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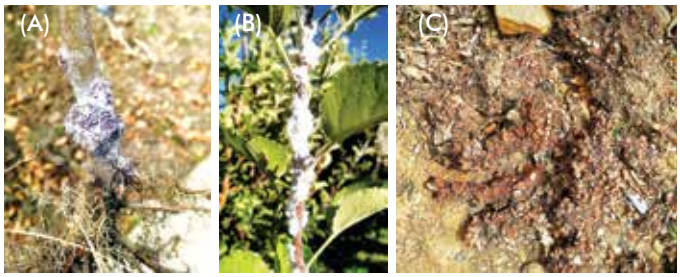
Woolly Apple Aphid in Dry Temperate Zone with Natural Farming

Under the changing climate scenario, with rising temperatures, the area apple cultivation is increasing in Spiti, and the orchardists are facing serious infestation of woolly apple aphids in their orchards. The nymphs and adults cause the damage by sucking the sap and forms characteristic knots or galls. Subterranean aphid colonies can kill the young apple plants with prolonged feeding, while fruits from heavily infested trees remain undersized, malformed and insipid in taste. Synthetic pesticides are capable of eliminating pest populations but they also pose a threat to non-target organisms, development of pesticide resistance, and have negative environmental impacts, especially in the fragile agro-ecosystem of these cold desert regions. Natural farming has demonstrated successful pest control using low-cost, locally sourced inputs when compared to conventional farming methods in the region.

SPITI Valley is a remote tribal region and is an integral part of Indian cold deserts and located in the western Himalayan region in India. Apple has become an important cash crop in this tribal area, contributing significantly to the economy of farmers. Although very less area is occupied by apple orchards in comparison to other apple-producing areas in the state, the produce from the apple orchards in Spiti is of very good quality fetching the highest prices in the market. Agriculture in Spiti (dry temperate zone), Himachal Pradesh is the mainstay of the local economy and shares a delicate balance with the geo-climatic conditions of this cold desert region. The area is characterized by harsh climatic conditions with monsoon shadow Himalayas *i.e.* dry and cold weather, low temperature, heavy snowfall and scarce annual rainfall of about 50-150 mm resulting in erosion and landslides. Apart from green pea, apple is considered an important source to increase the economy of resource-poor farmers of this tribal area. With the changing climate scenario, rising temperatures in the valley is resulting in bringing more area under apple cultivation with every passing year and subsequently the orchardists are facing some problems about woolly apple aphid infestation in their orchards.

Apple plants at Tabo, Spiti, Himachal Pradesh

Woolly apple aphid, *Eriosoma lanigerum* (Hausmann) (Family: Pemphigidae) is one of the most destructive pests of apple in the world. In India, it is an exclusive pest of apple and crab apple. It is an exotic pest but specific to apple and is well spread in all apple-growing regions of India. It was first recorded at Conoor in 1889, and later in 1909 from Kumaon and Shimla hills. The aphid secretes woolly filaments of wax over their bodies and hence is named woolly aphid. Dispersal of this pest is mainly through nursery stock and sometimes through first-instar nymphs if branches of trees are touching each other. The pest is active throughout the year attacking primarily the roots but winged forms also infest trunks, branches, stems, twigs, leaf petioles and fruit stalks. The tissues around the feeding zone undergo excessive cell division and elongation resulting in formation of galls or knots which may split up in 1-2 months. Such splits can act as point of entrance for



Infestation of WAA on (A) nursery plants; (B) shoots of apple tree; (C) infected roots

pathogens. Severe galling interferes with nutrient uptake resulting in nutrition imbalance which ultimately reduces vitality and yield. Infested nursery plants are the main source of spread of this aphid. The infested plants have pale green leaves and whitish cottony patches on stems and branches. The nymphs and adults cause damage by sucking sap from the branches, twigs and roots. They keep on moving from aerial parts to the root zone and vice versa. Usually, the affected plants remain stunted with greatly reduced bearing capacity. In case of young trees, the roots disintegrate to such an extent that these trees are easily uprooted by even moderately strong winds. Further, the fruits from the heavily infested trees are of poor quality, being undersized, malformed and insipid in taste. The pest multiplies rapidly and is conspicuous during June-August. No specific monitoring procedures or treatment thresholds have been developed for woolly apple aphids. Generally, monitoring should begin in mid-summer or perhaps earlier if the winter is mild. If many colonies are in the fruiting zone of the tree, treatment will probably be needed.

Wolly Apple Aphid under Natural Farming

Natural farming aims to promote traditional indigenous practices which reduces externally purchased inputs and exclusion of all synthetic chemical inputs. Natural farming has also been adopted in Himachal Pradesh through its *Prakritik Kheti Khushhal Kisan Yojana* (PK3Y). Natural Farming is comprised of chemical-free alias traditional farming methods. It is considered an agroecology-based diversified farming system which integrates crops, trees and livestock with functional biodiversity.

Under Natural Farming, *Agniastr* is being used as a homemade liquid form pesticide (Table 1) which is used to kill or repel insect pests and also increase the richness of the soil. It contains cow's urine as a main ingredient which has antibodies and lots of beneficial factors. A creeper, commonly known as *Thuklang* (*Hyoscyamus niger* L.) in Spiti Valley, was used in the preparation of *Agniastr* as a herbal input in place of neem, which is not locally available. It is also known as *Khurasani ajwain, henbane, black henbane* or *stinking nightshade* in Spiti and is poisonous in large quantities. This herb belongs to the family Solanaceae and is an upright, hairy, and viscous plant. Its basal leaves are oblong-ovate with coarse serrations on the edges, and are attached to the stem *via* petioles. The leaves that grow up the stem are oval-shaped, with an irregularly lobed or pinnate structure, and no petioles. The flowers are a bright green colour with purple veins, with lower ones in the branch forks and upper ones growing singly in the axils of the leaf-like bracts, forming a one-sided spike. This plant is commonly found in open areas and along roadsides at an elevation of 3000-3600 meters in dry temperate zone. Its insecticidal significance lies in the high concentration of alkaloid compounds, such as hyoscyamine and scopolamine that have a direct effect on the central nervous system.

