Physical Education, Health and Social Sciences

https://journal-of-social-education.org

E-ISSN: 2958-5996

P-ISSN: 2958-5988

Efficacy of Different Botanicals for the Management of Peach Fruit Fly (Diptera: Tephritidae) under Laboratory Conditions

Asad Ullah[1], Kamran Sohail[2], Shabir Ahmed[3], Aleena Jalal[4], Abdul Basit[5] Muhammad Wasim[6]

[1,2,4] Department of Entomology, The University of Agriculture Peshawar – Pakistan
[3] Department of Plant Protection, The University of Agriculture Peshawar – Pakistan
[5] Department of Entomology, Bahauddin Zakaria University Multan – Pakistan
[6] Department of Agricultural Engineering, University of Engineering & Technology, Peshawar – Pakistan
Corresponding Author E-mail: aleenajalal60@gmail.com

DOI: https://doi.org/10.63163/jpehss.v3i3.590

Abstract

The peach fruit fly (Bactrocera zonata (Saunders)) poses significant challenges to fruit production, necessitating effective management strategies. The research study was conducted to evaluate the efficacy of selected botanical extracts in controlling B. zonata under labortory conditions in Plant Protection Division of NIFA, Peshawar, Pakistan during, 2024. Botanical extracts, including neem (Azadirachta indica), tobacco (Nicotiana tabaccum), garlic (Allium sativum), and bakain (Melia azedarach) were used to determine the repellency, deterrence and insecticidal properties against fruit fly. Results revealed that botanical treatments effectively reduced the peach fruit fly population, with Neem showing the most significant impact. Results further revealed that Bakain exhibited the highest percent non-preference (49.8%), while Neem showed lower percent non-preference (37.6%), indicating its least effectiveness in inducing non-preference behaviour in peach fruit fly. The mean pupal weight was lowest in tobacco (1.00gm), while its length was observed lowest in garlic, tobacco and neem all measuring 0.33cm. Pupal duration (11.3 days), pupal mortality (58%) and pupation inhibition (73.0%) was highest for Neem extract, corresponding to the lowest percent pupation (21.2%), while Bakain resulted in lowest pupal duration (7.6 days), pupal mortality (26.6%) and Garlic extract in pupation inhibition (52.4%) with corresponding highest percent mean pupation of 32.0%. A reduced adult emergence and longevity in peach fruit flies was observed in Neem with 7.3% and 7.3 days respectively. Bakain caused maximum adult emergence (17.3%), and control resulted in slightly higher longevity (32.6 days). The ovipositional deterrence and adult mortality were maximum (57.6% and 68.3%) for Neem, while lowest in Garlic and control (36.0% and 15%) respectively. Neem influenced sex ratio, often resulting in higher female proportions under treated conditions. It was concluded that Tobacco, Garlic and Bakain should be prioritized for their effectiveness in inducing non-preference behaviour and reducing pupal weight in peach fruit fly management, while the later demonstrated a preferred choice in repelling B. zonata. Neem is recommended with the primary goal to enhance mortality rates in peach fruit fly populations.

Introduction

Tephritidae fruit flies are severe pest that damage fruits and vegetables in Pakistan. They can seriously harm crops, sometimes to the point where they become unviable (Stonehouse et al., 2002) stated that the four main fruit- fly species of commercial significance in Pakistan are B. zonata, B. cucurbitae, B. dorsalis, and Myiopardalis pardaline. dorsalis is one of the most

destructive species that can inflict 5–100 percent loss to different fruits. The greatest loss in guava fruit, recorded by Ishtiaque et al. (1999), was eighty percent. Similar to this, Jalaludin et al. (1999) observed that Bactrocera correcta (Bezzii) caused a 60–80% loss in guava fruit. In Pakistan's diverse ecological zones, the peach fruit fly, known scientifically as B. zonata (Saunders), reigns as yet another menacing pest. Its voracious appetite for fruit spells disaster, with potential losses ranging from a mere 3% to a devastating 100%.

The pest shows a preference for infesting young, fragile fruits distinguished by their green skin. Following the insertion of eggs, typically positioned 2 to 4 mm deep within the fruit tissues, the larvae commence feeding internally. According to Dhillon et al. (2005), pupation takes place in the soil between 0.5-15 cm below the surface. Fruit-flies are thought to cost Pakistani fruit and vegetable growers more than $200 million a year in lost revenue. Various chemicals and attractants are employed to draw in and eliminate fruit-fly adults (Muhammad et al., 2007).

B. zonata is widely distributed in semi desert regions, the northern areas of Punjab, and coastal and subcoastal parts of Baluchistan and Sindh. But it has also been reported to be an uncommon pest in Peshawar and the foothills of Islamabad (Sarwar, 2006 b). According to White and Helson-Harris (1992), this fruit-fly is indigenous to tropical Asia and can be seen in many tropical nations of the region.

The management of fruit-fly species involves a range of strategies, such as farm sanitation, insecticide applications, bait sprays, biological control, male annihilation techniques, release of sterilized flies and parasitoids. However, the use of insecticides, although effective, raises environmental concerns and poses risks to non-target organisms and international trade due to toxic residues in fruits (El-Aw et al., 2008). Therefore, alternative management strategies such as botanicals extracts (neem, tobacco, garlic, bakain etc) have been used for the management of fruit flies.

In the quest for safer alternatives, botanical extracts have gained attention, with studies demonstrating their effectiveness against fruit fly species. Neem (Azadirachta indica), tobacco, garlic, and Bakain are among the botanicals explored for their potential repellent properties (Ugwu & Nwaokolo, 2020).

