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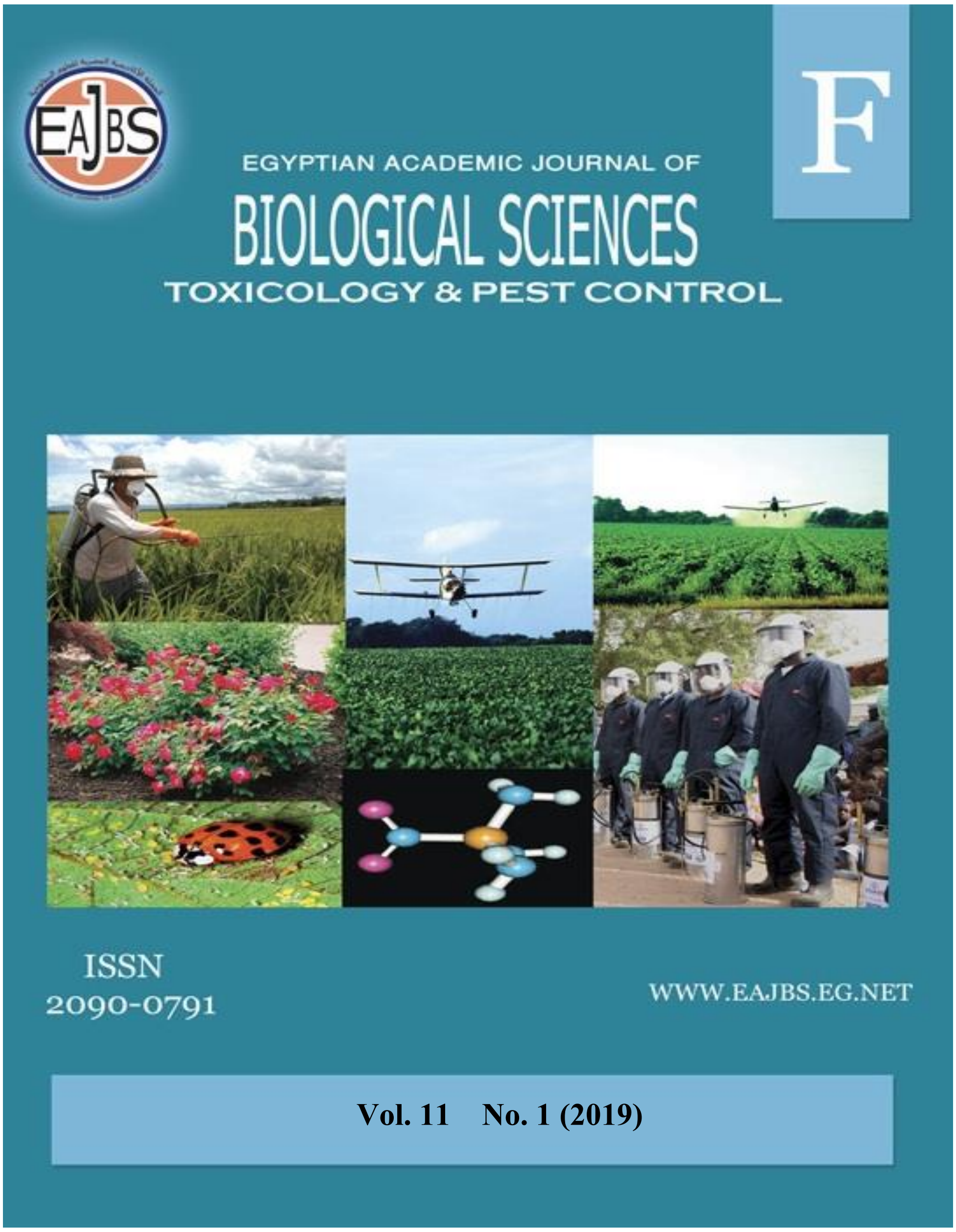

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Trunk Injection a Promising Approach for Long-Lasting Suppression of Mango Leaf Hopper, *Idioscopus clypealis*