Table 1. Composition of *Agniastr* used at Spiti against woolly apple aphid under natural farming

Particulars	Quantity
Leaves of local herb (*Thuklang*)	5 Kg
Cow urine	20 litre
Tobacco powder	500 gm
Green chilli paste	500 gm
Garlic paste	250 gm

Agniastr was made up by mixing crushed leaves of *Thuklang* (local herb), tobacco powder, spicy chilli and garlic paste in cow's urine and cooked at low flame till the boiling point. The solution was kept for 48 hours and was rotated with stick during the morning and evening hours for 2-3 minutes in clockwise direction. The solution was diluted as 5 litres of concentrated *Agniastr* in 200 litres of water (for application) with a precaution that this *Agniastr* concentrate must be used within three months of manufacture.

The trials on the efficacy of conventional farming (CF) (Chloropyrifos 20EC), organic farming (OF) (Azadirachtin 0.003%) and natural farming (NF) (*Thuklang* local shrub as the main ingredient in *Agniastr*) products for the management of woolly apple aphid (*E. lanigerum*) population and subsequent effects on the population of its parasitoid wasp (*A. mali*) were conducted during 2020-21 and 2021-22 in three different blocks with 40 apple (*cv.* Royal Delicious) plants in each block at Regional

Woolly apple aphid colonies on twigs of apple tree in Spiti

Table 2. Population of woolly apple aphid and parasitoid wasp in different farming methods before and after treatment

	Plant protection methods of apple cultivation					
	Conventional Farming (Chloropyrifos 20EC)		Organic Farming (Azadirachtin 0.03%)		Natural Farming (Thuklang)	
	Before (Pre-count)	After (7 DAT)	Before (Pre-count)	After (7 DAT)	Before (Pre-count)	After (7 DAT)
Woolly apple aphid* **Eriosoma lanigerum	6.36	0.10	7.48	4.48	6.06	2.96
Parasitoid wasp *** *Aphelinus mali*	1.20	0.00	2.74	2.88	1.54	0.82

*Number of woolly apple aphid colonies per twig (cottony masses clustered)

**Ten number twigs counted per tree and ten trees per treatment

***Ten number of leaves per tree and ten trees per treatment

(A) Exotic parasitoid *Aphelinus mali; (B) Local shrub, Hyoscyamus niger* used in *Agniastr*

Horticulture Research Sub-station and Krishi Vigyan Kendra, Lahaul & Spiti II at Tabo, Dr. YSP University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. Infestation of Woolly apple aphid (WAA) was recorded on apple trees under all systems at weekly intervals from June-August (peak activity time) in both cropping seasons.

Impact of Natural Farming

The results indicated a sharp and effective decline of the woolly apple aphid population in conventional farming (CF) while it also destroyed the population of parasitoid wasps, whereas in natural farming (NF) 2.96 number of woolly apple aphid colonies per twig (cottony masses clustered) after 7 days of treatment were recorded. Maximum population of parasitoid wasp (2.88) was observed in apple block of organic farming (OF) where *Azadirachitin* 0.03% as biopesticide was applied. Possible reason for the build-up of wasp parasitoid population is the availability of abundant host (4.48 number of woolly apple aphid colonies per twig) after 7 days of treatment (Table 2). Under natural faming, the killing, repellent and deterrent behaviour of local shrub was found effective against the woolly apple aphid population build-up and was found to maintain population below that which can cause economic losses in terms of crop yield. The possible reason for repellent behaviour regarding the parasitoid wasp is the odour of *Jeevaamrit* (cow urine) which is being regularly applied in the natural farming apple block and low availability of insect host colonies.

The Economic Threshold Level (ETL) in woolly apple aphid is a mystery which is based on parameters that are changing all the time, damage or losses caused by a certain density cannot be predicted at all and often remain unknown. Farmers have to consider many other aspects of the crop (crop ecology, growth stage, natural enemies, weather conditions, etc.) and their own economic and social situation before they can make the right pest management decisions.

The unfair approach of managing the sucking insect pests by synthetic insecticides in apple has dictated the necessity for evolving cost-effective, eco-friendly and safe pest management strategies without using any chemical toxicants. Fortification of cow urine with leaf extracts of local herb resulted in a decrease in the woolly apple aphid population with significantly equal yield over conventional farming. Hence it proved an eco-friendly alternative to hazardous pesticides.

CONCLUSION

In the present study, the natural farming system appears to be effective in suppressing woolly apple aphid population. The main component in the solution mixture was cow urine which upon fermentation releases ammonia and other gases which probably repel woolly apple aphid adults from colonisation. Other ingredients like tobacco also have insecticidal action of nicotine and other organic acids which is well reported by several scientists, garlic bulb extracts naturally rich in sulphur also reported as toxic to aphids while chilli with Capsaicin also acts as repellent against sucking pests. Use of the local shrub *H. niger* (*Thuklang*) in the form of *Thuklanster* was effective against sucking insect pests like woolly apple aphid in apple of Spiti Valley. Therefore, large-scale adoption of this farming will increase the net income of the farmers. By using such products in an integrated approach will help to reduce the use of synthetic pesticides from entering into the environment and also reduce the cost of production.

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