This study focused on assessing different repellent constituents of botanical origin against B. zonata in laboratory conditions. The aim is to identify a botanical extract with robust repellency, offering a potential solution to mitigate the challenges associated with fruit fly infestations.

Materials And Methods

The experiments were performed in fruit-fly laboratory of Plant Protection Division of NIFA, Peshawar, Pakistan during 2024. A laboratory population of B. zonata were established and maintained under controlled conditions. The colony was reared on a standardized diet consisting of a mixture of 10g yeast, 10g sugar, and 100ml water. The insects were maintained in environmental chambers set at a constant temperature of 25 ± 2°C, relative humidity 65-70%, with a photoperiod of 12:12 (L:D) hours.

Treatments: Botanical extracts, including neem (Azadirachta indica), tobacco (Nicotiana tobaccum), garlic (Allium sativum) and bakain (Melia azedarach) were used to determine the repellence, deterrence and insecticidal properties against fruit fly.

Table given below shows the different treatments with necessary required information.

S. No.	Treatments	Active Ingredients	Concentration
1.	Neem	Azadirachtin	10%
2.	Tobacco	Nicotine	10%
3.	Garlic	Allicin	10%
4.	Bakain	Meliatoxin	10%
5.	Control	Water	

Non-preference behavior of adult B. zonata

Repellency of Adult B. zonata: Ten pairs of 10 days old adult flies were carefully gathered and transferred into compact cages measuring 30x30x30 cm. These cages were equipped with a nourishing blend of protein hydrolyzate and sugar to sustain adult feeding. A 250 mL glass jar were provided for water, accompanied by a water-soaked cotton swab positioned in a manner ensuring half of it is submerged, allowing easy access to water for adult fruit flies. In a free-choice test, both treated and untreated guavas, each treated with the specified concentrations of plant extracts, were presented to adult flies in the cages (n = 5). The percent repellency was calculated by following methodology of Rehman et al. (2009).

Repellency (%) = (Half no. of flies settled on both treated and untreated guavas – No. of flies settled on treated guavas / Half no. of flies settled on both treated and untreated guavas) ×100

Ovipositional Deterrence of Adult B. zonata: To evaluate settling and ovipositional responses, the fruit-flies on treated and untreated fruits was counted during a ten-minute period starting from 8:00 am to 4:00 pm over 2 days. After 48 hrs, the treated and untreated fruits were carefully collected and placed in plastic tubs filled with sawdust for pupation. These tubs were covered with muslin cloth. The process of sieving sawdust was commenced on the 6th day and continued until the 10^{th} day to recover pupae. The pupae retrieved from each tub were individually kept in rearing cages to facilitate adult emergence, and the count of pupae recovered was served as a metric for assessing the impact of plant extracts on the fruit fly population. Oviposition deterrence data were calculated based on pupae production, which is given in the below equation. (Ilyas et al., 2017).

Deterrence (%) = (Half no. of pupae emerged from treated and untreated guava – No. of pupae emerged from treated guava / Half no. of pupae emerged from treated and untreated guava) ×100

Percent Pupation Inhibition: The percent Pupation Inhibition was calculated by using the following formula (Siddiqi et al., 2011)

Percent Pupation Inhibition = Control – Treated/ Untreated × 100

Percent Pupation: The total numbers of pupae recovered from each treatment were counted, calculated and further analyzed.

Pupal Weight (mg): Pupae from each treatment were weighed on an electric balance (BOECO, BBI-31) to get their respective pupal weight.

Pupal Length (cm): The total number of pupae from each treatment in each replication were measured using a standard measuring tape.

Percent Adult Emergence: Percent adult emergence was calculated by:

Adult emergence (%) = Number of adults emerged x 100

Total number of pupae

Longevity: The mean duration in days were recorded from the emergence of adults from pupae till the last fly died in each treatment within each replication.

Pupal Mortality: A predetermined number of pupae (n=50) were placed in a pupal substrate comprising sawdust/sand, and this substrate was subjected to treatment with the botanical extracts. The data obtained from the subsequent adult emergence, pupal duration, sex ratio and their adult longevity were analyzed to determine the most effective extract for inducing pupal mortality.

Adult Mortality: For evaluating the influence of botanical extracts on adult mortality, twenty adult B. zonata flies were obtained from the laboratory population and introduced into individual cages employing a no-choice setting provided with banana, and each cage was treated with a specific botanical extract. The mortality rates were systematically monitored for two days to assess the lethal effects of the botanical extracts on adult flies. Further, adult longevity in days and the mean number of pupae recovered from B. zonata adults remained alive post-treatment application were counted. This experimental configuration was replicated 3 times for each treatment.

Statistical Analysis: The experiment was carried out using one-way analysis of variance (ANOVA) utilizing Statistix 8.1 software. Comparisons of means were carried out using LSD test, maintaining a significance level of 0.05 (Steel and Torrie, 1980).

Results and Discussion

The experiments were performed at Nuclear Institute of Food and Agriculture (NIFA) Peshawar during, 2024. The current studies aimed at the efficacy of different botanicals for the management of fruit fly Bactrocera zonata under laboratory conditions wherein neem performed better in assessing and controlling the fruit fly infestation. The results obtained are reported under the following headings.

