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Studies on population dynamics and management of pomegranate aphid, *Aphis punicae* Passerini (Hemiptera: Aphididae) on pomegranate under semi-arid conditions of South-western Punjab

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ABSTRACT

Pomegranate aphid (*Aphis punicae*) is an important pest of the pomegranate. Seasonality of *A. punicae* and its relationship with weather factors were observed during 2015 and 2016 at the Regional Research Station, Abohar of Punjab Agricultural University. We analyses temporal patterns in *A. punicae* abundance, and also highlights the factors influencing its abundance. Principal Component Regression Analysis (PCRA) was used to find out the relationship between abundance of *A. punicae* and the climatic variables. The population build-up of *A. punicae* peaked in 12th SMW (160.25 aphids / 10 cm twig). The optimum range of temperature (Tm 21.44 °C – 30.77 °C; Tmn 7.52 °C–15.72 °C) and humidity (RHm 97.20%–98.64%; RHmn 44.39%–39.17%) for the multiplication of *A. punicae* population was depicted. Among different cultivars of pomegranate, Bhagwa was most and Phule Arkata was least susceptible to *A. punicae* infestation. The prediction model formulated based on maximum, minimum temperature, maximum minimum relative humidity, radiation and wind speed using Principal component regression technique performed well with reasonably accuracy (R^2 = 0.88) to forecast *A. punicae* population on the pomegranate plants. Regarding the management of *A. punicae* in field the different pesticides tested gave 42.33–96.60% reduction of *A. punicae* population. The results were persisted upto 15 days of the treatment. The greatest control of *A. punicae* was achieved by flonicamid > thiamethoxam > imidacloprid > Azadirachtin > HMO > Rogar. Both Azadiractin and HMO were found least harmful to predators of *A. punicae* with an average reduction of 14.27–16.67 % at different dosages after 14 days of treatment. Rogar, imidacloprid, flonicamid and thiamethoxam was found high to moderately toxic to predators with 38.46–64.28% reduction of coccinelid larvae/adults. These results suggested that *A. punicae* population dynamics on pomegranate was greatly influenced by climatic variables and host nutrition and both azadirachtin and HMOs can be considered as potential weapons for controlling *A. punicae* as they are significantly less toxic to *A. punicae* predators.

1. Introduction

Pomegranate (*Punica granatum* L.) is one of the ancient, high value fruit crop commercially cultivated in India. In 2016-17, the gross area and production under this crop was 209,000 ha and 2,442,000 MT (Anon, 2017). Under field conditions, the plants of pomegranate are being attacked by different insect pests which influence the productive health of the plant. The pomegranate aphid, *Aphis punicae* Passerini is an important pest of pomegranate and is found to colonize/feeding on newly developed leaves, tender shoots, flowers, flower buds and developing fruits (Sreedevi et al., 2006; Rouhani et al., 2013; Abd-Ella, 2015). Both adult and nymphs feed by sucking sap which resulted in discolouration of the affected parts. Severe infestation may lead to stunted growth and drying of tender parts (Moawad and Al-Barty, 2011). Also, the aphids secrete honey dew the accumulation of which causes sooty mould thus, inhibiting the photosynthetic activity and leads to remarkable loss in yield and quality.

Weather parameters like temperature, relative humidity and rainfall, wind speed and wind direction and radiation has a profound effect in the fluctuations of insect numbers, survival, development, reproductive potential as well as host plant interactions (Bale et al., 2002 and Tomar, 2010). Complete physiology and development of living organisms undergoes unexpected shifts at particular threshold values (Allen and Breshears, 1998; Easterling et al., 2000a,b). Existing studies suggest that direct effects of temperature are likely to be larger and more important for the growth and development (Bayhan et al., 2005).

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Use of chemicals, mostly systemic insecticides, is a widely followed method for the management of *A. punicae* (Verghese and Jayanthi, 2001; Kambrekar et al., 2013; Kambrekar and Biradar, 2015 and Abd-Ella, 2015). However, the sole dependence on the chemicals has resulted in several ecological and physiological problems for humans, animals and beneficial insects. Also, as both the insects and their natural enemies belong to same class, insecticides usually cause mortality in both (Croft, 1990). In this concern, botanicals and mineral oils are being the safe options with various benefits such as reduced environmental degradation, safety for farm workers, high food safety, reduction in pesticide resistance and improved profitability of production (Erdogan et al., 2012). Keeping in view the present study was aimed to investigate the infestation of *A. punicae* in different cultivars of pomegranate, to develop correlation of different weather parameters to *A. punicae* population and development of aphid population and the effect of ecofriendly options on the management of pomegranate aphid and their effect on its natural enemies under field conditions.

2. Materials and methods

The study was carried out during the years 2015 and 2016, at the experimental farm of the Punjab Agricultural University Regional Research Station, Abohar, India located at 30°08′N; 74°12′E with an altitude of 185.78 above mean sea level. It receives 75–300 mm of annual rainfall occurring mostly during July to September. Climate of study area is semi-arid, characterized by hot and dry weather. According to Köppen-Geiger system of classification, this type of climate has been symbolized as BWh. During the experimental period, the mean monthly temperatures ranged between 16.02 °C–40.51 °C. The study was conducted in a 7-year old pomegranate orchard (*cv. Bhagwa, Mridula, Phule arkata and Ganesh*) consisting of 80 trees planted at a spacing of 15 × 15 feet. The orchard was maintained on recommended horticultural practices by Punjab Agricultural University, Ludhiana (Anon, 2016). The daily weather data was recorded on Automatic Weather Station (Model No. DCPAW502, BioScientific Limited, UK).

