helicoverpa armigera (Hubner)(Lepidoptera: Noctuidae). Academic J. Entomol. 5: 22-27.

Yi F, Zou C, Hu Q, Hu M (2012). The joint action of destruxins and botanical insecticides (rotenone, azadirachtin and paeonolum) against the cotton aphid, Aphis gossypii Glover. Mol. 17, 7533–7542.