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Incidence and management of coconut scale, *Aspidiotus destructor* signoret (Hemiptera: Diaspididae), and its parasitoids on mango (*Mangifera* sp.)

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ABSTRACT

Populations of coconut scale, *Aspidiotus destructor* Signoret (Hemiptera: Diaspididae), and its parasitoids were surveyed on 4 mango cultivars in the southern district of Khyber Pakhtunkhwa, Pakistan, from July 2011 to June 2013. The populations of *A. destructor* built up in July and continued for 6 consecutive months reaching a peak in November 2011 (54 scales/leaf) and in October 2012 (44 scales/leaf). Two parasitoids, *Aphytis melinus* DeBach (Hymenoptera: Aphelinidae) and an *Anagyrus* sp. (Hymenoptera: Encyrtidae) were first observed in August, reaching peaks in November 2011–12 and 2012–13 (13.6 and 16.3% parasitism) and December 2011–12 and 2012–13 (14.2 and 14.9% parasitism), respectively for the two species. The efficacy of two winter oils, one IGR (pyriproxyfen 10.8 EC), one organophosphate (profenofos 500 EC), one pyrethroid (bifenthrin 10 EC), and two neonicotinoid insecticides (imidacloprid 20% SL and thiamethoxam 25 WP) were evaluated at recommended rates against 1st and 2nd instars and mature *A. destructor* on nursery plants and mature mango trees. In both cases, the highest *A. destructor* mortalities were recorded with petroleum oil, imidacloprid and pyriproxyfen. Thiamethoxam was effective after 14 days (70–80 % scale insect mortality) while bifenthrin showed good results against all life stage in the first 14 days. For management of *A. destructor*, parasitoids may be conserved by using oils and insect growth regulators (IGRs) while systemic insecticides may also be used in the case of severe infestations. The 1st spray must be applied in early August (before parasitoids emergence), the 2nd spray in October, as one spray controls the pest for one month. One dormant spray may be applied in February after pruning of infested leaves and branches to clean the plants from *A. destructor* for the next season.

1. Introduction

Mango (*Mangifera indica* L.) (Anacardiaceae) is ranked as second important fruit after citrus and third cash crop after cotton and rice in Pakistan (Anonymous, 2011). Pakistan is the fifth major producer (FAO, 2013) and third major exporter (Shahnawz et al., 2012) of mango in the world. During 2010–11, the area of mango crops was 171.9 thousand hectares and total production was 1885.9 thousand tons/annum (Anonymous, 2010–11).

In Pakistan, mango is attacked by 86 different species of insect pests (Qureshi and Mohiuddin, 1982). Of these, 27 scale insect species have been recorded from mango (Mohyuddin and Mahmood, 1993), in which *Aspidiotus destructor* Signoret is a very serious pest throughout the country (Mohyuddin, 1981). *A. destructor* was first reported from Punjab Province by Rehman and Ansari (1941) and Sindh Province by Cavin in 1956 (UK CAB International, 1966) while its damage and distribution was provided by Ansari (1942). *A. destructor* is a pest of over 75 plant genera in 45 families in both tropical and sub–tropical areas especially on various varieties of coconut, banana, avocado, mango, guava, citrus, cocoa, papaya, breadfruit and tea (Simmonds, 1960; Howard et al., 2001; Mariau, 2001).

A. destructor mostly attacks the underside of leaves but other parts including fronds, flowers and younger plants are also affected

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in the case of severe infestations; however, older trees more than 4 years old or trees in well–drained soil are less infested (Watson, 2005). Highly infested leaves become curled, yellow and drop from trees. As a result, fruit become malformed, dwarf and sub-standard in quality. The pest can also cause plant death especially in an environment where natural enemies are scarce (DeBach, 1974). *A. destructor* damaged 300,000 out of 400,000 coconut plants over three years in North Celebes (Indonesia) and reduced the coconut production up to one third in 1955 after three years of its invasion (Reyne, 1948; Simmonds, 1960).

Aphytis melinus DeBach (Hymenoptera: Aphelinidae) is an important parasitoid of *A. destructor* (Ahmad and Ghani, 1972). In Pakistan, 37% parasitism of *A. melinus* was observed on *A. destructor* infesting mango plants. The parasitoid lays 25–49 eggs per female in 7–16 days on *A. destructor* within 24 h after emergence. It parasitizes the host at both low and high densities and has been recorded from all parts of Pakistan. *A. melinus* is another important parasitoid of other scale insects including *Aonidiella auranti* (Mast.), *A. citrina* (Coq.) and *A. orientalis* (Newst.) in Pakistan and India (DeBach, 1959; Ahmad and Ghani, 1972). The parasitoid was introduced into California and it substantially controlled an outbreak of *Aonidiella aurantii* (DeBach, 1959).

