Field observations of the effect of Metarhizium anisopliae var. acridum on the saxaul locust, Dericorys albidula Serville (Orthoptera: Dericorythidae)

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Available online: 13 Feb 2012

To cite this article: Heydar Valizadeh, Habib Abbasipour, Mohammad Mahmoudvand, Hassan Askary & Vahid Reza Moniri (2012): Field observations of the effect of Metarhizium anisopliae var. acridum on the saxaul locust, Dericorys albidula Serville (Orthoptera: Dericorythidae), Archives Of Phytopathology And Plant Protection, 45:10, 1162-1169

To link to this article: http://dx.doi.org/10.1080/03235408.2012.658630

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Field observations of the effect of *Metarhizium anisopliae* var. *acridum* on the saxaul locust, *Dericorys albidula* Serville (Orthoptera: Dericorythidae)

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(Received 4 January 2012; final version received 12 January 2012)

*Dericorys albidula* Serville (Orthoptera: Dericorythidae) is a major pest of *Haloxylon ammodendron* and other saxaul plant species in the Qom province, Iran. Using fungal insecticides can be an alternative method for chemical insecticides. Effect of insecticide fungi, *Metarhizium anisopliae* var. *acridum*, on the various nymphs of *D. albidula* was studied in the field through 2005 and 2006. Fixed concentrations of fungi (\(10^6\), \(10^7\), \(10^8\), \(10^9\), \(10^{10}\) and \(10^{13}\) spore mL\(^{-1}\)) were prepared as gasoline formulation and were sprayed on the locusts on *H. ammodendron* trees, and mortality percentage was recorded 15 days after treatment. The results showed that various concentrations significantly affected on the second, third, fourth and fifth nymphal instars of *D. albidula* compared to control in 2006, although this effect was lower in 2005 on nymphs. Mortality of the highest concentration (\(10^{13}\) spore mL\(^{-1}\)) was higher (17.6–24%) than other concentrations in all tests, but these values were not notable. The results of this study showed that using *M. anisopliae* var. *acridum* diluted in gasoline can be effective on nymphal instars of locust, *D. albidula*, in two continuous years.

**Keywords:** *Haloxylon ammodendron*; *Dericorys albidula*; field trial; *Metarhizium anisopliae* var. *acridum*

**Introduction**

The main control strategies for locusts and grasshoppers are based on the use of chemical insecticides. Increasing this phenomenon raised concerns for their impact on the environment and human health. Hence, the researchers were directed to develop microbial insecticides for the locusts’ and grasshoppers’ control (Johnson and Goettel 1993; Prior and Streett 1997). Using entomopathogens as biological control agents of locusts and grasshoppers will become possible if economic methods of their mass production will be available (Kleespies and Zimmermann 1992). Among fungal species, 400–500 species have pathogenic property on insects. These entomopathogens belong to all five subdivisions of fungi (including Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and

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Deuteromycotina; Burges and Hussey 1971; Starnes et al. 1993; White and Elson Harris 1994). Fungal penetration can be occurred through insect cuticle (Lacey et al. 1999) or through the respiratory system (Burges and Hussey 1971). Temperature, humidity and solar radiation are three of the important environmental parameters in the effectiveness of insect fungal pathogens (Blanford and Thomas 1999, 2000; Inglis et al. 2001). A well-known entomopathogenic fungus, *Metarhizium anisopliae* (Deuteromycotina: Hyphomycetes), is an economically important biological agent that can infect nearly more than 200 species from more than 50 insect families (Roberts and Humber 1981).

In the past two decades, most outbreaks of *Dericorys albidula* locust likely developed due to expansion of cultivated *Haloxylon* trees. To limit damage to these trees, treatment is required virtually every year, usually with large amounts of broad-spectrum chemical pesticides that pollute the environment and cause health and safety issues as well as exacerbating locust problems due to the loss of natural enemies (Moniri et al. 2005). *M. anisopliae* kills the infected host between 3 and 4 days after its infection. The time depended on insect species and size of insects (Whitten and Oakeshott 1991; Starnes et al. 1993). *M. anisopliae* var. *acridum* (trade name: Green Muscle®) is a variety that has been developed for the control of locusts and grasshoppers (Thompson et al. 2000).

A monophagous pest, *D. albidula* Serville (Orthoptera: Dericorythidae), is known as saxaul locust (Adeli and Abaei 1989; Moniri 1998). It is the most important pest of saxaul plants of *Haloxylon ammodendron* (C.A.Mey.) Bunge (siah-tagh in Persian) and *Haloxylon persicum* Bunge ex Boiss. et Buhse (zard-tagh in Persian; Chenopodiaceae). These plants are shrubs found in the desert regions of Qom province and the central parts of Iran. *H. persicum* is found only on non-saline land. By contrast, *H. ammodendron* appears on both saline and non-saline lands, although it is not a dominant species on saline land. The leaves of two species are small but the green branches have photosynthesis (Wallace et al. 1968; Sharma and Sen 1989).

