Research Article

Mealybug (*Drosicha* sp. Monophlebidae: Hemiptera) Population Density on Different Host Plants and Their Management

Muhammad Ayub[1*], Syed Arif Husain Rizvi[2], Ishtiaq Hussain[3], Musa Ali Hashmi[4], Iqbal Hussain[5], Shahid Hussain[1], Zakir Hussain[1] and Rehmat Kabir[6]

[1]Pakistan Agricultural Research Council, Agricultural Research Station, Skardu, Pakistan; [2]Crop Sciences Research Institute, National Agriculture Research Centre, Islamabad, Pakistan; [3]Department of Botany, University of Baltistan Skardu, Pakistan. [4]Department of Agriculture, Skardu, Pakistan; [5]Directorate of Agriculture, Gilgit, Pakistan; [6] Pakistan Agricultural Research Council, Agricultural Research Station, Chilas, Pakistan.

Abstract | Mealybug (*Drosicha* sp.) is an invasive insect pest of forest trees in Skardu (Gilgit-Baltistan). Currently, its management relies on the use of synthetic chemical insecticides. The massive use of these synthetic chemical insecticides results in environmental pollution. Therefore, combining integrated pest management strategies is considered a practical approach to control this pest. During 2019-20, the individual and combined effects of cultural control techniques including soil racking, egg burning, and egg removal from stem crevices, were evaluated for their effectiveness in controlling this invasive insect pest. Three types of forest trees including willow (*Salix wilhelmsiana* M. Bieb), poplar (*Populus ciliata* Wall.), and Russian olive (*Elaeagnus hortensis* M. Bieb) were examined for mealybug population density trends and host preference. The findings indicated that implementing both soil racking and egg removal techniques resulted in a significant reduction (92.29%) in the population of mealybugs compared to the control trees. Furthermore, a maximum number of adult mealybugs (512) were recorded in Gunny bags wrapped on willow (*S. wilhelmsiana* M. Bieb) tree trunks among three types of forest trees during July 2020. In conclusion, soil racking and egg removal should be carried out simultaneously during winter for eco-friendly mealybug management.

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***Correspondence** | Muhammad Ayub, Pakistan Agricultural Research Council, Agricultural Research Station, Skardu, Pakistan; **Email:** ayubskd2011@gmial.com
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Introduction

The mealybug is a prevalent insect pest that infests a broad variety of agricultural and ornamental plants (Ben-Dov, 1994) and if they become established in a new environment lacking natural enemies, they may cause serious problems (Miller *et al*., 2002). Mealybug identified as *Drosicha* sp. Martin and Gullan (Monophlebidae: Coccoidea: Hemiptera) is a recently introduced destructive insect pest of forest trees, willow (*Salix wilhelmsiana* M. Bieb), poplar (*Populus ciliate* Wall.) and Russian olive

(*Eleagnus hortensis* M. Bieb) in Skardu, Baltistan. Infestation of insect pests is extremely severe, to the point where it is rapidly spreading to fruit trees such as apricot (*Prunus armeniaca* Marsh), apple (*Pyrus malus* L.), pear (*Pyrus communis* L.), and mulberry (*Morus alba* L.) etc. (Khan and Ahmad, 2008) and these fruit plants are widely distributed in Baltistan Up to 3100 m (Hussain et al., 2011). Such observation has been reported by Rizvi *et al.* (2015) that the mealybug (*Drosicha* spp.) is mainly a pest of willow tree, however, in areas of heavy population, it has the tendency to attack a variety of other fruit trees like peach (*Prunus persica* L.), appricot (*Prunus armeniaca* L.) and mulbury (*Morus alba* L.), etc.

Female mealybugs lay eggs in loose masses of cottony wax or felt-like ovisacs. Newly hatched mealybug, also called crawlers move from one part to another within the plant and also between plants for feeding (Mani and Shivaraju, 2016).

Studies have shown that mealybug feeding reduces plant growth and the honeydew secreted promotes the growth of a black sooty mold, interfering with photosynthesis and affecting fruit quality (Franco *et al.*, 2009; Gullan and Martin, 2009). Likewise, high population densities may also cause leaf fall, fruit loss, or even plant death (Franco *et al.*, 2000).