Non-preference behavior of adult B. zonata

Repellency of Adult B. zonata: The results in figure 1 highlighted the impact of various botanical treatments on the non-preference behaviour of fruit fly (B. zonata). The highest level of non-preference was observed with bakain treatment, showing 49.8% non-preference, indicating its strong deterrent effect on the flies. Garlic and tobacco also demonstrated considerable non-preference rates of 43.3% and 42.6%, respectively, suggesting they were effective in reducing host selection by the flies. Neem exhibited a slightly lower non-preference rate of 37.6%, although still significantly higher than the control group. The untreated control group, as expected, showed only a minimal non-preference rate of 1.3%, indicating high host preference in the absence of botanical treatments. These results are in line with Silva et al. (2012) which supports the efficacy of neem leaves in inhibiting oviposition behaviour in medflies, indicating its potential in behavioural control of insect pests. Akyazi et al. (2018) also found that tobacco leaf extract, garlic bulb extract, and their mixtures demonstrated high toxicity against Tetranychus urticae, highlighting their potential for pest control. Certain botanical extracts have been shown to deter B. zonata from ovipositing in treated areas.

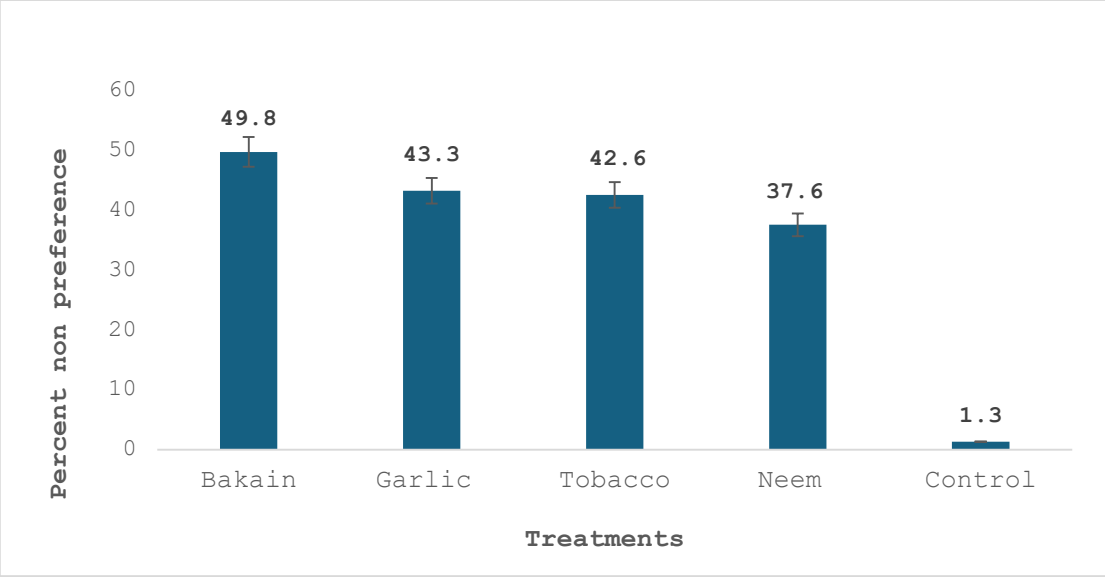

Fig. 1. Effect of different treatments on percent repellency of adult B. zonata.

Ovipositional Deterrence (%) of Adult B. zonata: The ovipositional deterrence of B. zonata was assessed using different botanical extracts as shown in Figure-2. Neem showed the highest deterrence of 57.6%, significantly outperforming other botanicals. Bakain and Tobacco had moderate effects, with deterrence rates of 40.6% and 40.5%, respectively. Garlic recorded the lowest deterrence of 36.0%. Neem's efficacy was notably higher than the other treatments, suggesting its strong potential for reducing oviposition in peach fruit fly management. These results are in line with Shivendra and Singh (1998) who demonstrated that A. indica extract has shown effects like anti-feeding, repellence, toxicity and anti-oviposition against the oriental fruit fly and melon fly. Similarly, Thakur and Gupta reported that A. indica shows an effective deterrent for oviposition by melon fly, with Allium sativum and Melia azedarach also having strong deterrent effects against these pests.

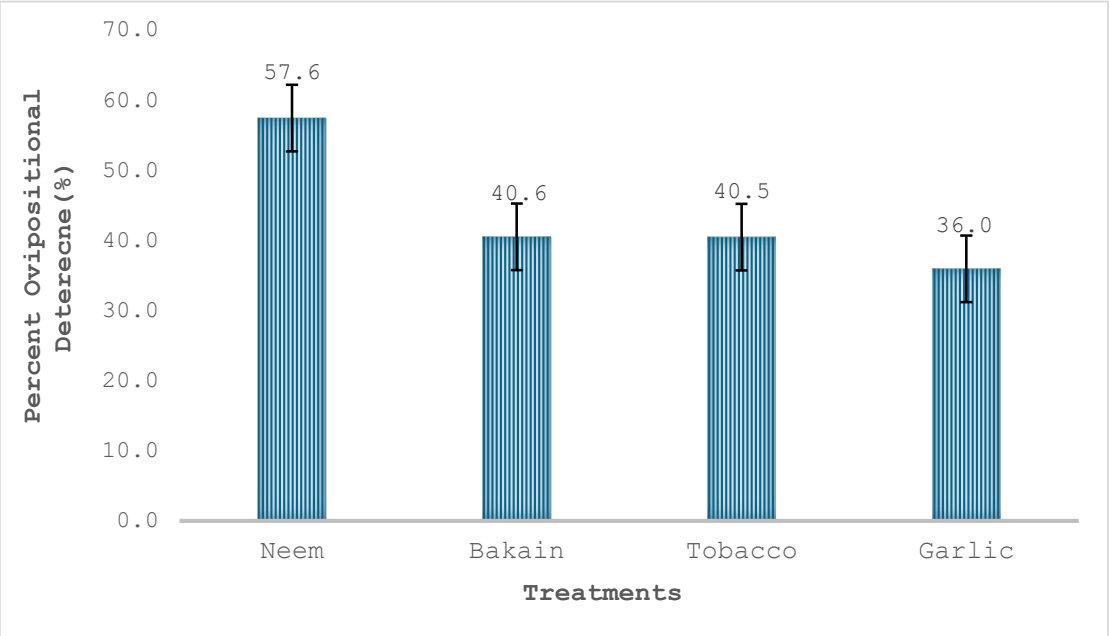

Fig. 2. Effect of different extracts on percent ovipositional deterrence of adult B. zonata.