This paper presents the effect of *M. anisopliae* var. *acridum* on various nymphs of *D. albidula* through 2005 and 2006 in the field conditions. According to best knowledge, the report about *D. albidula* is limited and there are not any reports regarding the effect of mycoinsecticide on it through fields.

**Materials and methods**

**Experimental site**

The field experiments were conducted at 30 km of Qom, Iran. Geographical location was latitude 34°10′ to 34°50′ N, longitude 50°15′ to 51°30′ E and altitude 729 m above sea level. Their rainfall patterns are bimodal with an average annual rainfall of about 126 mm per annum. The recorded temperatures in this area were in the ranges of 47 and −11°C, respectively.

**Field bioassay tests**

The ultra volume value (ULV) gasoline formulation of *M. anisopliae* var. *acridum* isolate IMI 330189 with 400 g (2 × 10^{13}) viable conidia per litre was used in the experiments. Like the toxicity assays, spray method was used, Different conidial (Green Muscle®) concentrations (10^6, 10^7, 10^8, 10^9, 10^{10} and 10^{13} spore mL^{-1}) were prepared in sterile distilled gasoline. As a control, the gasoline was used. Some
saxaul bushes (25 cm in diameter and 25 cm in height) were selected, and 25 one-
day-old nymphs were placed on the bushes. For prevention of the nymphs flying, all
bushes were covered by a net cage (1 × 1 × 1 m³). The mortality was recorded after
15 days from treatments. The experiments were repeated five or six times. This
method was performed for various nymphal instars (second, third, fourth and fifth).

Data analysis
The data obtained were subjected to one-way analysis of variance \((p < 0.05)\) after
checking for normality. Means were compared by Tukey’s studentised range test,
admitting significant differences at \(p < 0.05\). SAS software was used for all analyses
(SAS Institute 1997).

Results
Effect of M. anisopliae var. acridum on the saxaul locust in 2005
Effect of \(M.\) anisopliae var. acridum on various nymphal instars of \(D.\) albidula in 2005
was indicated in Figures 1 and 2. Effect of conidial concentrations on the mixture of
second and third instars of locust showed that all concentrations \((10^8, 10^9 \text{ and } 10^{10}
\text{ spore mL}^{-1})\) significantly increased mortality of nymphs, but there are no significant
difference among concentrations (Figure 1; df = 3, 16, \(F = 4.78, p = 0.0114\)). On the
other hand, these conidial doses had no significant efficacy on mortality on the
mixture of fourth and fifth nymphs (Figure 2; df = 3, 20, \(F = 1.77, p = 0.1860\)).

Effect of M. anisopliae var. acridum on the saxaul locust in 2006
Results of insecticidal of \(M.\) anisopliae var. acridum on the saxaul locust are seen in
Figures 3–6. Figure 3 shows only the highest concentration \((10^{13} \text{ spore mL}^{-1})\) of
\(M.\) anisopliae var. acridum that significantly killed the second nymphal instars of
locust in 2006 at field (df = 3, 16, \(F = 5.22, p = 0.0105\)). Also, the mortality of this
concentration was higher than other concentrations. The mortality trend of third

![Figure 1](image-url)

Figure 1. Effect of various concentrations of \(M.\) anisopliae var. acridum (Green Muscle®) on
the mixture of second and third nymphal instars of \(D.\) albidula (year 2005) in the field. Similar
letters show no significant difference using Tukey’s test \((p < 0.05)\).
Figure 2. Effect of various concentrations of *M. anisopliae* var. *acridum* (Green Muscle®) on the mixture of fourth and fifth nymphal instars of *D. albidula* (year 2005) in the field. Similar letters show no significant difference using Tukey’s test (*p* < 0.05).

Figure 3. Effect of various concentrations of *M. anisopliae* var. *acridum* (Green Muscle®) on the second nymphal instars of *D. albidula* (year 2006) in the field. Similar letters show no significant difference using Tukey’s test (*p* < 0.05).