Chemical control is still the most common control tactic used against mealybug pests. However, the cryptic behavior of mealybugs, their typical waxy body cover, clumped spatial distribution pattern, and living deep inside cracks and crevices of trees render many insecticides ineffective. Excessive use of insecticides, especially of broad-spectrum chemicals, also adversely impacts mealybug's natural enemies (Franco *et al.*, 2004; Charles *et al.*, 2006; Rizwan *et al.*, 2022; Walton *et al.*, 2006). Therefore, some alternate measures are needed to be adapted for the management of mealybugs. Insecticidal activities of plant extracts as biopesticide and Cultural practices suppress pest build-up by disrupting the normal relationship between pests and the host plants and thus render the pest less likely to survive, grow or reproduce (Ayub et al., 2019). Crop rotation, tillage, hoeing/plowing, earthing up, planting trap crops, etc. are standard cultural practices (Karar *et al.*, 2010). According to Rizvi *et al.* (2015), the application of tobacco and neem extract at a concentration of 2.00% along with appropriate cultural practices is recommended for controlling mealybugs during their initial stage to protect beneficial insects. Therefore, the current study aimed to evaluate various cultural practices; soil racking, eggs burning, and eggs removal from soil and stem crevices to keep the population under limits.

Materials and Methods

Combined and individual cultural techniques of soil racking, eggs burning, and removal of diapausing eggs from stem crevices of three non-fruit trees were evaluated under randomized complete block design with three replications at Chumik, Skardu (35°17′25″N 75°38′40″E) at an elevation of 2,228 m (Hussain *et al.*, 2019*)* during 2019-20. Willow (*Salix wilhlmsiana* M. Bieb), Poplar (*Populus ciliate* Wall.), and Russian olive (*Eleagnus hortensis* M. Bieb) were selected randomly and tagged. The treatments included: T1: Soil racking. This involved racking the soil to a depth of six inches in a radius of 12 inches around the tree trunks. It was performed three times at 15-day intervals from October to November 2019 to expose the diapausing eggs. T2: Diapausing egg Masses removal. In this treatment, diapausing egg masses were removed from stem crevices up to a height of 6 feet by using iron brushes. T3: Egg masses burning. This treatment involved burning the egg masses on the trees' stems and ground with a fire gun. T4: Soil racking and egg removal. This treatment combined soil racking around the trees with the removal of egg masses. T5: Soil racking and egg burning. In this treatment, soil racking and egg burning were performed simultaneously.

To determine host plant preference and population trends, three plants of willow, poplar and Russian olive were selected for each of the three replications and no treatment was carried out and marked as control (T6). Direct counting of eggs in the soil and scattered crawling nymphs was difficult because of being dull-colored, this tiny creature is hard to detect at emergence. At later stages, the insects can be seen adhering around the entire inflorescence peduncle and other tender shoots to suck the sap (Ashfaq *et al.*, 2005). As indirect monitoring strategies, mealybug s can be sampled with a sticky trap (Hill and Burts, 1982; Vitullo, 2009; Cid *et al.*, 2010), therefore, indirect counting of the surviving population of mealybug emerged from diapausing eggs in the soil and stem crevices were carried out by trapping climbing nymphs that came out from soil in spring.

For this purpose, 4 inches wide bands of gunny bags were wrapped around tree trunks at two feet above ground level in treatments of soil racking whereas in other treatments gunny bags were wrapped at a height of 6 feet from the ground in April 2020. The bands were removed once a month during June, July, and August 2020. The bands were rewrapped after counting the number of mealybugs. Percent reduction in population over control was calculated using below equation (Abid *et al*., 2020; Sana *et al*., 2022).

$$\% \text{ reduction} = (x - y)/x \times 100$$

x= Number of mealybugs trapped on control trees. y= Average number of mealybugs trapped on trees under cultural practices.

Statistical tests were conducted by using PROC GLIMMIX (SAS Institute, 2010), and less than 0.05 *P*- values were considered significant to compare the effectiveness of various cultural practices.

Results and Discussion

Cultural control

The spatial and temporal variation in the life cycle of this insect provides an opportunity to apply a range of cultural, biological, and chemical control measures alone or in combination. Reduction in average number of mealybugs entrapped in bands indicated that the viable eggs were destroyed when they exposed by soil racking and egg removal from stem crevices during winter. Table 1 indicates that simultaneously soil racking around tree trunks and egg removal from stem crevices has significantly reduced the number of mealybug nymphs as compared to egg burning and egg removal from stem and control plots. The highest percent reduction in the mealybug population 91.67 recorded on trees treated with simultaneous soil racking and egg removal from stem significantly varied with treatments of soil racking alone (74.00%) and soil racking combined with egg burning (70.56%). Percentage reduction in the mealybug population recorded on trees treated with combined soil racking and egg removal was highly significant to egg removal and egg burning treatments giving 23.67 and 14.43% reduction in population over control, respectively.