Percent Pupation Inhibition: Figure 3 presents data on various botanicals showing the efficacy of different compounds for inhibition of B. zonata in pupation. Inhibition level was the highest recorded in Neem with a level of 73.0% followed by bakain and tobacco treatments at par with their inhibitory action on pupation with 57.7%, and 57.6% respectively. The lowest inhibition was that of garlic which recorded 52.4% pupation inhibition. The results clearly show that neem was the most effective botanical, followed by bakain and tobacco, with garlic not being as effective in pupation inhibition. Previous studies have demonstrated that aqueous plant extracts significantly affect insect mortality, growth, and reproduction (Ciepielewska et al., 2005; Roy et al., 2012; Ahad et al., 2015). Certain extracts of Acorus calamus, Azadirachta indica, A. Juss, Curcuma longa, Peganum harmala, Saussurea lappa and Valeriana jatamansi Jones exhibited repellency and growth inhibition against B. zonata (Akhtar et al., 2004). Siddiqi et al. (2006) also stated that the maximum repellence and growth inhibition of B. zonata appeared for the preparation of extracts in acetone.

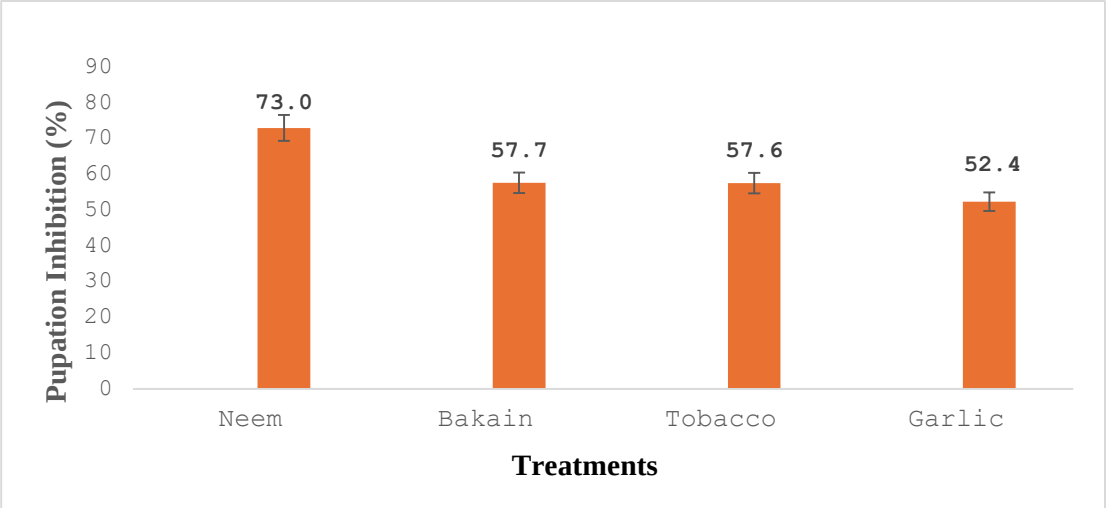

Fig. 3: Effect of different botanical extracts on percent pupation inhibition of B.zonata.

Percent Pupation: Figure 4 showing effect of various botanical extracts namely Neem, Bakain, Tobacco, and Garlic on the percentage pupation of peach fruit fly. Percent pupation depicted a substantially lower value by Neem extract at 21.2%. Percent corresponding to percent pupation values were on par between Bakain and Tobacco with 29.7% each. The highest percent pupation due to the garlic extract was 32.0%. These studies reveal that Neem extract is the most effective tested botanical against pupation of B. zonata, followed by Bakain, Tobacco, and Garlic.

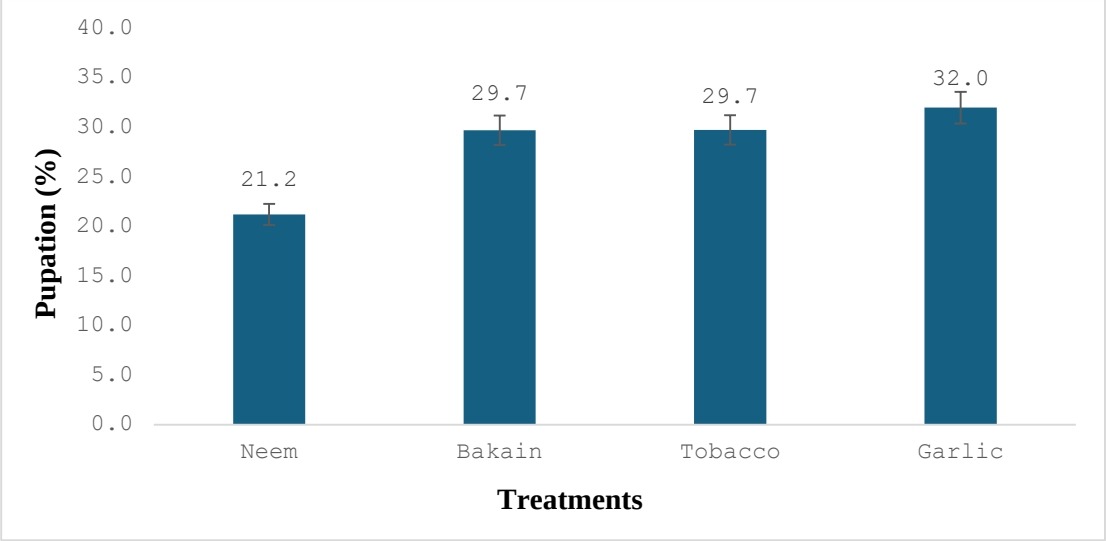

Fig. 4: Effect of botanical extracts on percent pupation of B. zonata.

