Indian Journal of Agricultural Sciences **89** (9): 1547–9, September 2019/Short communication
https://doi.org/10.56093/ijas.v89i9.93523

Relative resistance of indigenous and exotic accessions of apple against woolly apple aphid (*Eriosoma lanigerum*)

K C NAGA[1], R K SHARMA[2], S SUBRAMANIAN[3], M K VERMA[4], K K PRAMANICK[5] and J KUMAR[6]

ICAR-Indian Agricultural Research Institute Regional Station, Shimla, Himachal Pradesh 171 004, India

Received: 24 September 2018; Accepted: 13 February 2019

Key words: Apple, Himalayan wild apples, Host plant resistance, Woolly apple aphid

Apple (*Malus domestica* Borkh.) is one of the most economically important fruit crops of the temperate zones of the world (Harris *et al.* 2002). Among the several types of insect pests, arthropod creating bottleneck in higher production of apple (Schoonhoven *et al*. 2005) the woolly apple aphid (WAA), *Eriosoma lanigerum* (Hausmann) is an important pest of apples in many apple growing countries including India. WAA, a serious pest of apples, particularly on young trees in the orchard, can also weaken mature trees (Staniland 1923). Galls are formed at feeding site on the roots and shoots (Staniland 1924). Subterranean aphid colonies can kill the young apple plants with prolonged feeding, while it impacts on both the number and weight of fruit, on mature trees (Brown *et al*. 1995). Although the aerial population of WAA is regulated by a parasite, *Aphelinus mali* (Haldeman), the colonies on the roots, however, escape parasitization and are difficult to be controlled by insecticides. Host plant resistance involving resistant rootstocks is considered to be the durable means of pest management for WAA.

'Northern Spy' apple cultivar identified as resistant to WAA has been used as a parent in the breeding programs to obtain resistance apple rootstocks against WAA. The apple rootstocks such as Malling (M) and Malling Merton (MM), resulting from those breeding programs are being propagated commercially. However, several studies indicate the apparent breakdown of resistance to WAA in some of the derived lines. WAA infestation in propagation bed of resistant rootstocks such as MM in South Australia (Knight *et al*. 1962), Northern Spy, Merton and MM rootstocks in South Africa (Giliomee*et al*. 1968) created severe losses to nursery industry. Hence, identification of novel resistant sources is considered as significant aspect of breeding strategy for durable resistance against WAA and for sustainable management of WAA on apples. Keeping in view the importance of the issue, the present experiment was conducted to identify resistance against woolly apple aphid among apple accessions belonging to six different species.

Twelve apple accessions, belonging to six apple species were used to screen relative resistance against WAA (Table 1). The experiment was conducted at IARI Regional Station, Shimla, India (1900 MSL, 31° 06' 21.6"N, 77° 07' 02.5"E). Mound layering was followed to obtain the apple clones; the apple clones were maintained in pots under glasshouse conditions; one and half year old plants were used for screening against WAA during May, 2014. Aphid colonies derived from progeny of a single apterous virginop araeadult was maintained on a susceptible apple variety (Golden Delicious) in a glasshouse at 25 ± 5°C; RH 70% conditions. Established colonies were used, to infest different apple accessions. Six replicate of each apple accessions were used for screening against WAA.

One hundred adult aphids were inoculated on each apple accessions. The inoculation was repeated five times for further colony establishment. Monitoring of aerial colonies of WAA commenced two months from date of inoculation and continued for six months and observations were made during the first week each month. Each tree was rated on a rating scale of 0–4 using a visual indexing technique Bower (1987) (Table 2).

Regular screening of apple accessions is necessary to generate a data base of varietal resistance to WAA. This would help in identification of resistance sources which can be used in resistance breeding programs. The current study was undertaken to find resistance source in indigenous Himalayan wild apples (*M. Baccata* Shillong, *M. baccata* Kashmir, *M. baccata* Kinnour and *M. baccata* Dhak) in comparison with standard resistant checks (Northern spy and its derivates MM 111 and MM 106).The variability in the experiment was reduced by conducting the experiment in protected glasshouse conditions thereby reducing the chances of extrinsic resistance. Repeated inoculations of WAA were done to reduce the chances of pseudo-resistance. Moreover,

[1]Research Scholar (kailashnaga3j@gmail.com), [2,3]Principal Scientist (rksharma57@iari.res.in, subramanian@iari.res.in), Division of Entomology, [4]Principal Scientist (mkverma@iari.res.in), Division of Fruits and Horticultural technology, ICAR-IARI, New Delhi, [5]Head, Principal Scientist (head_shimla@iari.res.in) [6]Technical assistant (jatin.k.verma@gmail.com), ICAR-IARI, Regional Station, Shimla.

