***Original Research Article***

**Screening Apple and Apricot Cultivars for Resistance against Key Insect Pests in Trans Himalayan Region**

**Abstract**

Apricot (*Prunus armeniaca* L.) and apple (*Malus domestica* Borkh.) are the most widely cultivated fruits in Ladakh, but their production is increasingly threatened by insect pests like aphids and codling moths (*Cydia pomonella*). This study aimed to evaluate the resistance of three popular apricot varieties Halman, Raksteykarpo, and Narmo to aphid infestations, and three apple varieties Tha-kushu, Mongol, and Phemar-khushu to codling moth damage. Field surveys were conducted in orchards across the Leh district during the 2022 and 2023 growing seasons to assess pest incidence and varietal response. The results showed that Halman was the most susceptible to aphids among apricots, with an infestation rate of 47.76%, followed by Raksteykarpo (38.44%). In contrast, Narmo exhibited the lowest infestation (23.11%) and demonstrated moderate resistance. Similarly, in apples, Tha-kushu suffered the highest fruit damage from codling moths (55.49%), followed by Mongol (36.66%), while Phemar-khushu experienced the least damage (26.83%), likely due to its early maturation, which limited its exposure to multiple pest generations. These findings underscore the importance of selecting pest-tolerant cultivars for sustainable fruit farming in Ladakh. While none of the varieties was entirely resistant, Narmo and Phemar-khushu showed promising levels of tolerance, making them more suitable for cultivation in pest-prone regions. As climate change continues to impact pest dynamics, further research on plant resistance traits and eco-friendly pest management strategies is crucial. Identifying naturally resilient cultivars will not only support breeding programs but also help local farmers adopt sustainable agricultural practices while reducing reliance on chemical pesticides.

*Keywords: Apricot, Apple, Aphids, Codling moth, Pest resistance, Ladakh, Sustainable agriculture, Integrated Pest Management (IPM).*

**Introduction**

 Apricot (*Prunus armeniaca* L.) and apple (*Malus domestica* Borkh) are the dominant fruit crops of Ladakh, with apricot leading in production. Ladakh contributes over 62% of India’s apricot yield, covering 2,127 hectares with an output of 12,686 metric tons and a productivity of 5.96 MT/ha (Anonymous, 2019; Stobdan *et al*., 2020). The region’s apricots are renowned for their quality, preserved due to natural geographic isolation. Historically, dried apricots were a key trade commodity (Angmo *et al*., 2017), and quarantine laws since 1981 have restricted the introduction of external varieties. Apple, the second most cultivated fruit, is grown in Kargil district and the lower to mid-altitude regions of Leh. Rich in biodiversity, Ladakh's apple cultivation is shifting to higher altitudes due to climate change, expanding to Leh town and nearby villages. A 2019–20 survey by LAHDC, Leh, reported a total apple-growing area of 360.33 hectares, with the largest plantations in Saspol (62.51 ha), Khaltsi (46.72 ha), and Skurbuchan (42.90 ha) (Anonymous, 2019).

 The dynamics of insect pest infestations in agriculture have undergone significant changes in the early 21st century, primarily due to ecosystem shifts and technological advancements (Dhaliwal, 2010). The expansion of global agricultural trade has heightened the risk of introducing invasive pest species. Additionally, factors such as altered cropping patterns, excessive pesticide use, climate change, and the widespread adoption of high-yielding, input-intensive cultivars and hybrids have contributed to shifts in pest populations ((Zhai *et al*., 2007, Chen *et al*., 2010). As a result, several insect pests have broadened their host range, developed resistance to chemical control methods, and emerged as serious threats to crop production (Rathee, 2018). Insect pests such as the codling moth (*Cydia pomonella*), aphids (*Aphis pomi* and *Myzus persicae*), fruit borers (*Grapholita spp.*), and scale insects (*Quadraspidiotus perniciosus*) pose significant threats to apple and apricot cultivation (Sherwani *et al.,* 2016; Lhadon *et al.,* 2024) in the Trans-Himalayan region. The perennial nature of orchards presents a significant challenge for pest management, as different parts of the tree offer diverse microhabitats that support the colonization and survival of various arthropods (Beers *et al*., 2003). The region’s distinctive climate, marked by low temperatures, minimal precipitation, and high-altitude isolation, influences pest behaviour, often modifying their population dynamics and infestation patterns (Bhagarathi and Maharaj, 2023). Due to environmental concerns and pesticide residue limitations, reliance on chemical control methods is restricted, making host plant resistance a more sustainable and eco-friendly pest management alternative (Vlaiculescu and Varrone, 2022).