Pre and Post Treatment pupal weight: The data presented in Figure 4.5 depicts the effect of botanical treatments on the pre and posttreatment pupal weight of the (B. zonata) fruit fly. Pupal weights were significantly lowered with all treatment applied in comparison to the control that was not treated. Treated pupal weights with Neem, Garlic and Bakain were 6.67 g, 7.0 g and 7.33 g, which were significantly lower than the non-treated weights. The minimum weight loss was incurred in the pupae treated with tobacco, weighing 7.33 g after treatment. Weight analysis threw light on significant reduction in all treatments in contrast to that of the nontreated control, but the pupae treated with Neem, Garlic and Bakain had the least weight (Zhang et al., 2022).

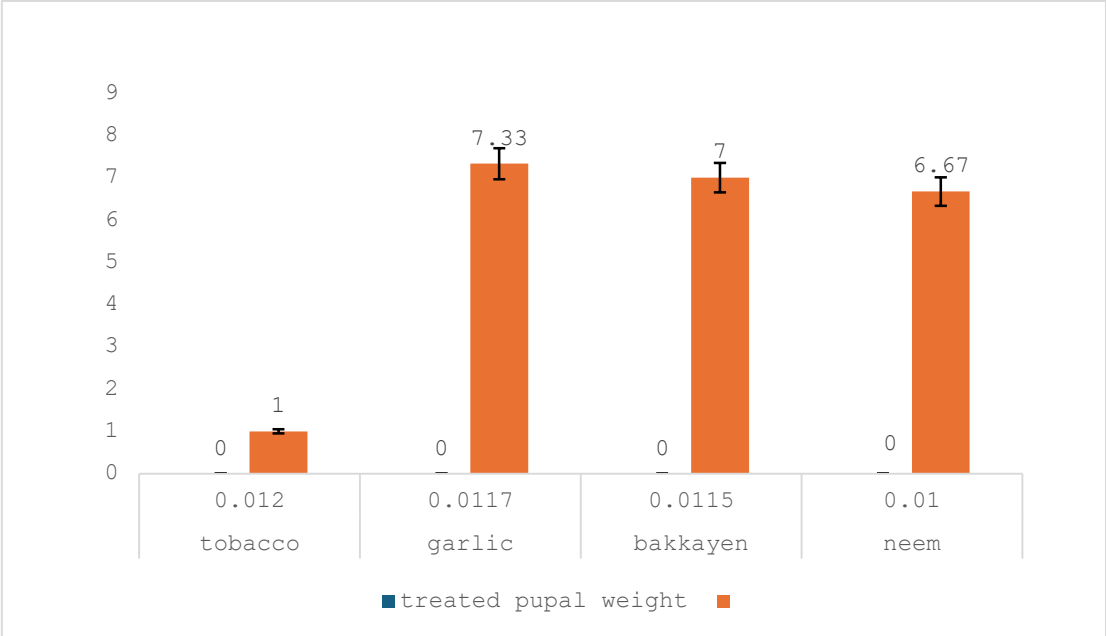

Fig. 5. Effect of different botanical treatments on pre and post treatment pupal weight of B. zonata.

Pupa Length: The Figure-4.6 illustrates the various botanical treatments on the pupal length of B. zonata showed statistical differences among the treatments. Untreated pupae across all treatments (Bakain, Garlic, Tobacco, and Neem) maintained a consistent length of 0.5 cm, except

for the Neem treatment, where the untreated pupae measured slightly shorter at 0.46 cm. In contrast, treated pupae showed a reduction in length across all botanicals. Bakain-treated pupae measured maximum of 0.4 cm, followed by Garlic, Tobacco and Neem-treated pupae all measured 0.33 cm, while minimum was observed in control (0.49 cm).

