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Field efficacy of some insecticides against hibiscus mealybug, *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae)

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Abstract
Hibiscus mealybug, Maconellicoccus hirsutus (Hemiptera: Pseudococcidae) is the pest having serious economic importance. Its infestation on crops, fruits, vegetation and ornamental plants results in defoliation, sooty mold growth and abnormal shaped fruit. The study was conducted to verify toxic effects of Advantage, Telsta, Imidacloprid, Talstar and their possible mixtures for the control of 3rd instar of mealybug under field conditions. The study was held in University of Gujrat, Punjab, Pakistan. Toxicity of different insecticides and their mixtures was evaluated in the field at 0.14% concentration on the randomly selected Hibiscus rosa-sinensis (Shoe flower plants) with heavy infestation of 3rd instar of mealybug after 24, 48 and 72 h of spray. Talstar + Imidacloprid showed highest mortality of 68.09% and 87.23% after 24 and 48 h respectively whereas after 72 h Advantage+Talstar showed highest mortality (97.56%) and Talstar+Imidacloprid (95.75%) was the 2nd highly effective treatment after 72 h of spray. Other insecticide mixtures also gave significant results in showing mortality. Lowest mortality was shown by Talstar (42.86%), Advantage+Imidacloprid (72.22%) and Advantage+Telsta (77.78%) after 24, 48 and 72 h of spray respectively. The study emphasizes on the use of such insecticide mixtures that might be helpful in pest resistant management strategy for mealybug. It is suggested to check persistence and residual toxicity of these insecticide mixtures under field conditions.

Keywords: Mealybug Control. Shoe-flower pests. Insecticide combinations

1. Introduction
Hibiscus Mealybug (*Maconellicoccus hirsutus*) belong to order Hemiptera and class Pseudococcidae. It has been one of the most destructive sap sucking pests of forest trees, root crops, fruit plants, vegetables, ornamental plants, cultivated and non-cultivated plantations etc. It is an exotic pest that was first discovered in the US in Florida in 2002 and seems native to southern Asia. It infests on more than 300 species in 74 plant families [1]. Its infestation on plants results in deformed leaves and shoots growth and stunting. Direct feeding of hibiscus mealybug results in malformation of shoots, leaves, flowers and fruits, therefore lowering food production and marketability [2]. Mealybug is represented by the largest family of scale insects with about 300 genera and 2000 species and has been reported from 35 locations of different ecological zones of the world [3-6]. Crop damage occurs when mealybug infest leaves of fruits and excrete honeydew that covers leaves and fruits. Many species of mealybug spread viruses e.g. grape vine leafroll. Heavy mealybug infestation is capable of inhibiting the usual ripening process of fruits and premature leaf fall [7]. The pest has been recorded from various parts of Pakistan as a severe pest of different crops and ornamental plants [3, 8]. It has been reported from 183 plants in 52 families [3, 4]. Mealybugs are normally kept below economic threshold by many natural beneficial species but considerable outbreaks in current seasons have resulted in application of pesticides. Many insecticides are used for mealybug management but insecticide resistance is also a problem by using these insecticides [9]. Early treatments included sodium cyanide, sulfur fumigation, and potassium cyanide [10]. With the passage of time these treatments were banned due to their less effectiveness and their concerns on the non-target organisms [11, 12]. Now there are several newer treatments available with more novel modes of action e.g. neonicotinoids, botanical insecticides, biosynthesis inhibitors and insect growth regulators [13, 14].