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ABSTRACT

The current study was conducted to investigate strength and durability of the effect of three widely used insecticides against mango leafhopper (MLH), *Idioscopus clypealis* (Lethierry) (Hemiptera: Cicadellidae) in two different methods (foliar spray and trunk injection) in Roodan district (Hormozgan province). The study was performed as factorial arranged in a Randomized Complete Block design (RCB). In all sampling sessions (3, 7, 15 and 30 d post applications), the number of nymphs decreased significantly on the inflorescence, indicating insecticides used in both methods were able to suppress MLH, relatively. Although the insecticides showed no significant difference in foliar application, they were significantly different when injected through the trunk (F=8.85; df=2; P<0.01). Also, significant difference was found among different sampling times (F = 85.0; df = 3; P<0.01). By comparing various sampling sessions, the highest mortality rate was observed at day 30 (74.8 ± 2.31%) and the lowest ones occurred on day 3 (23.9 ± 4.06%). Over time, the percent of the insect mortality increased. The highest rate of mortality was observed in Dimetoat through injection method (57.2 ± 5.89%) and the lowest occurred in Acetamiprid by the same method (33.8 ± 7.37%). By these results and considering high susceptibility of mango to foliar application of chemicals at flowering stage, trunk injection of appropriate pesticides can be a promising approach to suppress MLH and probably other common mango pests present and damage at that stage like gall midge.

INTRODUCTION

Chemical attributes of systemic insecticides may have a profound effect on their movement within plant tissues (Byrne *et al.,* 2010). Some systemic insecticides are not influenced by pH differences and therefore may move freely between the xylem and phloem based on bio membrane permeability and diffusion rule (Sur and Stork, 2003).

The passive transport of systemic insecticides within plant tissues may be influenced by several factors. For instance, the rate of passive transport in the transpiration stream of the xylem depends on the rate of water movement through the plant (Cloyd and Bethke, 2011). Light intensity, ambient air temperature, relative humidity, plant physiology; soil/growing medium, water availability (Cloyd and Bethke, 2011) and soil/ growing medium organic matter content (Byrne *et al.,* 2010) are amongst the main factors affecting the passive transport of chemicals. As such, persistence in plants is influenced by the amount of insecticide used, storage within plant tissues and metabolism and degradation of the active ingredient (Cloyd and Bethke, 2011).

Systemic insecticides applied in a non-foliar method are translocated throughout plants and can suppress properly xylem and phloem-feeding insects for a more extended period due to their increased persistence. In addition, this approach does not leave unsightly residues on contactable part of the plant, which makes plants less harmful to farmers, consumers, and natural enemies compared with plants received high amounts of insecticides by spraying (Cloyd, 2010; VanWoerkom, 2012; Huang *et al.,* 2016). It has been shown that spray application of some insecticides has profound effects on some physiological processes of plants such as photosynthesis (Cloyd and Bethke, 2011) and production of secondary metabolites (Parrott et al., 1983). Although, systemic insecticides can rapidly suppress target insect pests in foliar spraying but their residual activities are less persistent than when they are exploited by soil or growing medium application (Byrne *et al.,* 2010; Cloyd, 2010). In addition, the effectiveness of foliar application may also be affected by plant type. For instance, absorption by the upper and lower leaf surfaces may vary (Cloyd and Bethke, 2011). The lower leaf surface is more absorptive than the upper surface. However, chemicals need more time for translocation over plants in the non-foliar manner (Cloyd and Bethke, 2011), so they should be used earlier than when are used in foliar manner.

The mango leafhopper, *Idioscopus clypealis* Letheirry (Hemeptera: Cicadellidae) is one of the devastating pests on mango in southern Iran, causing high economic damages (20-100%) on mango trees (Adnan *et al.,* 2014). In the result of mango leafhopper damage, flowers become wrinkled,withered and dried at the end. Also, fruit ripening stops and newly-formed fruits fall down. A large amount of honeydew was produced by leafhoppers in high densities, which may also be associated with sooty molds. Chemical control of mango leafhopper is a widely used approach against this pest in infested orchards. However, spraying chemicals resulting in many drawbacks threatening either environment, natural enemies or farmers and necessitates a reconsideration in application methods of chemicals. Here, we aimed to study the effect of chemical applications in controlling mango leafhopper when used in two various methods including trunk injection and foliar application, and study persistence of the chemical residues in both two methods.

