Research Article

Ecofriendly Management of Green Pea (*Pisum sativum* L.) Insect Pests through Plant Extracts

Riaz Hussain[1*], Adnan Ihsan[2], Azaz Ali Shah[2], Najeeb Ullah[2], Hamza Iftikhar[3] and Ranra Jalal[4]

[1]Department of Entomology, The University of Agriculture, Swat, Pakistan, Pakistan; [2]Department of Entomology, The University of Agriculture Peshawar, Pakistan, Pakistan; [3]Department of Agriculture, Bacha Khan University, Charsadda, Pakistan; [4]Department of Weed Science and Botany, The University of Agriculture Peshawar, Pakistan 25100 Pakistan.

Abstract | Plant extracts appear as promising biorational alternatives to hazardous synthetic insecticides. This research was carried in a farmer's field in Malam Jaba (Swat, KPK) during 2019-2020 Rabi season to evaluate the efficiency of some selected botanical extracts against the key insect pests of green pea (*Pisum sativum* L.) and their effect on yield/cost benefit ratio. The randomized complete block design (RCBD) was followed with 9 treatments and a control each replicated thrice. Treatments including the extracts of garlic bulb (*Allium sativum*) @ 2%, tobacco dry leaves (*Nicotiana tabacum)* @ 2%, red chili (*Capsicum* spp.*)* @ 5% and Chinaberry dry fruits (*Melia azedarach)* @ 10% concentrations were used singly and tobacco dry leaves (*N. tabacum)* + Chinaberry dry fruits (*M. azedarach)* @ 1% + 5%, garlicbulb (*A. sativum*) + Red chili(*Capsicum* spp.) @1% + 2.5%, tobacco dry leaves (*N. tabacum)* + Red chili (*Capsicum* spp.*)* @ 1%+2.5%, and garlic bulb (*A. sativum*)+ Chinaberry dry fruits (*M. azedarach)* @ 1%+2.5% were used in combination as treatments. The results showed that Chinaberry dry fruits (*M.azedarach*) caused highest percent decrease of leafminer (71.92 %), followed by the combination of garlic bulb (*A.sativum*) + red chili (*Capsicum* spp.) (59.98 %), and tobacco dry leaves (*N.tabacum*) + Red chili (*Capsicum* spp.) (33.32 %). The plot treated with Chinaberry dry fruits (*M.azedarach*) caused the least amount of pod borer damage (10.10 %), followed by the combination garlic bulb (*A.sativum*) + red chili (*Capsicum* spp.) (13.63 %), while the control plot caused most of the pod borer damage (44.25 %). The Chinaberry dry fruits (*M.azedarach*) plot had the highest yield of 3333.3 kgha^{-1}. Chinaberry dry fruits (*M.azedarach*) had the lowest cost with the highest production in the form of yield at 1:45. This research will serve as an important step towards developing sustainable pesticide management strategies in the future to increase production while reducing control costs and environmental impact.

Received | May 04, 2022; **Accepted** | June 28, 2022; **Published** | October 05, 2022
***Correspondence** | Riaz Hussain, Department of Entomology, The University of Agriculture, Swat, Pakistan, 19120 Pakistan; **Email:** riazhussain4343@gmail.com
Citation | Hussain, R., A. Ihsan, A.A. Shah, N. Ullah, H. Iftikhar and R. Jalal. 2022. Ecofriendly Management of Green Pea (*Pisum sativum* L.) Insect Pests through Plant Extracts. *Sarhad Journal of Agriculture,* 38(4): 1405-1411.
DOI | https://dx.doi.org/10.17582/journal.sja/2022/38.4.1405.1411
Keywords | Botanicals, Green pea, Insect pests, Chinaberry, Garlic, Tobacco, Red chili, Swat

Introduction

Pea (*Pisum sativum* L.) belongs to family Fabaceae and is an important winter vegetable crop being cultivated in most tropical and sub-tropical countries (Khan *et al*., 2013). It is a rich source of carbohydrate, proteins, sugar, amino acid, vitamins A and calcium, phosphorus and iron. It helps in food, feed and cash to the producers and play an important part in biological nitrogen fixation and soil fertility (Ali *et al*., 2005). According to MNFSR (2018-19), the total area under cultivation of pea crop in Pakistan is 24.854 hectares with a total production of 170,836 tons. In Khyber Pakhtunkhwa province, the area under pea cultivation is 1.959 hectare while the total production of pea crop is 15.789 tons. However, per unit area production of pea crop in Pakistan is far less than other pea producing countries. Some factors are responsible for this low production of pea crop including poor cultural practices, little weed control and high pest and disease attack are significant one (Khan *et al*., 2013).