Hibiscus Rosa-Sinensis (Shoe flower plant) belongs to family Malvaceae. It is a bushy, evergreen shrub or small tree with 2.5–5 m tallness and 1.5–3 m wideness. It is widely cultivated as an ornamental plant and native to tropical and sub-tropical regions. Many insects are the pests of Hibiscus rosa-sinensis including thrips, aphids, whiteflies and mealybug. *Phenacoccus solenopsis* is one of the serious and invasive pests of *Hibiscus rosa-sinensis* in India, Pakistan and Nigeria [15]. Invasiveness of *Phenacoccus solenopsis* was reported on vegetable crops, weeds and ornamental plants in Eastern region of Sri Lanka and on shoe flower plants in China [16, 17]. Efficacy of different insecticides was checked against cotton mealybug. Buprofezin was proved to be the most effective insecticide against cotton mealybug and resulted in 95% decrease in mealybug population [18]. Toxicity of various insecticides single and in combination was evaluated against mealybug (*P. solenopsis).* The combination of insecticides spirotetramat (12%) + imidacloprid (36 %) was resulted in most efficient treatment. Whereas spirotetramat was found to be the least effective when used singly [19]. Due to harmful effects of insecticides especially conventional insecticides it is necessary to use the new chemistry insecticides which are safer to use, more effective and less toxic to ecosystem [20]. Insecticide mixture increases toxicity against insect pests [21]. It is recommended as “resistance management program” because insects don’t develop resistance to multiple modes of action at once [22]. Pesticide mixtures actually alter translocation and absorption in plant. Mixtures of Sumithion and Fenvalerate delayed development of resistance in *Myzus persicae* for 14 generations. Insecticide mixture can control more than one pest species, save time, decrease application cost, lower quantity, less number of spray, synergistic joint action and safe to environment [23].

Knowing the major damages caused by mealybug it is necessary to seek out the best possible way that may help in controling the mealybug. This urged to find new possible potentiating mixtures against mealybug. In the present study Toxic effects of Advantage 20 EC (Carbosulfon), Telsta 20 SL (Clothianidin), Talstar 10 EC (Bifenthrin) and Imidacloprid 20 SL (Imidacloprid) were checked under field conditions for the control of mealybug. These insecticides were evaluated alone and in combination.

2. Materials and Methods

The experiment was conducted to evaluate the field performance of various commercial insecticides available in the market. Insecticides compared for their insecticidal activity were: Carbosulfon (20 EC), Clothianidin (20 SL), Bifenthrin (10 EC), Imidacloprid (20 SL), (Advantage + Telsta), (Advantage + Talstar), (Advantage + Imidacloprid), (Telsta + Talstar), (Telsta + Imidacloprid), (Talstar + Imidacloprid) and the control (no pesticide applied) when applied @ 0.14% a. i. against mealybug under field conditions. The commercial insecticides were obtained from the market and their doses were prepared as per direction devised on the labels of the product.

2.1 Study Site

The experiment was conducted at university of Gujrat, Punjab, Pakistan (32.6367° N, 74.1674° E) in August 2015 to evaluate the effect of different insecticides on the mortality of 3rd instar of mealybug.

2.2 Experimental Design

The experimental design was a Randomized Completely Block Design (RCBD) with eleven treatments and three replications.

2.3 Preparation of 0.14% concentration of insecticides and insecticide mixtures:

The required volume of each insecticide was obtained by putting required quantity of formulation in the beaker and adding water to make the volume of 1 liter. This procedure was repeated for all the insecticides to make concentration of 0.14% of all insecticides. Different insecticide mixtures were prepared by selecting one insecticide as standard and mixing it in the other insecticides in 1:1 [24]. 0.14% concentration of all insecticides was prepared by using the below mentioned formula:

$$\text{Volume of insecticide(ml)} = \frac{\text{Total volume (L) x Percentage of insecticde required(\%)}}{\text{Formulation of insecticide}}$$

2.4 Selection of Experimental Plants and Field Evaluation:

The infested Shoe-flower plants (*Hibiscus rosa-sinensis*) were identified, selected and labelled before the application of treatments. The number of mealybug on selected twigs was recorded before the spray. The plants were selected randomly and treatments were also applied randomly. 33 Shoe flower plants of 50-60 cm height with heavy infestation of mealybug were randomly selected in the field. Plant to plant distance was 50 cm. Each plant was acted as a replica. Spray was done on twigs of 10-15 cm size with heavy mealybug infestation in each replication. These plants were infected with 3rd instar of mealy bug. Spray was done on 30 plants with mealybug infestation by prepared doses of all insecticides and three plants were kept as control without any application of insecticide [25]. Hand knapsack sprayer was used for the purpose of spray. Tags containing all information were placed on the plants. All the treatments were replicated three times.