MATERIALS AND METHODS

The current study was carried out in an infested mango orchard located in Roodane district. The selected trees were almost uniformly either from the age or from other horticultural perspectives. Each experimental block included all treatments, Imidacloprid, Acetamiprid and Dimethoate and two application methods, trunk injection and foliar spaying as well as one unapplied pesticide unit as control. Each experimental unit consisted of four trees therefore by considering four replications in total of 112 mature trees were selected for the experiment. The blocking was made in a manner in which uniformity of the treatments is respected. For each insecticide, a volume of 4 cc was dissolved in 4 liters of water. The injection was made using a short hose as non-continuously (two times in a day) and totally eight days needed to complete the injection. A motorized sprayer was used in foliar application to make a well insecticide coverage on the trees canopy.

Five sampling sessions were characterized as follows, one-day pre-experiment and 3, 7, 15 and 30 d post-experiment. In each sampling session, the number of six blossoms and deliberate branches from four geographical directions were cut and gently moved into nylon bags. The sampling was restricted to the two trees where located in between rows in each experimental unit mentioned above. On return to the laboratory the nylon bags were kept in a low freezer at -4°C for 20 minutes to keep the insect semi-paralyzed and allowed counting them. When the nymphs were immobilized, the number of nymphs in each replication was counted carefully under a stereomicroscope. This data was loaded in the Henderson and Tilton formula (Henderson & Tilton, 1955) for further analyses.

Data Analysis:

The normality of data was checked by kurtosis and skewness tests in SPSS prior to analysis. Two-way analysis of variance (ANOVA) was used to test significant differences among treatments and then means were separated by the least significant difference (LSD) test. Statistical analysis was performed by SAS version 9.1.3.

RESULTS

A significant difference was found among different sampling times ($F = 85.0$; $df = 3$; $P<0.01$) as well as among the insecticides treatments ($F=8.85$; $df=2$; $P<0.01$). However, no significant difference was found between two methods of application in overall combined data. In addition, the interaction of sampling time and method of application, as which sampling time and type of insecticide were not significant. By contrast, a significant difference was found where we checked the interaction between insecticides and application method. Also, the interaction between sampling time, insecticides and application method was not significant. By comparing different sampling sessions, the highest mortality rate was observed at day 30 (74.8%) and the lowest ones occurred on day 3 (23.9%). Over time, the nymph's mortality rate increased. Although, the increase in nymph's mortality was not significant from day 3 to 7 over time and from day 7 onwards, a significant increase in adult's mortality was observed (Fig. 1).

The individual effects of the studied insecticides on the mortality rate of *I. clypealis* revealed no significant difference between Dimethoate and Imidacloprid but both produced significant mortality than Acetamiprid (Fig. 2).

The highest mortality rate of *I. clypealis* in injection method was observed in Dimetoate (57.2%), followed by Imidacloprid. The lowest mortality rate occurred in Acetamiprid by the same method (33.8%). All three insecticides were statistically in the same level of efficacy when applied by foliar spray (Fig. 3).

Moreover, a negative trend in mortality rate was observed in Acetamiprid from the day seven post application compared with the other insecticides (Fig. 4).