Assessing the response of different apple and apricot cultivars to insect pest infestations is essential for developing effective integrated pest management (IPM) strategies. Some cultivars may possess natural resistance or tolerance to these pests, making them ideal for cultivation in pest-prone areas. This study aims to evaluate the resistance of various apple and apricot cultivars against key insect pests in the Trans-Himalayan region. The findings will facilitate the identification of pest-resistant genotypes, providing valuable insights for breeders, policymakers, and farmers in selecting resilient cultivars for sustainable fruit production.

**Materials and methods**

 A systematic orchard survey was conducted during the 2022 and 2023 growing seasons in selected apple and apricot orchards of Leh district to evaluate pest incidence and varietal response. The study examined three commonly grown apricot varieties Halman, Raksteykarpo, and Narmo for their susceptibility to aphid infestations, as well as three local apple varieties Tha-kushu, Mongol, and Phemar-khushu for their vulnerability to codling moth (*Cydia pomonella*).

 Aphid infestation in apricot trees was monitored biweekly from May to September, with each variety assessed for infestation severity and assigned a resistance rating based on its tolerance level. Incidence was recorded by counting the number of aphids per 10 randomly selected leaves in each tree and per cent incidence was calculated according to the following formula: -

Per cent of Incidence shall be calculated as (PI) : $\frac{n}{N}$ × 100

 Where, n = Number of leaves infested

 N = Number of leaves examined

 List 1 : Severity of infestation was determined by using 0-4 scale (Jayappa and Ligappa, 1988)

|  |  |  |
| --- | --- | --- |
| **Grade** | **Intensity of infestation** | **Resistance rating** |
| 0 | Free from aphids | Resistant |
| 1 | < 25% plants infested by aphids | Moderately resistant |
| 2 | 25-50% plants infested by aphids | Moderately susceptible |
| 3 | 50-75% plants infested by aphids | Susceptible |
| 4 | 75-100 % plants infested by aphids | Highly susceptible |

 Likewise, the extent of codling moth infestation in apple orchards was determined by evaluating fruit damage on trees. Ten fruits from each variety was randomly collected and observed for punctures and dissected to ascertain infestation by codling moth larvae.

Per cent damage of the infested fruits was worked out as:

|  |  |
| --- | --- |
| Number of infested fruits | ×100 |
| Total number of fruits examined |

**Result and discussion**

**Varietal screening of apricots for aphid**

 The present study aimed to identify the source of resistance for which three popular varieties of apricots: Halman, Raksteykarpo, and Narmo were screened against aphids. The mean per cent infestation of aphids on apricot trees was monitored biweekly, beginning in May and continuing through September**.** Grading of various varieties against aphids in apricot were made based on the intensity of infestation and resistant ratings for each variety are given as detailed in Table 1.