2.5 Data collection and Statistical analysis

The data on Mortality (%) of mealybug was recorded after 24, 48 and 72 h of exposure to the treatments by using following formula.

$$\text{Mortality (\%)} = \frac{\text{Population before treatment - Population after treatment}}{\text{Population before treatment}} \text{ X 100}$$

Data was recorded from three selected twigs of 10-15 cm size in each replication. The area on the soil below each selected plant was cleaned to collect the nymphs falling out of the treated twigs onto the ground. The area below the twigs was also checked regularly for their mortality. The mealybug present on the tagged twigs were counted and mortality was recorded by subtracting the number from initial data. The obtained data was analyzed by using Analysis of Variance (ANOVA) and means were compared by using Least Significant Difference (LSD) Test [26]. The statistical analysis was performed by using SPSS.

3. Results and Discussion

3.1 Effect of insecticides and their mixtures on mortality (%) of 3rd instar of mealybug after 24 h of spray:

The data on mortality of 3rd instar of mealybug indicated significant variations after 24 h of spray under the field conditions (Table 1). Carbosulfon (20 EC), Clothianidin (20 SL), Bifenthrin (10 EC), Imidacloprid (20 SL) and their different mixtures were evaluated against the control of 3rd instar of mealybug when applied at 0.14% concentration. All insecticide treatments showed significant differences with the control (no mortality observed in control where no insecticide was applied). The highest mortality (68.09%) was shown by (Talstar + Imidacloprid) followed by Imidacloprid (63.16%) (Fig 1). Talstar with 42.86% mortality was the least effective insecticide after 24 h of spray. Effect of other treatments in descending order showing mortality of 3rd instar of mealybug was: Advantage> (Advantage + Talstar) > (Telsta + Imidacloprid) > (Advantage + Imidacloprid) / (Telsta + Talstar) > and (Advantage + Telsta) / Telsta with 61.11%, 60.98%, 58.82%, 58.33% and 55.56% mortality, respectively.

3.2 Effect of insecticides and their mixtures on mortality (%) of 3rd instar of mealybug after 48 h of spray

The data indicated significant variations in mortality after 48 h under different treatments (Table 1). The highest mortality of 3rd instar of mealybug was recorded 87.23% in (Talstar + Imidacloprid) followed by Imidacloprid (81.58%) (Fig 1). The similar trend was observed in mortality after 24 h exposure of insecticides under field conditions. The lowest mortality (72.22%) was observed with the application of (Advantage + Imidacloprid). It was contrary to the result seen after 24 hrs of spray where Talstar caused lowest mortality after 24 hrs of initial application. Descending order of mortality of 3rd instar of mealybug caused by various treatments is as follows: Telsta / Advantage > Advantage + Talstar> Talstar > Telsta + Talstar > Telsta + Imidacloprid > and Advantage + Telsta with 80.56%, 80.49%, 78.57%, 77.78%, 76.47% and 75% mortality, respectively.

3.3 Effect of insecticides and their mixtures on mortality (%) of 3rd instar of mealybug after 72 h of spray

Significant differences were observed in mortality data of 3rd instar of mealybug under different treatments when applied in the field. The highest mortality (97.56%) was caused by Advantage + Talstar followed by Talstar + Imidacloprid (95.75%) after 72 h of exposure of insecticides (Fig 1). The lowest mortality (77.78%) was caused by (Advantage + Telsta). Descending order showing the performance of other insecticides was: Talstar > Advantage > Telsta + Imidacloprid > Imidacloprid > Advantage+Imidacloprid / Telsta> and Telsta + Talstar with 92.86%, 88.89%, 88.24%, 84.21%, 83.33% and 80.56% mortality respectively (Table 1).