Statistically lowest average total number of adults mealybugs 74.33 caught in gunny bag bands on trees of soil racking and egg removal treatment (T4) carried out simultaneously was not significantly different from 245.67 average total number of nymphs on trees of only soil racking treatment (T1). However, the average total number of mealybugs 245.67 recorded on trees of soil racking treatment was significantly varied with the average total number of mealybugs 734.33 and 826.33 caught in gunny bags in treatments of egg removal (T2) and egg burning (T3) carried out individually. Similar trends were observed in month wise number of mealybugs captured in all treatments. During June 2020, the r ecorded monthly average maximum number of adult mealybugs in the control group was 354.67, was found to be significantly different from the results observed in three treatment groups: T1- soil racking (71.67), T4-soil racking with egg removal (22.33), and T5-soil racking with egg burning (87.67). Wherease, in July 2020, the recorded average minimum number of mealybugs (22.33) recorded in T4 was significantly varied from the average number of mealybugs 274.00, 290.33, and 354.67 recorded in T2, T3, and T6 respectively. Furthermore, in August 2020, the recorded monthly average maximum number of adult mealybugs in the control group was 190.33, was non-significant to the treatments T2 (148.33) and T3 (189.67), while it was significantly different from T1 (78.67), T4 (24.00) and T5 (84.67). This trend indicated that diapausing eggs were not destroyed on the control trees (T6) during winter and the highest average number of mealybugs 354.67, 419.67, and 190.33 emerged and were trapped during June, July, and August 2020 respectively. These results indicated that soil racking is more effective than egg removal from stem cervices; however, destruction of diapausing eggs significantly increased to 92.29% rendering a reduction in the nymph's population when both practices were carried out simultaneously revealing that these techniques, including soil racking and eggs removal from stem crevices, are an effective component of IPM program for mealybug control. These findings are in concurrence with Ishaq *et al*. (2004) who also found simple methods of ploughing/hoeing to expose the eggs, burning off and physical destruction of eggs are more effective than traditional chemical control measures. In addition, the results of this study are also in consonance with the findings of Sial (1999), who reported that hoeing, burning of adult females, and removal of soil contaminated with eggs of *D. mangiferae* gave complete control of this pest without pesticides. Similarly, Mohyuddin and Mahmood (1993) also achieved the control of *D. mangiferae* by hoeing or ploughing the soil three times to a depth of 15 cm during June and December.

Table 1: *The monthly average number of mealybug (Drosicha sp.) trapped in gunny bag bands wrapped on tree trunks at Skardu, 2020.*

Treatment	June	July	August	Total	% Reduction in population
T1-Soil racking	71.67 b	95.33b	78.667bc	245.67b	74.00b
T2-Egg removal	274.00a	312.00a	148.33ab	734.33a	23.67c
T3-Egg burning	290.33a	346.33a	189.67a	826.33a	14.43cd
T4-Soil racking × egg removal	22.33b	28.00b	24.00c	74.33b	91.67a
T5-Soil racking × egg burning	87.67b	111.67b	84.667bc	284.00b	70.56b
T6-Control	354.67a	419.67a	190.33a	964.67a	0.00d

Data are the mean of three replicates and are represented as mean ± standard deviation. Means in the same column followed by the same lower-case letter are not significantly different at P = 0.05.

Population trend

Diapausing eggs hatch in early spring, and the resulting tiny nymphs climb onto tree trunks in search of suitable feeding sites. Once they find a suitable spot, they settle and insert their stylets to suck sap. As shown in Figure 1, the average population of mealybug nymphs was low (354.67) during June 2020. It then gradually increased to its peak (419.67) during July and abruptly declined to its lowest level (190.33) during August 2020. A host species-wise population trend was noted as 431 mealybugs on willow during June 2020. The peak population in the season was recorded during July, as 512 average mealybugs were observed in the bands wrapped around willow trees whereas in August, the number decreased to 220 mealybugs. Similar trends were observed in the other two host plants, with 342, 403, and 181 mealybugs recorded in bands on poplar trees and 291, 344, and 170 mealybugs on Russian olive during June, July, and August 2020, respectively as shown in Figure 1. Monthly data depicted that in spring, nymphs emerge up to July and then adults undergo for mating and egg-laying within white cottony masses in soil, stem crevices, and other hidden places around trees during August. Eggs remain dormant during winter in white cottony masses which protect them from extreme cold during winter and hatches in early spring. These findings are in line with the findings of Rizvi *et al.* (2015) who reported that the population of mealybug reached its peak during July and the highest infestation was recorded. Since August 15, the temperature starts declining in Skardu and at this time mealybugs cover themselves with wax when the temperature starts decreasing and a drastic decrease in population was noted. Furthermore, Rizwan *et al.* (2022) recorded that the population of mealybug adults started to increase during April (26.64 individuals per branch) and the maximum population (34.86 individuals per branch) was recorded in May.