Many insect pests attack on pea crop. For instance, pod borer (*Helicoverpaarmigera)*, stem fly (*Melanagromyzaphaseoli*), leafminer (*Phytomyzahorticola*), aphids (*Acyrthosiphonpisum*) and thrips (*Caliothrips indicus* Bagnall) are the serious insect pests (Yadav *et al*., 2019). In pea growing areas leafminer *P. horticola*is a serious pest. The larvae make galleries or mines in the leaf tissue of the epidermal layer and mostly attack newly emerged leaves (Kirichenko *et al*., 2018). Similarly, two species of pod borer *i.e. Etiellazinckenella* and *H. armigera*can damage the pods of the pea plants. Sometime the caterpillars can damage the flowers and make holes on the pods and feed on the seeds inside pods (Wadaskar *et al*., 2013).

Botanical extracts are very useful for the initial stages of the insect pests, as botanical extracts have advantage to be less harmful for human health, eco-friendly, safe to natural enemies and other non-target fauna. These are promising alternatives to synthetic pesticides as most of the botanical extracts have low toxicity to mammalian (Rizvi *et al*., 2015). Plant extracts have specific mode of action against target species (Duke *et al*., 2003) and have less toxic to other vertebrates and invertebrates. Variable volumes of components, as well as concentrations and ratios of active chemicals, can all have an influence on the efficacy of plant-based biological insecticides. Many studies have demonstrated the effectiveness of different plant extracts against a wide array of insect pest species (Majeed *et al*., 2018; Isman (2020); Akbar *et al*., 2021). Employing homemade pesticides would cut food production losses and allow us to utilize environmentally acceptable pest control approaches (Iqbal *et al*., 2021), The current study was carried out with the goals of evaluating some selected local botanical extracts alone and in combination against pea insect pests.

Materials and Methods

The experiment was conducted at a farmer's field in the hamlet of Shaltalo in 2019-2020. During the Rabi season, use the Climax pea variety.

Experimental design

During 2019-2020, the bio efficacy of many local plant extracts, both alone and in combination, was studied against insect pests of pea crop in farmer fields in Malam Jabba Swat. The pea variety Climax was seeded under RCBD design. The plot size was maintained at 43 m^2 with 9 treatments and a control, each of which was repeated three times. Plant-to-plant distance was maintained as 10 cm, while row-to-row distance was 50-60 cm.

Preparation of plant extracts

Extract of red chili (*Capsicum* spp.): The technique of (Reddy *et al*., 2013) was used to prepare red chili extract (RCE). About 25g of fresh red chilies was crushed and mixed with 500ml hot water and 2ml mustard oil and was kept at room temperature for 24 hours. Capsaicin's solubility was increased by the addition of oil. After 24 hours, the remaining 500ml of water was added. This mixture was filtered and about 6ml of dishwashing liquid was added to act as a binding agent. To get the field solution, the mixture was strained using a fine cloth (Fatima *et al*., 2015).

Extract of garlic (*A. sativum*) bulb: About 20 g of dried garlic bulb was ground, added in 20ml of water and was kept at room temperature for 24 hours. The solution was diluted up to 20ml in 1 liter of water to get the formulation ready for application in the field (Sohail *et al*., 2012).

Extract of tobacco (*N. tabacum*): Dried tobacco leaves weighing 30 g were groundand were added in 200ml of water and kept for 24 hours before being filtered, then one liter of solution ready for field application

was prepared from the stock solution (Sohail *et al.*, 2012).

Extract of Chinaberry fruits (*M. azedarach*): About 200 g of Chinaberry dry fruits were ground and steeped for 48 hours at room temperature in 1 liter of distilled water. The solution was filtered and obtained for use in the field (Hammad *et al.*, 2000; Jazzar *et al.*, 2003; Banchio *et al.*, 2003).