Table 1: Mortality (%) of 3rd instar of Mealybug after 24, 48 and 72 h of spray of various insecticides (0.14% concentration) under field conditions

Treatments	Insecticides	Mortality (%) after 24 h	Mortality (%) after 48 h	Mortality (%) after 72h
T_0	Control	0.00 d	0.00 d	0.00 d
T_1	Telstra(Clothianidin)	55.56 b	80.56 b	83.33 b
T_2	Advantage(Carbosulfon)	61.11 b	80.56 b	88.89 b
T_3	Talstar (Bifenthrin)	42.86 c	78.57 b	92.86 a
T_4	Imidacloprid(Imidacloprid)	63.16 a	81.58 b	84.21 b
T_5	(Advantage + Telsta)	55.56 b	75.00 b	77.78 c
T_6	(Advantage + Talstar)	60.98 b	80.49 b	97.56 a
T_7	(Advantage +Imidacloprid)	58.33 b	72.22 c	83.33 b
T_8	(Telsta + Talstar)	58.33 b	77.78 b	80.56 c
T_9	(Telsta + Imidacloprid)	58.82 b	76.47 b	88.24 b
T_{10}	(Talstar + Imidacloprid)	68.09 a	87.23 a	95.75 a

*Means sharing similar letters are not significantly different at $P \leq 0.05$

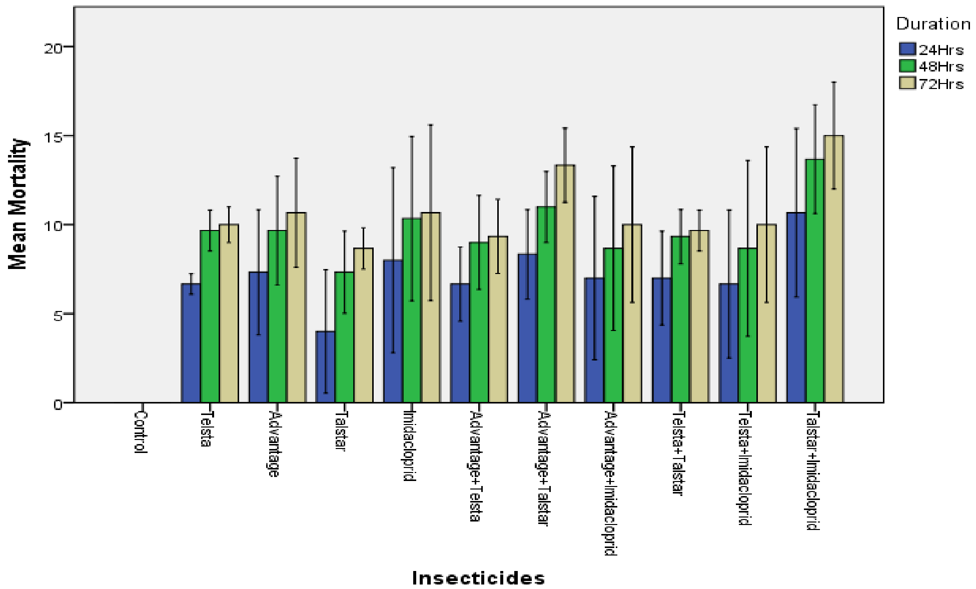

Fig 1: Mean mortality of 3rd instar of mealybug after 24, 48 and 72 h of spray at 0.14% concentration in the field study