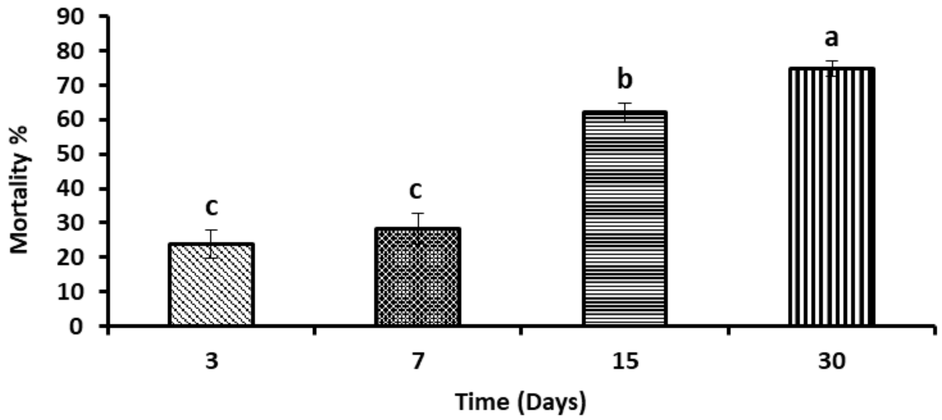

Fig. 1- The individual effect of time on the rate of mortality in *Idioscopus clypealis*. As seen, the highest mortality occurred at day 30 (74.8%) and the lowest was observed on day 3 (23.9%). The mortality increased significantly from day 7 onwards.

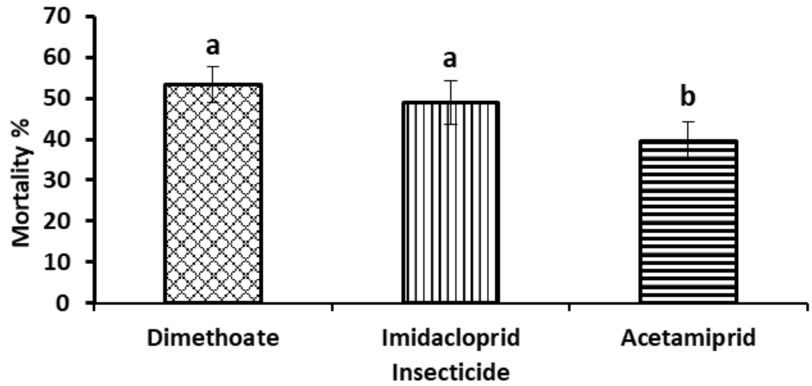

Fig. 2- The individual effect of Dimethoate, Imidacloprid and Acetamiprid on the mortality rate of *Idioscopus clypealis*. As seen, there was no significant difference between Dimethoate and Imidacloprid but both produced significant mortality in *I. clypealis* than Acetamiprid.

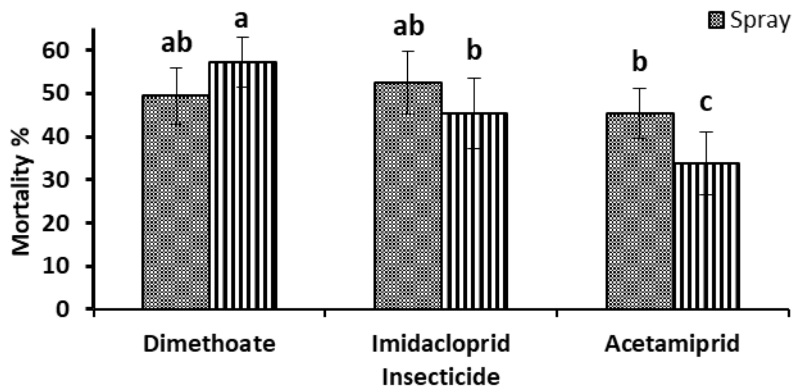

Fig. 3- The effect of application type on mortality rate in *Idioscopus clypealis*. As shown, all insecticides are the same in the foliar application in terms of produced mortality but they showed a significant difference in injection method. Dimethoate was the most effective insecticide in controlling *I. clypealis* in injection method, followed by Imidacioprid. Acetamiprid allocated the lowest mortality rate of *I. clypealis*.