Parameters studied

Leafminer (*P. horticola*): For each replication, five plants were chosen at random from each plot, and five leaves were chosen at random from each plant. Data on larvae per leaf were collected 24 hours before and after the application of botanicals at the frequency of 1, 2, 3, 7, and 14 days intervals. A total of four sprays were administered to the pea crop, with the first, second, and third sprays targeting pea leafminer and the fourth spray targeting pea pod borer. Using Abbot's formula (1925), the percentage reduction in pea leaf miner population was calculated.

$$\%\text{Reduction} = \frac{1-(\text{Post treatment pop.in treated plots})\times(\text{Post treatment pop.in control})}{(\text{Pretreatment pop.in treated plots})\,(\text{Pretreatment pop.in control})} \times 100$$

Pod borer (*H. armigera*): Ripened pea pods were collected randomly from five plants for each treatment for pod borer infestation, and sound pods were isolated from damaged and tallied. With a break of ten days, total of 3 pickings were made from the experimental plot. The following formula was used to convert the recorded data into percent damage.

$$Percent\ pod\ borer\ damage = \frac{Total\ number\ of\ damaged\ pods\ per\ five\ plant}{Total\ number\ of\ pods\ per\ five\ plants} \times 100$$

Crop yield (kg/ha)

After each pod plucking, the weight (kg) in each treatment was recorded. Yield of each treatment was converted to kg per hectare using the formula:

$$Yield\ kg\ per\ ha = \frac{Pods\ weight\ (kg)}{Area\ harvested\ (m2)} \times\ 10000$$

Cost Analysis

Cost of control in relation to its benefit was determined using the approach developed by Usman *et al.* (2015), to determine the most effective treatments in terms of cost benefit ratio using the formula.

$$C.B.R = \frac{estimated\ net\ benefit}{total\ expenditure}$$

Statistical analysis

Analysis of variance was used to analyze the data regarding pest infestation and damage, and treatment means were separated using the post-hoc Least Significant Difference (LSD) test at a 5% level of significance or probability.

Results and Discussion

Study initiated to evaluate the efficacy of botanicals in ecofriendly management of pea leaf miner was initiated at Malam Jaba area of District Swat. Among the tested botanicals singly and in combination, it was found that all the botanical extracts were found to have a substantial influence on the pea leaf miner population, pea pod percent damage, and yield kgha^{-1} in the study.

Percent reduction of pea leaf miner infestation

Data on the means percent decrease over control at five leaves per five plants for each treatment in the first, second, and third sprays were collected. The results in Table 1 show that, the mean percent population of pea leaf miner decreases between 1, 2, 3, 7, and 14 days after first application of experimental plots with the respective botanical treatments. The maximum mean percent reduction of pea leaf miner was recorded in plots treated with chinaberry (64.33), followed by tobacco+red chili (48.49), which was non-significant to red chili, tobacco, garlic, and garlic+redchilli 47.66, 45.08, 43.83, 43.73 respectively, followed by tobacco+chinaberry (37.47). The lowest mean percent reduction was recorded in garlic+chinaberry (23.73).

The mean percent reduction of pea leaf miner after 1, 2, 3, 7, and 14 days shows difference after the second spray treatment (Table 2). Chinaberry had the highest mean percent reduction (73.80), followed by tobacco+red chili (65.09), red chili (59.69), and tobacco, garlic, tobacco+chinaberry, garlic+red chili (57.55, 57.34, 55.06, 54.74), all of which were statistically similar, while garlic+chinaberry had the lowest mean percent reduction.

Mean percent reduction in the population of pea leaf miner after the third spray treatment on above mentioned frequency of days was observed (Table 3). It was observed that the maximum mean percentreduction was recorded in plots treated with chinaberry (77.79), followed by tobacco+redchilli (66.37), red chilli, garlic, tobacco, tobacco+chinaberry

Table 1: *Percent reduction of pea leafminer (Phytomyzahorticola) infestation after 1st spray of different botanical extracts during 2019-20.*