Figure 4. Effect of various concentrations of *M. anisopliae* var. *acridum* (Green Muscle®) on the third nymphal instars of *D. albidula* (year 2006) in the field. Similar letters show no significant difference using Tukey’s test (*p* < 0.05).
nymphal instars in the control group was significantly lower than the treatment groups. Also, there were differences among concentrations (Figure 4; df = 3, 16, \( F = 6151 \), \( p < 0.0001 \)). Comparing the mortality of the control and \( 10^6 \), \( 10^7 \) and \( 10^{13} \) spore mL\(^{-1} \) concentrations in Figure 5 indicated that the fourth nymphal instars were significantly affected by \( 10^7 \) and \( 10^{13} \) spore mL\(^{-1} \) treatments unlike \( 10^6 \) spore mL\(^{-1} \) (Figure 5; df = 3, 16, \( F = 6.85 \), \( p = 0.0035 \)). In addition, Figure 1 reports that various concentrations (\( 10^7 \), \( 10^{10} \) and \( 10^{13} \) spore mL\(^{-1} \)) significantly affected the fifth nymphal instars of \( D. \) albidula compared to control. In addition, the effect of concentrations was different (Figure 6; df = 3, 16, \( F = 157.8 \), \( p < 0.0001 \)).

**Discussion**

In the current research, field study of various concentrations of gasoline formulation of \( M. \) anisopliae var. acridum conidia on different nymphal instars of \( D. \) albidula was evaluated in two continuous years (2005 and 2006). This was the first report from researching the field efficacy of a fungal insecticide on \( D. \) albidula. The results of

![Figure 5](image_url)

**Figure 5.** Effect of various concentrations of \( M. \) anisopliae var. acridum (Green Muscle\(^{16} \)) on the fourth nymphal instars of \( D. \) albidula (year 2006) in the field. Similar letters show no significant difference using Tukey’s test (\( p < 0.05 \)).

![Figure 6](image_url)

**Figure 6.** Effect of various concentrations of \( M. \) anisopliae var. acridum (Green Muscle\(^{16} \)) on the sixth nymphal instars of \( D. \) albidula (year 2006) in the field. Similar letters show no significant difference using Tukey’s test (\( p < 0.05 \)).
those 2 years were different, although the concentrations were similar. Results showed that this variety (*M. anisopliae* var. *acridum*) is effective on various nymphal instars of *D. albidula*. We previously found that these concentrations had a high toxicity on nymphs of this pest in the laboratory conditions. Although these concentrations showed high toxicity in the populations of the saxaul locust in laboratory, but in the field mortality was only about 20% in the highest concentration. The used concentrations of this study were fixed and similar to those that were used in the laboratory tests. The results showed that the mortality trend was so different in laboratory and field and they must be increased in the field trials.

Because there are not any reports about using mycoinsecticides on this pest, we compare the results of this study with the reports of *M. anisopliae* var. *acridum* tests on the other Orthoptera insects. Peng et al. (2008) showed that *M. anisopliae* var. *acridum* had a good toxicity against oriental migratory locust, *Locusta migratoria manilensis* (Meyen), in the field in two continuous years. Also, Milner et al. (2003) studied the effect of *M. anisopliae* var. *acridum* on the wingless grasshopper, *Phaulacridium vittatum*, and reported that it is good choice for biological control of this locust. In this study, we used ULV formulation using gasoline for treating the *M. anisopliae*. As the saxaul plants are not used as nutrient, using petroleum products can be a suitable method for solving the spores. In acceptance of our method, Kassa et al. (2004) researched the effect of *M. anisopliae* var. *acridum* on *Hieroglyphus daganensis* (Krauss) and *L. migratoria* (R. & F.) in the laboratory and field and stated that using oil emulsions may be an effective option to improve efficacy of submerged spores for ultra-low volume application. Alves et al. (1998) observed that *M. anisopliae* caused 79–90% mortality of short horned locust in Africa, Brazil and Australia. Blanford and Thomas (2001) showed that variety of *acridum* of *M. anisopliae* can affect on survival, maturation and reproduction of the desert locust, *Schistocerca gregaria* Forskål. In the other study, mortality of Central American locust, *Schistocerca piceifrons* Walker, treated by *M. anisopliae* var. *acridum* was acceptable in the laboratory and field tests (Hernandez Velazquez et al. 2003). Magalhaes et al. (2000) stated that *M. anisopliae* var. *acridum* caused up to 88% mortality on the second nymphal instar of *Rhammatocerus schistocercoides*.

In conclusion, the outcome data of this study demonstrated that *M. anisopliae* var. *acridum* diluted in gasoline had impact on increasing the mortality of various nymphal instars of important pests of the saxaul, *D. albidula*, in the years 2005 and 2006. Also, current research showed that mortality (specify the trend) of all stages in the second year (2006) was higher than the first year (2005).

**Acknowledgements**

We thank the members of Agricultural and Natural Resources Research Center of Qom, Iran, for their assistance.

**References**