Table 1 Apple accessions used in the experiment

Common name	Botanical name	Distribution/Origin
Maruba apple	*M. prunifolia* var. Maruba Borkh.	Northern China and eastern Siberia
Chinese apple	*M. prunifolia* var. ringo Asami	China
Paradise apple	*M. pumilla* Mill.	Europe, including Britain, from Scandanavia south and east to Spain, Greece and S.W. Asia
Sargent crab apple	*M. sargentii* Rehder	Japan
Nagasaki zumi	*M. x maicromalus* Makino	Japan
Kashmir	*M baccata* (Linn.) Borkh	J & K, India
Kinnour	*M. baccata* (Linn.) Borkh	Himachal, India
Dhak	*M. baccata* (Linn.) Borkh	Himachal, India
Shillong	*M. baccata* (Linn.) Borkh	Meghalya, India
Northern spy	*M. domestica* (Linn.) Borkh	East Bloomfield, New York, USA
MM 111	Northern spy × Merton 793 (*M. domestica*)	Merton, England
MM 106	Northern spy × M 1 (*M. domestica*)	Merton, England

Table 2 Visual indexing technique and ratings for monitoring of aerial colonies of WAA

Rating scale	Infestation level
0	Nil infestation
1	Trace infestation
2	Up to 10% of the tree with severe infestation
3	Up to 25% of the tree with severe infestation
4	More than 25% of the tree with severe infestation

the aphids used in our experiments were homogeneous as they had been derived from a single apterous virginoparae adult female. Woolly apple aphids colonize the plants and the colony of aphids remain surrounded by woolly mass, hence population based observations are difficult. Hence, the extent of damage by woolly aphid on apple accession is better reflected by damage symptoms. We have followed visual rating scale as demonstrated earlier by Bower (1987), Ateyyat and Al-Antary (2009), Abu-Romman, and Ateyyat (2014).

The mean infestation of WAA on the apple accessions varied from 3.42. Three apple accessions scored the lowest (zero) mean infestation rating, viz. Northern spy, *M. prunifolia* var. Maruba and *M. prunifolia* var. Ringo Asami. The *M. baccata* (Kashmir) and *M. pumila* cored the highest (3.42) mean infestation rating followed by *M. baccata* (Dhak) (3.17), *Malus* spp. Nagasaki zumi (2.96), *M. sargentii* (2.50), *M. baccata* (Kinnour) (1.42), *M. baccata* (Shillong) (0.50), MM 106 (0.50) and MM 111 (0.42) (Table 3).

It was observed that Northern spy, *M. prunifolia* var. Maruba and *M. prunifolia* var. Ringo Asami could be categorized as immune, as these apple accessions did not support a single WAA colony during course of evaluation.

Table 3 Woolly apple aphid infestation rating on different apple accessions

Apple accessions	July	August	September	October	November	Mean rating
NS	0.00	0.00	0.00	0.00	0.00	0.00
MPM	0.00	0.00	0.00	0.00	0.00	0.00
MPR	0.00	0.00	0.00	0.00	0.00	0.00
MM111	0.33	0.33	0.50	0.50	0.00	0.42
MM106	0.50	0.50	0.50	0.50	0.00	0.50
MBS	0.33	0.33	0.67	0.67	0.00	0.50
MBKN	1.00	1.17	1.67	1.83	1.00	1.42
MS	1.83	2.50	3.00	2.67	1.83	2.50
NZ	2.33	3.00	3.33	3.17	1.83	2.96
MBD	2.50	3.33	3.50	3.33	2.17	3.17
MBK	2.67	3.50	3.67	3.83	2.17	3.42
MP	2.83	3.50	3.67	3.67	2.33	3.42

NS- Northern Spy; MPM- Maruba (*M. prunifolia*); MPR- RingoAsami (*M. prunifolia*); MM111; MM106; MBS- *M. baccata* (Shillong); MBKN- *M. baccata* (Kinnour); MS- *M. sargentii*; NZ- nagasaki zumi; MBD- *M. baccata* (Dhak); MBK- *M. baccata* (Kashmir); MP- *M. pumil**a.***

It is significant to note that even the alate forms of WAA developing on the susceptible apple accessions could not establish and colonize on these apple accessions. Our observations are in consistent with the findings of Knight *et al.* (1962) who reported that Northern spy could not be colonized by WAA. Mackenzie and Cummins (1982) also reported that WAA could not reach up to the reproductive stage on Northern spy. The resistance characteristic against WAA of *M. baccata* (Shillong) and susceptibility of *M. baccata* (Dhak) was also observed by Kishore *et al*. (2006).

The host plant resistance in apple germplasm against WAA infestation has been attributed to three major resistance genes *Er1*, *Er2* and *Er3* (Bus *et al*. 2008). The variable resistance levels in different apple accessions as reported in this study also supported by (Knight *et al*. 1962, Machenzie and Cummins 1982, Kishore *et al*. 2006), underscore the need for functional characterization of these three resistance genes and the mechanism of resistance in different resistant cultivars.