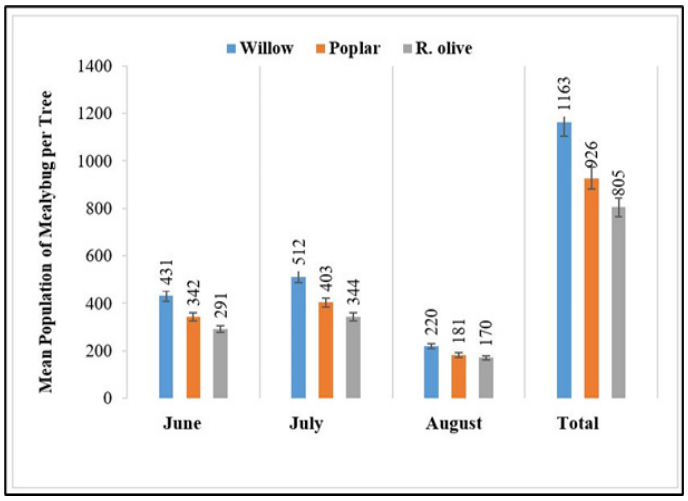

Figure 1: *Monthly mean population of mealybug recorded on three host plants Species, at Skardu, 2020.*

Host plants

Mealybug is a polyphagous insect pest, however, it prefers some plant species as primary hosts. Figure 1 indicates that willow trees were most susceptible to mealybugs as the highest number of 1163 nymphs and adult female mealybugs trapped in gunny bag bands wrapped on tree trunks. Whereas lower numbers 926 and 802 mealybugs were recorded on poplar and Russian olive trees respectively. Similar trends were also recorded in the month-wise population these three host plants as shown in Figure 1. Thus, the result of this study revealed that willow is the primary host and most susceptible to this mealybug species "*Drosicha*" found in Skardu, but in heavy infestation, it is spreading over to fruit trees rapidly. These results agreed with the findings of Khan (2001), Khan and Ahmad (2008). who reported a similar tendency in giant mango mealybug (*Dorsicha stebbingi* Green) and studied *Drosicha sp*. Similarly, in a host range study, Bhau *et al.* (2017) reported more than 30 plant species are most susceptible to mealybugs in the Jammu region.

Conclusion and Recommendations

Based on the findings of the current study, it can be concluded that the most effective method for destroying mealybug eggs before the emergence of nymphs in early spring is the simultaneous application of soil racking around trees and the removal of egg masses from stem crevices during October and November. The month of July marks the peak population of mealybugs, which subsequently declines in August. Besides, in Skardu, GB, Pakistan, the willow tree (*Salix wilhelmsiana* M. Bieb) is identified as the most susceptible and primary host of the mealybug species (*Drosicha* sp.).

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Novelty Statement

Chemical insecticides widely used to control Mealybug population despite environmental risks.

This study advocates for IPM techniques, specifically combine use of soil racking and egg removal, as a practical approach to control the devastating pest and reduce reliance on harmful synthetic insecticides as well as biodiversity conservation of fruit trees in long run

Author's Contribution

Muhammad Ayub: The author's contribution is mainly conceived the idea, methodology and overall management of the article.
Syed Arif Husain Rizvi: Contributed in introduction, data collection and manuscript writing.
Ishtiaq Hussain: Contributed in Data compilation and analysis and overall management of the article.
Musa Ali Hashmi: Data collection, conceived the idea, methodology and technical input during the study.
Iqbal Hussain: Provided technical input at every step.
Shahid Hussain: Contributed in data collection and entry.
Zakir Hussain: Contributed in data entry, analysis, introduction and revision of manuscript.
Rehmat Kabir: Contributed in technical input and Discussion and References.

Conflict of interest

The authors have declared no conflict of interest.

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