 The information on the percentage of aphid infestation in various apricot varieties during 2022 and 2023 is presented in Table 1**.** The presence of aphids in the orchards provided crucial information about vulnerability rather than resistance. During 2022, the infestation was first detected across all varieties with varying degrees, the analysis indicates none of the screed varieties were free from aphids, Halman variety had the highest average infestation rate (51.33%), followed by Raksteykarpo (42.55%), while Narmo recorded the lowest infestation rate (24.66%). These varieties are graded according to the intensity of infestation. Halman was regarded as Susceptible (50-75% plants infested by aphids) whereas Raksteykarpo was reported as moderately susceptible ((25-50% plants infested by aphids)) and Narmo as Moderately resistant (< 25% plants infested by aphids). Similarly in 2023, Halman had the highest average infestation rate (44.20%), followed by Raksteykarpo (34.33%), with Narmo having the lowest infestation rate (21.56 %). These varieties were categorized according to the severity of infestation: Halman, Raksteykarpo as Moderately Susceptible (25-50% of plants infested), and Narmo as Moderately Resistant (< 25% of plants infested). The pooled data on the percentage of aphid infestation on apricot trees across different apricot varieties for the years 2022 and 2023 as summarized in Table 1. The results indicate that Halman had the highest Mean per cent infestation (47.76%), followed by Raksteykarpo (38.44%). The lowest infestation was noted in Narmo (23.11%). These varieties were categorized according to the severity of infestation and hence were put in the category of susceptible ones according to the scale given by (Jayappa and Lingappa, 1988) (Table 2). Halman, Raksteykarpo as Moderately Susceptible (25-50% of plants infested), and Narmo as Moderately Resistant (< 25% of plants infested). Since no published information on the cultivars screened is available the information is a new contribution in this particular field of research. In the recent past, no work has been reported in the literature focusing screening of apricot genotypes in Ladakh and India. With the change in climatic situation aphids on apricots have become one of the bottlenecks for the growers of apricots in Ladakh. This situation created a gap in screening out the existing genotype for the needs of growers, researchers and scientists thus needs further warrant

Our findings are somewhat consistent with the work done by (Sauge *et al*. 1998a, b; Sauge 1998) where they analyzed the mechanism of resistance to green peach aphids in *prunus* species and found that the peach cultivar "GF305" exhibited low resistance to M. persicae, whereas the cultivars "Summergrand" and "Malo Konare" showed minor resistance, and the cultivars "Rubira" and "Weeping Flower Peach" showed moderate resistance. Verdugo et al. (2012) also found similar findings in their experiment where they found that ‘August Red’ and ‘Summer Bright’ varieties of peach had the highest aphid occurrence values, although other cultivars showed a low frequency of aphids in the assessed orchards.

**Table 1: Screening of local apricot varieties for the incidence of apricot aphid**

|  |
| --- |
|  **Aphid infestation (%) \*** |
| **S.no.**  | Varieties | 2022 | 2023 | Pooled data | Grading |
| **1** | Halman | 51.33 (7.16) | 44.20 (6.65) | 47.76 (6.91) | **2** |
| **2** | Raksteykarpo | 42.55 (6.52) | 34.33 (5.86) | 38.44 (6.20) | **2** |
| **3** | Narmo | 24.66 (4.97) | 21.56 (4.64) | 23.11 (4.80) | **1** |
|  | Mean | 39.51 | 33.33 | 36.43 |  |

**\*Each values represents mean of 3 replications; figure in parenthesis are square root transformation**

|  |  |  |  |
| --- | --- | --- | --- |
| **Grade** | **Intensity of infestation** | **Resistance rating** | **Varieties**  |
| 0 | Free from aphids | Resistant | Nil |
| 1 | < 25% plants infested by aphids | Moderately resistant | Narmo |
| 2 | 25-50% plants infested by aphids | Moderately susceptible | Halman, Raksteykarpo |
| 3 | 50-75% plants infested by aphids | Susceptible | Nil |
| 4 | 75-100 % plants infested by aphids | Highly susceptible | Nil  |

**Table 2: Categorization of screened apricot cultivars against aphid.**

**Varietal screening of apple varieties for incidence of codling moth**

 This study was conducted to assess the level of damage and percentage of infestation by *Cydia pomonella* in 3 selected local apple varieties: Tha-kushu, Mongol, Phemar-khushu the research took place in selected apple orchards in district Leh, during the years 2022 and 2023. The percentage of infestation by *Cydia pomonella* in on-tree fruits was recorded based on the percentage of fruit damaged.