SUMMARY

Twelve apple accessions, belonging to six apple species were screened to ascertain the relative resistance against Woolly apple aphid (WAA), *Eriosoma lanigerum* (Hausmann). The experiment was conducted at ICAR-Indian Agricultural Research Institute Regional Station, Shimla, India (1900 m, 31°06' 21.6''N, 77°07'02.5''E) during 2014–16. The screening was done by visual indexing technique of apple accessions based on mean infestation of WAA on a 0–4 rating scale. The mean infestation rating differed significantly among apple accessions and ranged from zero to 3.42. Three apple accessions were scored the lowest (zero) mean infestation rating, i.e. Northern spy, *M. prunifolia* var. Maruba Borkh. and *M. prunifolia* var. Ringo-Asami. The *M. baccata* (Kashmir) and *M. pumila* were scored the highest (3.42) mean infestation rating, a pair wise comparison using Kruskal-Wallis test shows a significantly higher mean infestation on apple accessions *M. baccata* (Dhak), *M. baccata* (Kashmir) and *M. pumila* compare to Northern spy, *M. prunifolia* var. Maruba and *M. prunifolia* var. ringo Asami.The present study gave an update of resistance screening of apple accessions against WAA by Kishore *et al*. (2006) and this data set may help in identifying resistance sources which may directly be used as rootstocks to combat the edaphic WAA problem in apple and the identified resistance sources could be utilized for developing improved apple accessions with durable resistance and improved quality traits of high yielding apple cultivars. Further studies are required to unravel the mechanism of resistance in resistant apple accessions against WAA.

REFERENCES

Ateyyat M A and Al-Antary T M. 2009. Susceptibility of nine apple cultivars to woolly apple aphid, *Eriosoma lanigerum* (Homoptera: Aphididae) in Jordan. *International Journal Pest Management* **55**(1): 79–84.

Bower C C. 1987. Control of San José scale (*Comstockaspis perniciosus* (Comstock) (Hemiptera: Diaspididae) and woolly aphid, *Eriosoma lanigerum* (Hausmann) (Hemiptera: Pemphigidae) in an integrated mite control program. *Plant Protection Quarterly* **2**: 55–8.

Brown M W, Schmitt J J, Ranger S and Hogmire H W. 1995. Yield reduction in apple by edaphic woolly apple aphid (Homoptera:Aphididae) populations. *Journal of Economic Entomology* **88**: 127–33.

Bus V G M, Chagné D, Bassett H C M, Bowatte D, Calenge F, Celton J M, Durel C E, Malone M. T, Patocchi A, Ranatunga A C, Rikkerink E H A, Tustin D S, Zhou J, Gardiner S E. 2008. Genome mapping of three major resistance genes to woolly apple aphid, *Eriosoma lanigerum* (Hausmann). *Tree Genetics and Genomics* **4**: 223–36.

Giliomee J H, Strydom D K and Van Zyl H J. 1968. Nothern Spy, Merton and Malling-Merton rootstocks susceptible to woolly aphid, *Eriosoma lanigerum*, in the Western Cape. *South African Journal of Agricultural Science* **11:** 183–6.

Harris S A, Robinson J P and Juniper B E. 2002. Genetic clues to the origin of the apple. *Trends in Genetics* **18**(8): 426–30.

Kishore D K, Pramanick K K and Sharma S K. 2006.A crab apple from India suitable for high density orcharding in apple. (In)'Proceeding of National Symposium on Production, utilization and Export of Underutilized fruits with Commercial Potentialities' held at Bidhan Chandra KrishiViswavidyalaya, West Bengal, 2006. pp. 60– 4.

Knight R L, Briggs J B, MasseeA M and Tydeman H M. 1962: The inheritance of resistance to woolly aphid, *Eriosoma lanigerum* (Hausmann) in the apple. *Journal of Horticulture Science* **37:** 207–18.

MacKenzie J D and Cummins J N. 1982. Differentiation of *Malus* clones into resistance classes by their effects on the biology of *Eriosoma lanigerum* (Hausmann). *Journal of the American Society for Horticultural Science* **107:** 737–40.

Schoonhoven L M, van Loon J J and Dicke M. 2005. *Insect-Plant Biology*. Oxford University Press, Oxford, UK.

Staniland L N. 1923. The immunity of apple stocks from attacks of woolly aphis, *Eriosoma lanigerum* (Hausmann), part 1. The relative resistance of different root stocks. *Journal of Pomology and Horticulture Science* **3:** 85–5.

Staniland L N. 1924. The immunity of apple stocks from attacks of woolly apple aphids (*Erosoma lanigerum*) part II.The cause of relative resistance of root stocks. *Bulletin of Entomological Research* **15**: 127–33.