In insecticide tests, acephate 75 WP @ 1.5 g/l, methyl parathion @ 2 ml/l and imidacloprid @ 0.3 ml/l were reported very effective against *A. destructor* (Kumari et al., 2014). Cultural practices in the form of pruning *A. destructor* infested leaves from the plant are also useful for the management of coconut scale (Chou, 2003). Excessive use of chemical insecticides against scale insects often negatively disrupts its parasitoids and predators may cause acute and chronic health and environmental hazards and development of resistance in insects (Beardsley, 1970; Malr, 1997). Integrated pest management program on the basis of monitoring scale insects populations with natural enemies have been developed and successfully applied in many regions (Pinese and Piper, 1994; Tauili'ili and Vargo, 1993).

The aim of the present work was to manage *A. destructor* on the basis of annual monitoring data with natural efficiency of its parasitoids. Efficacy of different insecticides was also investigated against different life sages of *A. destructor* on mango nursery plants and mature trees.

2. Material and methods

2.1. Field site

A survey was conducted in five mango orchards in the southern part of Khyber Pakhtunkhwa, Pakistan (Fig. 1). Four mango cultivars i.e. Langra, Kala Chounsa, Anwar Ratoul and Sindhry were tagged for data recording in the selected orchards. The study area lies at 31° 49′/North, Latitude and 70° 55′/East, Longitude. The climate of the study area is arid to semi–arid, hot and dry in summer with average annual rainfall is 180–200 mm. The elevation above sea level is 121–210 m.

2.2. Incidence of A. destructor

A total of 12 mango trees (three trees from each of 4 mango cultivars) were tagged for data recording in each of 5 orchards. For monitoring 20 randomly selected leaves from each tree (5 leaves from each side) in the range of 2–4 m height were cut and examined under binocular microscope in the laboratory. Number of adult and immature stages were counted fortnightly from July 2011 to June 2013. Scales were considered alive if they had pale bodies or released yellow body fluid when pricked while those having a dark brown or desiccated body were assessed as dead.

2.3. Natural efficiency of parasitoids on A. destructor

Two parasitoids *A. melinus* and *Anagyrus* sp. were recorded from *A. destructor* collected from mango plants. Infested leaves/twigs were collected from five locations in the study area in transparent polythene bags separately from July 2011 to June 2013. Infested plant materials were transferred to plastic pots (15 cm diameter and 20 cm height) to observe parasitoid emergence. The pots were covered with muslin cloth for proper aeration and held with rubber bands. Three leaves were kept in each plastic pot and replicated 5 times. The pots were observed daily and the emerged parasitoids were collected with aspirator, counted and then the percentage parasitism was calculated as follows

$$\text{Percent parasitization} = \text{Parasitoids emerged from scales/Total scales} \times 100$$

2.4. Evaluation of insecticides on mango nursery plants

Mango nursery plants were obtained in July–August 2012 from Fruit Nursery Farm (FNF), Department of Agriculture Extension, Government of Khyber Pakhtunkhwa, Pakistan. The plants were exposed to scale crawlers by placing the pots under mature mango trees that were infested with the insect at the Fruit Nursery Farm. The upper portion of the nursery plants were wrapped with scale–infested leaves for 24 h so that newly hatched crawlers could attach to the test plants. Infested nursery plants with crawlers of uniform age were kept for 10, 15 and 20 day to get 1st instar, 2nd instar and mature stage of scale insects. Nursery plants infested with particular stages were sprayed using a hand held atomizer sprayer with recommended rates (Table 1). Experiments were arranged in a completely randomized block design with nine treatments including the control and with three replicates.

Data were taken by counting the number of scale insects on three tagged leaves (upper, middle and lower) on each individual nursery plant. Efficacy of insecticides was assessed from the number of living and dead scales on treated leaves compared to control. Data were recorded before spraying and at day 1, day 7, day 14 and day 21 post spray application. Scales were considered dead if they had desiccated bodies or had their scale cover removed.

Percent mortality of scale insects was calculated by the following formula:

$$\text{Percent mortality} = (\text{pre-spray data} - \text{post-spray data})/\text{pre-spray data} \times 100$$

2.5. Evaluation of insecticides on mature mango trees

The second experiment was conducted at the same location on 15 year old fruit bearing mango trees cultivar Langra in FNF during October 2012. A motorized sprayer (BJ Power sprayer GX 120 Honda 4.0, Honda Motor Co. Ltd, Japan) was used to spray the mature trees. Three replicate trees were sprayed with same insecticides as given in Table 1. Twelve leaves (3 leave from each side in the height range of 2–4 m) were cut from each trees to observe alive and dead scale insects. Data were recorded before spraying and at day 1, 7, 14 and 21 days post spray application. Percentage mortality of scale insects was calculated as before.

Monitoring data were presented by bar graphs with standard errors using MS Excel sheet. Management data were subjected to statistical analysis with one way ANOVA using Statistix 8 (version 8.1) Software. Means were separated by Tukey HSD test at $P \leq 0.05$.