Among eleven treatments tested for the control of 3rd instar of mealybug under field conditions, (Talstar + Imidacloprid) was found to be highly effective after 24 and 48 h of spray whereas (Advantage + Talstar) showed highest mortality after 72 h of spray. (Talstar + Imidacloprid) was the 2nd highest ranked treatment in showing mortality after 72 h of spray. It was observed as the time of exposure of insecticides increased, (Advantage + Talstar) became more effective as it might be more persistent than (Talstar+ Imidacloprid). The reason for the effectiveness of (Talstar + Imidacloprid) and (Advantage + Talstar) can be their dual mode of action. Talstar is a pyrethroid insecticide that targets on "sodium channel transmission" of insect nervous system whereas Imidacloprid (a neonicotinoid insecticide) acts on many types of "post-synaptic nicotinic acetylcholine receptors" present in nervous system of insects [27, 28]. Advantage (carbosulfon) acts by inhibiting the activity of acetylcholinesterase in the insect nervous system [29, 30]. Thus Talstar, Imidacloprid and Advantage have different modes of action. Interaction of Talstar with Imidacloprid or Advantage proved very effective against 3rd instar of mealybug under field conditions.

In our study Talstar resulted in lowest mortality of 42.86% against 3rd instar of mealybug after 24 h of spray under field conditions. The study confirmed the results presented by karar *et al* (2010) [31] who reported low mortality (26%) of adult female mango mealybug caused by Talstar after 24 h of exposure of insecticide in the mango orchads. Whereas after 48 h of spray (Advantage +Imidacloprid) showed lowest mortality. (Advantage + Telsta) was found to be the least effective treatment after 72 h. The results depicted that when the time of exposure of insecticides increased in the field trials, Talstar became more effective as it ranked 3rd highest in showing mortality after 72 h of application against 3rd instar of mealybug whereas after 24 h it showed the lowest mortality. The reason for this trend of Talstar might be due to its greater persistence. Our results according to Talstar after 72 h were similar with the results of karar *et al* (2010) [31] who evaluated Talstar against 1st instar nymphs of the mango mealybug after 72 h of spray in mango orchads and resulted in high mortality of 73%.

According to the results of present study all the insecticide mixtures showed significant decrease in the population of mealybug with (Talstar + Imidacloprid) the most effective insecticide mixture. This effectiveness of insecticide mixtures can be due to their double mode of action. Our results pertaining to the effect of insecticide mixtures were similar to those reported in a study by Dhawan *et al* (2009) [19] who checked out the efficacy of different insecticides against mealybug population (*P. solenopsis)* and found combination of insecticides spirotetramat (12%) + imidacloprid (36 %) the most efficient treatment.

In the present study (Advantage+imidacloprid) showed 83.33% mortality of 3rd instar of mealybug after 72 h of spray under field conditions. This is in accordance with the experiment conducted by khan *et al* (2012) [24] who checked out the effects of different insecticides alone and in combination against mustard aphid (*Lipaphis erysimi)* and depicted that the best insecticide mixture was (carbosulfon+ profenofos) followed by (Advantage+ imidacloprid), (carbosulfon+ acetamaprid) and (carbosulfon+ triazofos).

4. Conclusion

The present study revealed the effectiveness of various insecticides and their possible mixtures against insect pest (mealybug). (Talstar + Imidacloprid) proved to be the highly effective treatment among all the treatments tested for the control of 3rd instar of mealybug in the field study. The 2nd highly effective insecticide mixture was (Advantage + Talstar). These insecticide mixtures can provide better options to be included as control tools in the integrated management of serious pest like mealybug. Talstar was observed as the least effective insecticide after 24 h of initial application. (Advantage +Imidacloprid) caused lowest mortality after 48 h and (Advantage + Telsta) showed lowest results of mortality after 72 h of spray. Therefore varying trend was observed among insecticides in showing lowest efficacy after different time intervals under field conditions. All the insecticide mixtures showed significant results in mortality data of mealybug. Non-target effects and residual toxicity of such insecticide mixtures should be determined in the environment.

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