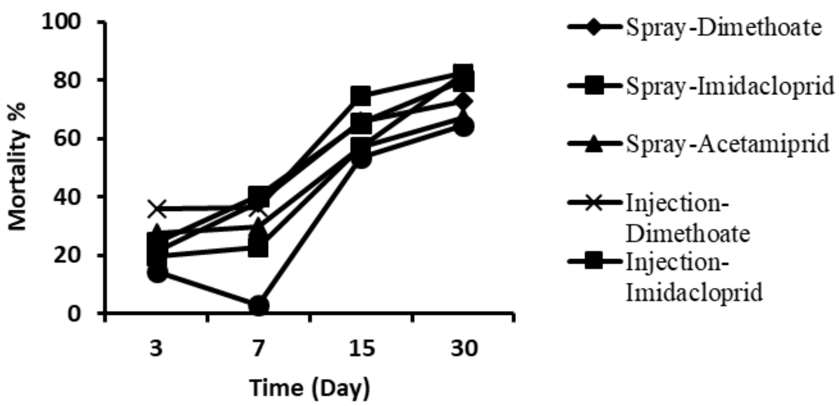

Fig. 4- Trend of mortality rate in *Idioscopus clypealis* produced by different insecticides and application methods.

DISCUSSION

Results of the current study revealed sharp and significant differences in the mortality of mango hoppers in all insecticide treatments compared with control in all sampling sessions. Efficacy of different insecticides was found also significantly vary when we compared the application method.

By this study, we investigated the efficiency of two chemical application methods comprised of trunk injection and foliar spray to suppress mango leafhopper damage. Our results revealed a high efficacy and stability of the trunk injection in suppressing MLH population which agrees with findings of Arbab Tafti et al. (2014) on the high efficacy of trunk injection in long-lasting suppression of Dubas bug, *Ommatissus lybicus* de Bergevin (Hemiptera: Tropiduchidae) on date palms. Also, they have documented fewer side effects of trunk injection on natural enemies compared with foliar application due to less direct contact with natural enemies. Furthermore, the non-foliar application can also diminish chemical drift and mitigate environmental pollution (Arbab Tafti *et al.*, 2014). Moreover, the injection method is a cost-benefit approach by which the number of pesticide application decreases drastically, causing an increase in farmers' investment indirectly. There are many successful instances on the non-foliar application of chemicals in particular injection method. (Gill *et al.,* 1999) showed that some systemic insecticides like Imidacloprid and Abamectin when are used through drenching or trunk injection show a good controlling effect on sucking insects feeding on ornamental trees. In the majority of non-foliar application of chemicals, no negative impact on non-target organisms has been documented, confirming high safety of this method in the application of chemicals (see Gill *et al.,* 1999; Arbab tafti *et al.,* 2014).

Dimethoate was the influential chemical among treatments in the injection method followed by Imidacloprid. Acetamiprid placed in the last rank. All three insecticides performed similarly with no significant difference in foliar application, showing variation in efficacy of chemicals by altered type of application. The difference in the efficacy of chemicals in a result of the changed mode of application has been evidenced by Arbab Tafti et al. (2014) who found that same insecticide showed different effects when a type of application was changed. For instance, they showed a higher efficiency of Imidacloprid in the injection method over experiment although Imidacloprid caused more mortality at the beginning of the experiment when used in foliar manner. The main reason for the decreased efficiency of Imidacloprid in a foliar manner can result from its degradation by photolysis over time. However, the effect of photolysis in drenching application decreased, resulting in long-lasting efficiency of Imidacloprid (Scholz and Fritz, 1998).

Irrespective of high benefits of the non-foliar application of chemicals, it has been restricted with some disadvantages for wide applications. A lag in efficacy has been reported for trunk injection, chemicals need more time for translocation over plants (Cloyd, 2010), and therefore in injection or drench application pesticides need to be applied earlier than the moment needs to affect compared with the foliar.

A difference in mortality trend was seen between Acetamiprid and the other insecticides seven days after implementing the treatments in which Acetamiprid showed a decrease in mortality over time. Lower absorption of Acetamiprid in comparison with the other two insecticides is a strong reason to explain this discrepancy. Variation in absorption rate is one of the most determinant factors in improving chemicals efficacy (Byrne et al., 2014). In agreement with our results, Byrne et al. (2014) showed a difference in efficacy of some insecticides used against avocado thrips. They concluded that variation in absorption rate of insecticides is the main reason in emerging the discrepancy. In overall, we can conclude trunk injection can be suggested as long lasting method to control mango hoppers in orchards with scattered distribution, which make uniform foliar application impossible. Choosing appropriate pesticide and application in right time prior to pest emergence is the key and crucial points to obtain an acceptable result in this method.

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