Treatment	% Reduction after 1st spray at different days					Mean
	1 day	2days	3 days	7 days	14 days	
Garlic	31.04d	43.24c	57.62cd	49.17 cd	38.41 c	43.83bc
Tobacco	27.84e	45.18c	68.24 b	51.27 c	32.87 d	45.08 b
Red Chili	36.11c	43.69c	70.48 b	55.76 b	33.58 d	47.66 b
Chinaberry	44.74a	58.26a	85.81 a	81.71 a	51.61 a	64.33 a
Tobacco + chinaberry	24.16f	34.10d	48.33e	45.51 ef	35.29 d	37.47 c
Garlic + red chili	35.07c	44.79c	56.74d	43.35 f	39.02 c	43.73bc
Tobacco +red chili	38.24b	52.77b	61.42 c	47.50 de	42.56 b	48.49 b
Garlic + chinaberry	15.66g	31.61d	35.83 f	16.56 g	19.28 e	23.73 d
LSD Value	1.90	2.71	4.29	2.70	2.85	7.60

Means followed by same letters within a column are not significantly different at 5% level of significance (LSD test).

Table 2: *Percent reduction of pea leafminer (Phytomyzahorticola) infestation after 2nd spray of different botanical extracts during 2019-20.*

Treatment	% Reduction after 2nd spray at different days					Mean
	1 day	2days	3 days	7 days	14 days	
Garlic	47.92d	58.27d	70.37de	58.62c	51.90b	57.34 cd
Tobacco	51.80c	62.92c	73.83cd	55.71 c	43.54cd	57.55 cd
Red Chili	56.65b	68.26b	77.38bc	58.01c	39.68 de	59.69 c
Chinaberry	64.78a	80.62a	91.34 a	73.95 a	58.46 a	73.80 a
Tobacco + chinaberry	46.57d	57.90d	68.83e	54.77c	47.43 bc	55.06 cd
Garlic + red chili	53.26c	59.03cd	68.66e	56.07c	36.67e	54.74 d
Tobacco +red chili	20.50f	70.40b	79.30b	67.74 b	52.21 b	65.09 b
Garlic + chinaberry	38.59e	52.47e	57.18f	42.00d	29.18 f	43.88 e
LSD Value	3.35	3.65	4.59	5.23	4.84	4.34

Means followed by same letters within a column are not significantly different at 5% level of significance (LSD test).

Table 3: *Percent reduction of pea leafminer (Phytomyzahorticola) infestation after 3rd spray of different botanical extracts during 2019-20.*

Treatment	% Reduction after 3rd spray at different days					Mean
	1st day	2nd days	3rd days	7th days	14th days	
Garlic	62.01b	72.19b	83.01cd	54.98 d	39.15 c	61.82 bc
Tobacco	56.86cd	63.27d	85.31bc	55.02 d	36.90 c	59.31 cd
Red Chili	63.28 b	72.84b	81.52d	62.77 c	38.13 c	63.63 bc
Chinaberry	77.77a	85.86a	96.57 a	75.98 a	53.32 a	77.79 a
Tobacco + chinaberry	57.64 c	67.94c	71.86 e	46.92 e	31.29 d	55.07 d
Garlic + red chili	44.44 e	57.36e	63.25 f	41.31 f	23.08 e	45.41 e
Tobacco +red chili	53.09 d	74.77b	88.11 b	67.98 b	47.98 b	66.37 b
Garlic + chinaberry	36.74 f	39.81f	45.15 g	26.68 g	13.52 f	32.37 f
LSD Value	4.17	3.14	3.67	3.70	3.34	5.36

Means followed by same letters within a column are not significantly different at 5% level of significance (LSD test)

Table 4: *Percent damage caused by pea pod borer (Helicoverpaarmigera) infestation in pea crop treated with different botanical extracts during 2019-20.*

Treatment	% Damage by pea pod borer			Mean
	1st picking	2nd picking	3rd picking	
Garlic	28.43 b	30.00 b	26.90 b	28.44 b
Tobacco	22.40 de	20.43 e	17.86 d	20.23 bcd
Red Chili	23.50 d	24.40 d	22.20 c	23.36 bc
Chinaberry	14.50 g	10.43 i	5.36 h	10.10 e
Tobacco + chinaberry	22.46 de	18.43 g	15.96 e	18.95 cd
Garlic + red chili	21.70 e	19.50 f	15.23 e	18.81 cd
Tobacco +red chili	16.20 f	14.33 h	10.36 g	13.63 de
Garlic + chinaberry	26.60 c	27.43 c	13.93 f	22.65 bc
Control	35.63 a	41.367 a	55.76 a	44.25 a
LSD Value	1.41	0.41	1.04	8.66

Means followed by same letters within a column are not significantly different at 5% level of significance (LSD test).