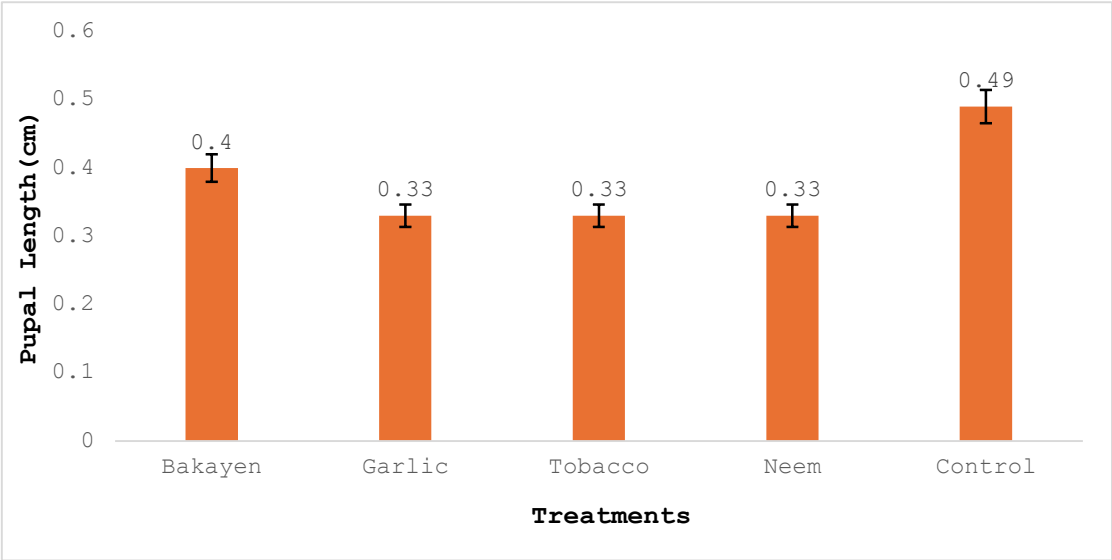

Fig. 6. Effect of different treatments on pupal length of B. zonata.

Adult Emergence: The data in Figure 7 demonstrated the effect of botanicals on percent adult emergence of B. zonata. The data in the graph, show a significant reduction in the percentage of adult emergence of fruit fly when treated with various botanical extracts compared to the control. Among the treatments, neem showed the greatest effect, resulting in only 7.3% adult emergence. Tobacco extract was also effective, with 12.0% adult emergence, followed closely by garlic extract at 11.3%. Bakain was the least effective among the botanicals tested, with 17.3% adult emergence. In contrast, the untreated control group exhibited the highest adult emergence rate at 41.9%. These findings suggest that all the tested botanicals significantly reduced the emergence of adult (B. zonata) fruit flies compared to the control, with neem being the most potent botanical treatment. These results are in line with García et al. (2006), Rao et al. (2007).

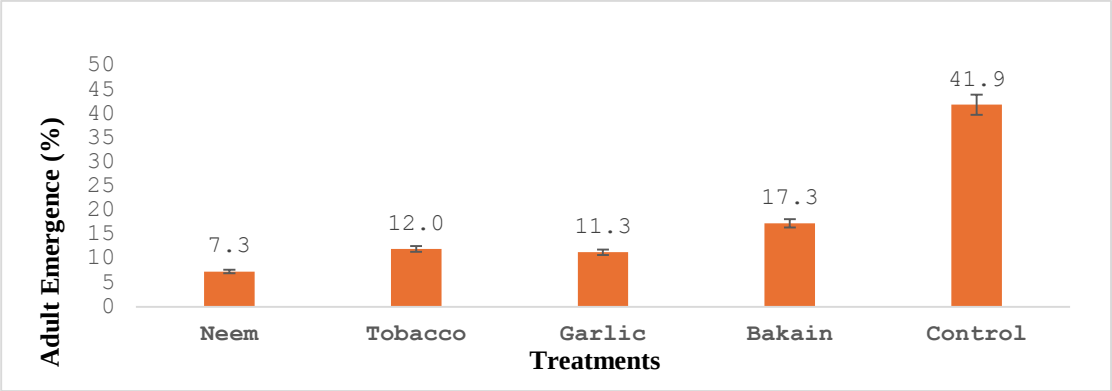

Fig.7. Effect of different botanical treatments on adult emergence of B. zonata.

Longevity: Figure 8 revealed the longevity of (B. zonata) fruit fly subjected to different botanical treatments i.e. Neem, Tobacco, Garlic and Bakain with untreated controls indicating statistically

significant differences in longevity across treatments. Neem treatment resulted in the shortest longevity among the treated groups, with a mean value of 23.33 days, significantly lower than the untreated control group with maximum (46.4 days) longevity. Tobacco-treated (B. zonata) fruit fly had a longevity of 29.3 days, followed by garlic (34.0 days) and Bakain (37.3 days) resulted in slightly higher longevity among the applied botanicals. Previous study indicated that Helicoverpa zea show the vulnerability of pupae and, as a result, direct effects their survival might have on adult populations (Igor et al., 2024).

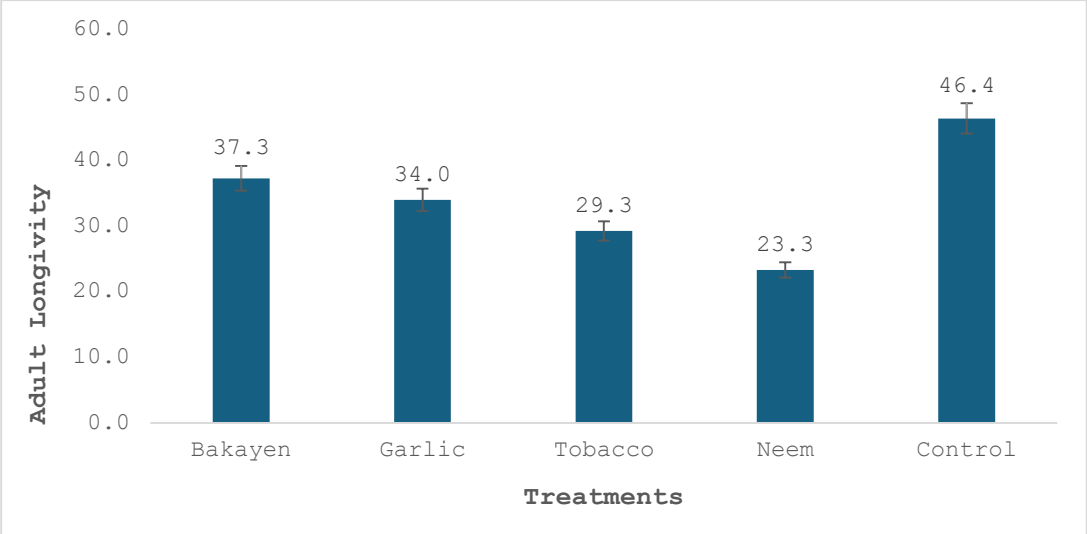

Fig. 8. Effect of different treatments on the longevity of B. zonata.