2.1. Infestation of pomegranate cultivars to A. punicae

Nine plants (3 plants/ replication) of each variety were randomly selected, marked and tagged for taking insect observations. The sampling unit was a 10 cm terminal shoot (5 shoots/tree) randomly selected from four directions *viz.,* East, South, West and North of the plant canopy. Thus, 45 terminal shoots were sampled per variety at weekly interval starting from 5th SMW to 18th SMW (Standard meteorological Week) for their reaction to *A. punicae* infestation during the years 2015 and 2016. The sampling involved visual *in situ* field estimation of *A. punicae* population. Also, to study the effect of major nutrient elements on the population build-up of *A. punicae* the leaf samples (8th pair of leaf) from growing tip were taken during March. Samples were prepared and analysed for N, P and K content as per the method described by Jackson (2005).

2.2. Chemical and biopesticides

Commercial formulation of thiamethoxam (Actara 25% WG, Syngenta Crop Protection), imidacloprid (Confidor 17.8% SL, Bayer Crop Science), Flonicamid (Ulala 50% WG, United Phosphorus Limited), dimethoate (Rogar 30% EC, Cheminova India Limited), azadirachtin (Neembicidine 300 ppm, T Stanes & Company Limited) and Horticulture Mineral Oil (MAK All Season HMO 89% EC, Bharat Petroleum Corporation Limited) were used. Based on preliminary tests, different concentrations of each pesticide were prepared with distilled water and sprayed on the plants to study the efficacy of these products for aphid management.

2.3. Management of A. punicae

Pomegranate trees (*cv. Bhagwa*) infested with *A. punicae* was used. Experiment was conducted in RBD (Randomized Block Design) with three replications of each treatment. There were five trees in each replication. Spraying of trees was done using a 15 L power operated knapsack sprayer (Mohindra GA-914) @ 5 L of spray solution to each tree. In control treatment pomegranate trees were sprayed with water only. Sampling was carried out one day before spray and 3, 7, 10 and 14 days after the spray. For sampling, 5 twigs of 10 cm length on each direction of the tree were randomly picked. The numbers of *A. punicae live* adults on each twig were counted. Aphids were considered to be dead if their bodies or appendages did not move when prodded with a fine brush. Also the effect of spray solutions on the activity of its predators *viz*. coccinellids and *Chrysoperla carnea* larvae at weekly intervals was recorded in terms of counts one day before and 14 days after the spray. The corrected efficacy percentage was calculated as per Henderson and Tilton (1955):

$$\text{Corrected Mortality \%} = 1 - \frac{N \text{ in control before spray} - N \text{ in treatment after spray}}{N \text{ in control after spray} - N \text{ in treatment before spray}} \times 100$$

Where: N = number of aphid population;

2.4. Statistical analysis

The data generated was subjected to analysis of variance. Principal Component Analysis (PCA) and development of regression equation for prediction of *A. punicae* population were done using SPSS (Version 20, SPSS, Inc., Chicago, Il, USA).

3. Results

3.1. Aphid infestation in pomegranate

The pooled data for the year of 2015 and 2016 revealed that *Aphis punicae* infestation on new flush of pomegranate (cv. *Bhagwa*) started with the rise in temperature in the last week of January (Fig. 1). It was observed to suck the sap from the tender leaves, shoots, flower buds and developing fruits of pomegranate from early February to April (Fig. 1). The population of *A. punicae* on pomegranate ranged from 2.65 ± 0.82–160.25 ± 5.62 during the study period *i.e* from SMW (Standard Meteorological Week) 5 to SMW 18 (Fig. 1). After that the population of *A. punicae* start decreasing and almost disappears in first week of May (Fig. 1). The population of *A. punicae* peaked during 12th SMW and was found to be lowest in 18th SMW. Furthermore, both the upper and lower boundaries of temperature and humidity greatly influenced the population dynamics of *A. punicae*. When we plotted (Fig. 1) the *A. punicae* population dynamics data against the various weather parameters, it was observed that a typical optimum range of temperature (Tma x 21.44 °C – 30.77 °C; Tmin 7.52 °C–15.72 °C) and humidity (RHmax 97.20%–98.64%; RHmin 44.39%–39.17%) was required for the buld-up of *A. punicae* population (Fig. 1). Beyond this range, the population of *A. punicae* followed a decreasing trend and reached to minimum level in 18th SMW when maximum temperature touched 39.95 °C (Fig. 1).

3.2. Screening of pomegranate cultivars to A. punicae

The results of the experiment revealed maximum (63.08 ± 5.53–129.24 ± 10.25 aphids / twig) and minimum (6.02 ± 1.32–12.06 ± 1.80 aphids / twig) infestation levels in different cultivars screened during the month of March and April, respectively (Fig. 2). Cultivar Bhagwa (F_3 = 66.27 aphids / twig and $p < 0.05$) was found statistically susceptible to *A. punicae*. However,