Table 5: *Cost benefit ratio of different botanical extracts applied against major insect pests of green pea.*

Treatments	Yield kg/ha A	Gross income Rs. B	Cost of control C	Return over control D	Estimated net benefit (Rs. ha^{-1}) E=(D-C)	C: B F=(E/C)
Garlic	2,731.50	218,520.00	2,867.13	85,184.00	82,316.87	28.71
Tobacco	2,407.40	192,592.00	3,041.13	59,256.00	56,214.87	18.48
Red chili	2,314.80	185,184.00	2,845.13	51,848.00	49,002.87	17.22
Chinaberry	3,333.30	266,664.00	2,845.13	133,328.00	130,482.87	45.86
Tobacco+chinaberry	2,592.60	207,408.00	2,867.13	74,072.00	71,204.87	24.83
Garlic+red chili	2,592.60	207,408.00	2,977.13	74,072.00	71,094.87	23.88
Tobacco+red chili	2,963.00	237,040.00	3,047.13	103,704.00	100,656.87	33.03
Garlic+chinaberry	2,129.60	170,368.00	3,007.13	37,032.00	34,024.87	11.31
Control	1,666.70	133,336.00	-	-	-	-

Means followed by same letters within a column are not significantly different at 5% level of significance (LSD test)

(63.63, 61.82, 59.31, 55.07) respectively. They were statistically insignificant with each other. However, minimum mean percent reduction was recorded in garlic+red chili (45.41), and garlic+chinaberry (32.37). After all the three spray treatments in treated plots, Chinaberry was the most effective in suppressing pea leaf miner population. The findings are consistent with those of Jazzar *et al.* (2003), Ghanim *et al.* (2014), Mckenna *et al.* (2014) and Magersa, (2016).

Percent damage of pea pod borer

Various herbal preparations were utilized to combat the pea pod borer. Variation in pod damage was detected in the first, second, and third pickings (Table 4). The lowest mean percent pod damage was observed in chinaberry (10.10) treated plots, followed by tobacco+red chili, garlic+red chili, tobacco+red chili, red chili, tobacco 13.63, 18.81, 18.95, 23.36, 20.23 respectively, which was statistically insignificant, followed by garlic (28.44). The highest mean percent pod damage was observed in control with pod damage of 44.25. In comparison to the control plot, all botanical extracts reduced the percentage of pod damage in pea plants. Reduced pea pod damage had a direct impact on crop output.

Among all the treated plots, Chinaberry treated plot had the highest yield (3,333.30) kgha^{-1} which was substantially greater than the control plot (1,666.70) kgha^{-1}. It was further discovered that there was reduced pod damage and a greater pea yield. These findings are in line with those of Kumara *et al.* (2018), Sharma *et al.* (2009) and Thulasiraman *et al.* (2020).

Cost benefit ratios

The farmer's goal is to make more money from his

crops. Cost-benefit ratios were used to observe benefit obtained from the treated plots against the pea leaf miner and pod borers. According to Table 5, the greatest CB ratio was found in plots treated with chinaberry (1:45.86), while the lowest was found in garlic+chinaberry (1:11.31) treated plots, while the remaining CB ratios computed were tobacco+red chili, garlic, tobacco+chinaberry, garlic+red chili, tobacco, red chili (1:33.03, 1:28.71, 1:24.83, 1:23.88, 1:18.48, 1:17.22).

Conclusions and Recommendations

According to the findings of this study, Chinaberry extract decreased leafminer infection, reduced pod damage, with a high commercial yield and net return. Hence, it is concluded that this local botanical extract has the ability to suppress these pea pests. The current investigation discovered that cost of control of pests were affected by the expense of pesticides. Chinaberry was the least priced and most efficient pesticide among all plant extracts tested. Hence, Chinaberry is recommended for safe and effective treatment of pea leaf miner and pea pod borer at Malam Jaba, Swat. Further research is needed to determine whether these extracts can be used alone or in conjunction with other natural enemies, predators, parasitoids to combat leaf miner and pod borer infestation in pea crop.

Acknowledgements

The authors are thankful to Syed Fahad Shah (Department of Entomology, The University of Agriculture, Peshawar-Pakistan) and Dr. Muhammad Usman (Assistant Manager-Technical Solution KP, Syngenta) for providing literature and other information.