Pupal Mortality Tests: The effects of different botanical treatments on the pupal mortality, adult emergence, and longevity of B. zonata are summarized in Table 2. Among the treatments, Neem resulted in the highest pupal mortality at 58%, followed by Tobacco (47.3%), Garlic (39.3%), and Bakain (26.6%). These mortality rates were significantly higher compared to the control group, which exhibited only 6% pupal mortality.

Pupal duration varied significantly across treatments, Bakain showing the shortest duration of 7.6 days, which was statistically different from the other treatments. Neem had the longest pupal duration among the botanicals of 11.3 days, but still shorter than the control group, which had the shortest duration of 4 days.

Adult emergence was inversely related to pupal mortality, as compare with the control group having the highest adult emergence of 94.6%, which was significantly higher than the treated groups. Bakain showed the lowest adult emergence among the treatments of 73.3%, indicating its higher effectiveness in reducing peach fruit fly survival to adulthood.

The sex ratio of emerging adults showed in the control group had the highest number of females (31.33), while the treated groups, particularly Bakain, significantly reduced female emergence (25) number. Longevity of the adults was also affected by the treatments, with the control group exhibiting the longest longevity (38.6 days), while Neem-treated adults had the shortest lifespan (12 days).

Table 9. Effects of different botanical extracts on pupal stage of fruit fly (Pupal mortality test).

Treatments	No of pupae	Pupal duration (Days)	Pupal mortality (%)	Adult emergence (%)	Male (No.)	Female (No.)	Longevity (Days)
Neem	50	11.3 a	58 a	42 d	8.6 b	12.33 d	12 d
Tobacco	50	10.3 ab	47.3 ab	52.6 cd	11 ab	15.3 cd	19 c
Garic	50	8 bc	39.3 bc	60.6 bc	9.3 b	20.6 bc	22.3 bc
Bakain	50	7.6 c	26.6 c	73.3 b	12 ab	25 b	24.6 b
Control group	50	4 d	6 d	94.6 a	15 ab	31.33 a	38.6 a
LSD value		2.228	18.410	18.434	4.674	6.107	4.228

Means with in column followed by different letters are significantly different at 5% probability level.

Adult Mortality Test: The impact of various botanical treatments on adult mortality, longevity, and pupal recovery is shown in Table 3. Neem exhibited the highest mortality rate at 68.3%, while the control group had the lowest at 15%. Longevity was significantly reduced in treated groups, with Neem having the shortest lifespan (7.3 days) compared to the control group (32.6 days). Pupae recovery was notably lower in all treated groups, with Neem showing the least recovery (12.3 pupae) and the control group the highest (60.6 pupae). The LSD values confirmed significant differences among treatments.

Table 3. Effect of botanical extracts on adult mortality (%), longevity (In Days), and pupae recovery (Adult mortality test).

Treatments	Mortality rate (%)	Adult Longevity (Days)	Recovered pupae (No.)
Neem	68.3 a	7.3 c	12.3 c
Tobacco	53.3 a	9.3 bc	18.6 b
Garic	55 a	12.3 b	21 b
Bakain	50 a	8.67 bc	21.6 b
Control group	15 b	32.6 a	60.6 a
LSD value	19.790	3.6987	4.7673

Means with in column followed by different letters are significantly different at 5% probability level.

Conclusion

In conclusion, the findings indicated that;

- Bakain, Garlic, and Tobacco are effective in inducing non-preference behavior and reducing pupal weight, with Bakain demonstrating the highest level of non-preference.
- Neem, while less effective in repelling peach fruit flys, showed strong impacts on pupal mortality, pupal weight and pupal length. A profound effect of neem was also observed in pupation inhibition.
- Being an outstanding insecticide, neem caused a significant mortality with reduced adult emergence and sex ratio in peach fruit fly.
- Neem also possess a strong potential for reducing the ovipositional behavior and adult longivity of (B. zonata) fruit flies.
- Sex ratio was profoundly reduced with higher female proportions under Neem treated conditions, suggesting potential impacts on the reproductive dynamics and long-term control of the (B. zonata) fruit fly populations.

Recommendations

- Neem is recommended for use against (B. zonata) fruit fly with an insight into its potential application in Integrated Pest Management (IPM) programs.
- Further research should focus on field trials to validate laboratory findings and assess the long-term efficacy and safety of the botanical insecticide especially against the natural enemies.

References

Ahad, M.A.,M.K . Nahar, M.R., Amin, S.J.Suh, and Y.J. Kwon, (2015). Biological activities of five weed extracts against Callosobruchus chinensis L. (Coleoptera: Bruchidae). Korean J. Appl. Entomol. 54: 83-89.

Akhtar, N., G. Jilani, R. Mahmood, M. Ashfaque and J. Iqbal. 2004. Effects of plant derivatives on settling response and fecundity of peach fruit fly Bactrocera zonata (Saunders). Sarhad J. Agric., 20: 269-274.

Akyazi, R., M. Soysal, E.Y. Altunc, A.T. Lisle, E. Hassan and D. Akyol. 2018. Acaricidal and sublethal effects of tobacco leaf and garlic bulb extract and soft soap on Tetranychus urticae Koch. (Acari: Trombidiformes: Tetranychidae). Sys. Appl. Acarol., 23: 2054-2069.