**Varietal apple varieties for incidence of codling moth in 2022 and 2023**

 The data on the percentage of codling moth infestation on fruit trees of various apple varieties in the year 2022, is provided in Table 3**.** The analysis shows that the Tha-kushu variety had the highest mean per cent infestation (60.66%), followed by Mongol (41.66%). The lowest infestation was recorded in Phemar-khushu (30.66%). Similarly in the year 2023, the data on the percentage of codling moth infestation follows a similar trend but with a reduced infestation level as compared to the previous year. The results as indicated in Table 3, reveal that Tha-kushu had the highest Mean per cent infestation (50.33%), followed by Mongol (31.66%). The lowest infestation was noted in Phemar-khushu (23%).

The overall data on the percentage of codling moth infestation on fruit trees across different apple varieties during both years (2022 and 2023) indicates that none of the screed varieties are free from codling moth infestation. Further, it is found that, Tha-kushu had the highest Mean per cent infestation (55.49%), followed by Mongol (36.66%). The lowest infestation was noted in Phemar-khushu (26.83%). Our findings are in close agreement with Zaki (1999) who reported all the local cultivars of apples grown in UT Ladakh are heavily infested with codling moths. It is important to note that the kushu and mongol are late maturing crops while Phemar kushu is early maturing crop so that can be one of the reasons for Phemar khushu having the least infestation of the codling moth as they are inflicted by one generation of the pest while mongol and tha khushu are faced by two generations of the pests. This finding needs further evaluation because our findings are consistent with work reported by Akroute *et. al.* (2023) investigated how certain fruit traits influence preference by codling moths in Morroco. Their findings revealed that, regardless of climatic conditions, the insect favoured medium and late-maturing varieties over early-maturing varieties. To help create sustainable pest management plans, screening of fruit cultivars with resistance or tolerance to common pests and diseases needs to be sought after through varietal screening.Further studies should attempt to identify induced responses to the attacks of aphids on the cultivars of apricot, and codling moth on apples which would aid in understanding the resistance of fruit varieties and cultivars to the attacks of insect pests and aid future breeding programs to develop resistant cultivars.

**Table 3: Screening of local apple varieties for fruit damage caused by Codling Moth**

|  |  |  |
| --- | --- | --- |
|  |  | **Fruit damage (%)** |
| **S.no.** | **Varieties** | 2022 | 2023 | Pooled data |
| **1** | Tha-kushu | 60.66 (7.78) | 50.33 (7.09) | 55.49 (7.44) |
| **2** | Mongol | 41.66 (6.45) | 31.66 (5.62) | 36.66 (6.05) |
| **3** | Phemar-khushu | 30.66 (5.53) | 23.00 (4.79) | 26.83 (5.17) |
|  | Mean | 44.32 | 34.99 | 39.66 |

**\*Each values represents mean of 3 replications; figure in parenthesis are square root transformation**

**Conclusion**

 This study provides valuable insights into the susceptibility of different apricot and apple cultivars to major insect pests in the Trans-Himalayan region. Among the apricot varieties, Halman recorded the highest aphid infestation (47.76%), followed by Raksteykarpo (38.44%), while Narmo exhibited the least infestation (23.11%) and was classified as moderately resistant. Similarly, in apples, Tha-kushu experienced the highest codling moth damage (55.49%), followed by Mongol (36.66%), whereas Phemar-khushu had the lowest infestation (26.83%). The reduced damage in Phemar-khushu could be attributed to its early maturity, limiting exposure to multiple pest generations. These findings emphasize the significance of selecting pest-tolerant cultivars for sustainable fruit production in a region like Ladakh. While none of the screened varieties were completely pest-resistant, Narmo and Phemar-khushu demonstrated a relatively higher level of tolerance, however further scientific validation is needed to work on to check the genetic basis and biochemical references for resistance in the screened varieties. The study also highlights the need for further research to identify genetic traits associated with resistance and to develop more effective pest management strategies. As climate change continues to impact pest populations and behaviour, fruit growers in Ladakh must adapt to emerging challenges. Long-term studies, improved breeding programs, and integrated pest management (IPM) approaches will play a crucial role in mitigating losses while reducing reliance on chemical pesticides. By incorporating pest-resistant varieties and sustainable farming techniques, orchardists can enhance productivity and ensure the long-term viability of apple and apricot cultivation in the region.

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