Novelty Statement

The study is novel in describing the use of plant extracts as an alternative to pesticides which are friendly to environment, human health and biocontrol.

Conflict of interest

The authors have declared no conflict of interest.

Author's Contribution

Riaz Hussain: Did the experiment and wrote the article

Adnan Ihsan: Supervised overall activities and helped in proofreading of the article.

Adnan Ihsan, Azaz Ali Shah, Najeeb Ullah, Hamza Iftikhar and Ranra Jalal: Provided technical support.

References

Abbott, S.W. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Ent., 18:265-267. https://doi.org/10.1093/jee/18.2.265a

Akbar, M.S., F. Sajjad, M. Afzal, M. Luqman, M.A. Riaz and M.Z. Majeed. 2021. Field evaluation of promising botanical extracts, plant essential oils and differential chemistry insecticides against subterranean termites *Odontotermesobesus* (Isoptera: Termitidae). Sarhad J. Agric., 37(1): 120-127. https://doi.org/10.17582/journal.sja/2021/37.1.120.127

Ali, K.S. and L. Swart. 2005. Component and Mechanisms of Resistance in Selected field pea Lines to pea Aphid (*Acyrthosiphonpisum* Harris). Pest Mgt. J. Ethiopia, 9: 17-27. https://doi.org/10.1079/IJT200566

Anonymous. 2018- 2019. Agricultural Statistics of Pakistan. Ministry of national food security and research. Government of Pakistan, Islamabad. 1-10.

Banchio, E., G. Valladares, M. Defag, S. Palacios and C. Carpinella. 2003. Effects of *Melia azedarach* (Meliaceae) fruit extracts on the leaf miner *Liriomyzahuidobrensis* (Diptera, Agromyzidae): Assessment in laboratory and field experiments. Ann. Appl. Biol. 143:187-193. https://doi.org/10.1111/j.1744-7348.2003.tb00285.x

Duke, S.O., S.R. Baerson, F.E. Dayan, A.M. Rimando, B.E. Scheffler, M.R. Tellez, D.E. Wedge, K.K. Schrader, D.H. Akey, F.H. Arthur, A.J. De Lucca, D.M. Gibson, H.F. Harrison, J.K. Peterson, D.R. Gealy, T. Tworkoski, C.L. Wilson and J.B. Morris. 2003. United States Department of Agriculture- Agricultural Research Service research on natural products for pest management. Pest Mgt. Sci., 59: 708–717. https://doi.org/10.1002/ps.633

Fatima, K., T. Lovejoy and K. Wisdom. 2015. Efficacy of Garlic (*Allium sativum*) and Red Chilli Pepper (*Capsicum annum*) Extracts in the Control of Red Spider Mite (*Tetranychusurticae*) in Tomatoes (*Lycopersicon esculentum*). Asia. J. Appl. Sci., 3(1): 2321- 0893.

Ghanim, M., Nabil and S.B.A. Ghani. 2014. Controlling *Tutaabsoluta* (Lepidoptera: Gelechii-

dae) and *Aphis gossypii* (Hemiptera: Aphididae) by aqueous plant extracts. Life Sci. J., 11(3): 299-307.

Hammad, A.F., N.M. Nemer, Z.K. Haw and L.T. Hanna. 2000. Responses of the sweet potato whitefly, *Bemisiatabaci*, to the china-berry tree (*Melia azedarach* L.) and its extracts. Ann. appl. Bid., 137: 79-88. https://doi.org/10.1111/j.1744-7348.2000.tb00039.x

Iqbal, T., N. Ahmed, K. Shahjeer, S. Ahmed, K.A. Al-Mutairi, H.F. Khater and R.F. Ali. 2021. Botanical insecticides and their Potential as Anti-Insect/Pests: Are they successful against Insects and Pests? In Global Decline of Insects. IntechOpen. https://doi.org/10.5772/intechopen.100418

Isman, M.B. 2020. Botanical insecticides in the twenty-first century—fulfilling their promise? Ann. Rev. Entomol., 65: 233-249. https://doi.org/10.1146/annurev-ento-011019-025010

Jazzar, C. and A.F. Hammad. 2003. The efficacy of enhanced aqueous extracts of *Melia azedarach* leaves and fruits integrated with the *Camptotylusreuteri* releases against the sweet potato whitefly nymphs. Bull. Insectol., 56(2): 269-275.