Ciepielewska, D., B. Kordan, and M. Nietupski, (2005). Effect of plant extracts on some stored-product insect pests. Polish Journal of Natural Sciences, 18, 7-14.

Dhillon, M.K., R. Singh, J.S. Naresh and H.C. Sharma. 2005. The melon fruit fly, Bactrocera cucurbitae: A review of its biology and management. J. Insect Sci. 5:1-16.

El-Aw, M.A.M., Draz, K.A.A.,A.G Hashem, and I.R El-Gendy, 2008. Mortality comparison among Spinosad-, Actara-, Malathion-, and Methomyl-containing baits against peach fruit fly, Bactrocera zonata (Saunders)(Diptera: Tephritidae) under laboratory conditions. J. Appl. Sci. Res. 4(2): 216-223.

Garcia, J. F.,E. Grisoto, J.D Vendramim, and P.S.M. Botelho, (2006). Bioactivity of neem, Azadirachta indica, against spittlebug Mahanarva fimbriolata (Hemiptera: Cercopidae) on sugarcane. Journal of Economic Entomology, 99(6), 2010-2014.

Igor S Schardong, Dominic D Reisig, Taynara Possebom, Joshua Heitman, Helicoverpa zea Boddie (Lepidoptera: Noctuidae) pupal success and adult eclosion across variable soil type and moisture, Environmental Entomology, Volume 53, Issue 4, August 2024, Pages 511–520, https://doi.org/10. 1093/ee/nvae045.

Ilyas, A.,H.A.A. Khan, and A. Qadir, 2017. Effect of Essential Oils of some Indigenous Plants on Settling and Oviposition Responses of Peach Fruit Fly, Bactrocera zonata (Diptera: Tephritidae). Pak J. Zoolo 49(5): 1547-1553.

Jalaluddin, S.M., K. Natarajan, S. S. Kathulla and S. Balasubramani_yan. 1999. Discovery of the guavafruitfly, Bactroceracorrecta (Bezzi). Entomon. 24(2):195-96.

Muhammad, D.G., A. Muhammad, A.J. Muhammad, K.A. Muhammad and A. Fiaz. 2007. Co-administration of insecticides and butanone acetate for its efficacy against melon fruit flies, Bactrocera cucurbitae (Diptera: Tephritidae). Pak. J. Entomol., 29(2): 111-116.

Rao, G. R., V. Visalakshmi, Suganthy, M., Reddy, P. V., Reddy, Y. V. R., and Rao, V. R. (2007). Relative toxicity of neem to natural enemies associated with the chickpea ecosystem: a case study. International Journal of Tropical Insect Science, 27(3-4), 229-235.

Rehman, J., G. Jilani, M.A. Khan, R. Masih and S. Kanvil. 2009. Repellent and oviposition deterrent effects of indigenous plant extracts to peach fruit fly, Bactrocera zonata Saunders (Diptera: Tephritidae). Pak. J. Zool., 41(2): 371-373.

Roy, B., Jalal, S. Sarker, B.C., Amin, M.R., Jeon, Y.H. and Chun, I.J. (2012). Evaluation of insecticidal activities of common cocklebur fruit extract against pulse beetle Callosobruchus chinensis (Coleoptera: Bruchidae). Korean Journal of Applied Entomology, 51, 325-329.

Sarwar M (2006 b). Management of Guava (Psidium guajava) Orchard against Insect Pests. Economic Review, 8/9 (XXXVIII): 28-30.

Shivendra, S. and R. P. Singh, 1998. Neem (Azadirachta indica) seed kernel extracts and azadirachtin as oviposition deterrents against the melon fly (Bactrocera cucurbitae) and the oriental fruit fly (Bactrocera dorsalis). Phytoparasitica, 26: 191-197.

Siddiqi, A. R., Rafi, A., Naz, F., Masih, R., Ahmad, I., & Jilani, G. 2011. Effects of Curcuma longa extracts on mortality and fecundity of Bactrocera zonata (Diptera: Tephritidae). Ciência e Agrotecnologia, 35 (06): 1110-1114.

Silva, M.A., Bezerra-Silva, G.C., Vendramim, J.D., & Mastrangelo, T.D. (2012). Inhibition of Oviposition by Neem Extract: A Behavioral Perspective for the Control of the Mediterranean Fruit Fly (Diptera: Tephritidae).

Steel, R.G.D., Torrie, J.H. (1980). Principles and procedures of statistics. A biometrical approach. 2nd edition. McGraw-Hill, New York.

Stonehouse, J., R. Mahmood., A. Poswal., J. Mumford., K. N. Baloch., Z. M. Chaudhary., A. H. Makhdum., G. Mustafa and D. Huggett, 2002. Farm field assessments of fruit flies (Diptera: Tephritidae) in Pakistan: distribution, damage and control. Crop Protec. 21(8): 661-669.

Ugwu, J.A. and Nwaokolo, V.M., 2020. Biocidal activity of selected botanicals and Beauveria bassiana on oriental fruit fly, Bactrocera dorsalis (Diptera; Tephritidae). J.Res. Forestry, Wildlife and Environ., 12(1): 53-61.

White IM, Elson-Harris M. 1992. Fruit Flies of Economic Importance: Their Identification and Bionomics. CAB International, Oxon, UK. 601

Zhang, P., Zhou, Y., Qin, D., Chen, J. and Zhang, Z. (2022). Metabolic changes in larvae of predator Chrysopa sinica fed on azadirachtin-treated Plutella xylostella larvae. Metabolites, 12(2), 158.