Khan, T.N., A. Ramzan, G. Jillani and T. Mehood. 2013. Morphological performance of peas (*Pisum sativum*) genotypes under rainfed conditions of Potohar region. J. Agric. Res., 51(1): 51-60.

Kirichenko, N., S. Augustin and M. Kenis. 2018. Invasive leafminers on woody plants: A global review of pathways, impact, and management. J. Pest Sci., 92: 93-106. https://doi.org/10.1007/s10340-018-1009-6

Kumara, A.K.M. and T. Ruchira. 2018. Bio-efficacy of fruit extracts against gram pod borer *Helicoverpaarmigera* (Hubner) in chickpea. J. Entomol. Zool. Stud., 6(5): 2360-2364.

Majeed, M.Z., M.I. Nawaz, R.R. Khan, U. Farooq and C.S. Ma. 2018. Insecticidal effects of acetone, ethanol and aqueous extracts of *Azadirachta indica* (A. Juss), *Citrus aurantium*(L.), *Citrus sinensis* (L.) and *Eucalyptus camaldulensis* (Dehnh.) against mealybugs (Hemiptera: Pseudococcidae). Trop. Subtrop. Agroecosyst., 21(3): 421-430.

Mckenna. M.M., E.M.A.F. Hamad and M.T. Farran. 2013. Effect of *Melia Azedarach* (Sapindales: Meliaceae) Fruit extracts on citrus leafminer, *Phyllocnistiscitrella* (lepidoptera: Gracillariidae) springer plus. 2: 144. https://doi.org/10.1186/2193-1801-2-144

Megersa, A. 2016. Botanicals extracts for control of pea aphid (*Acyrthosiphonpisum*, Harris). J. Entomol. Zool. Stud., 4(1): 623-627.

Reddy, M.V.B. and P. Sasikala. 2013. Capsaicin and colour extraction from different varieties of green and red chilli peppers of Andhra Pradesh. Int. J. Adv. Sci. Tech. Res., 2: 554-572.

Rizvi, S.A.H., S. Hussain, S. Rehman, S. Jaffar and M.F. Rehman. 2015. Efficacy of ecofriendly botanical extracts of Ginger (*Zingiber officinale*), Garlic (*Allium sativum*) and Tobacco (*Nicotiana tabacum* L.) for the control of cabbage looper (*Trichoplusiabinotalis*) under agro ecological conditions of Peshawar, Pakistan. J. Entomol. Zool., 4(1): 88-90

Sharma, A. and R. Gupta. 2009. Biological activity of some plant extracts against *Pieris brassicae* (Linn.). J. Biopest., 2(1): 26-31.

Sohail, A., F.S. Hamid, A. Waheed, N. Ahmed, N. Aslam, Q. Zaman, F. Ahmed and S. Islam. 2012. Efficacy of different botanical Materials against aphid *Toxoptera Aurantii* on tea (*Camellia sinensis* L.) cuttings under high shade nursery. J. Mater. Environ. Sci., 3(6): 1065-1070.

Thulasiraman, M., K. Raguvaran, M. Kalpana and R. Maheswaran. 2020. Green synthesis of silver nanoparticle using *Leonotisnepetifolia* and their toxicity against vector mosquitoes of *Aedes aegypti* and *Culex quinquefasciatus* and agricultural pests of *Spodoptera litura* and *Helicoverpaarmigera*. Environ. Sci. Pollut. Res., 27: 43103-43116. https://doi.org/10.1007/s11356-020-10127-1

Usman, A., I.A. Khan and M. shah. 2015. Evaluation of some selected IPM modules for the management of tomato fruit worm (*Helicoverpaarmegera Hub*). J. Entomol. Zool. Stud., 3(4): 379-382.

Wadaskar, R.M., S.K. Bhalkare and A.N. Patil. 2013. Field efficacy of newer insecticides against pod borer complex of pigeonpea. J. Food Legumes, 26(1-2): 62-66. http://eprints.icrisat.ac.in/id/eprint/12587

Yadav, A., V. Singh, A. Yadav and H. Singh. 2019. Studies on succession of insect pest complex associated with pea at Bikaner. J. Entomol. Zool. Stud., 7(3): 1606-1608.