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# Evaluation of Microbial and Repellent Insecticides for Control of Migratory Grasshopper, *Melanoplus sanguinipes* (Fabricius), in Colorado

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**Abstract:** The migratory grasshopper, *Melanoplus sanguinipes* (Fabricius) (Orthoptera: Acrididae), is one of the most important grasshoppers in western North America rangelands in Fort Collins, CO (USA). The laboratory bioassay trials were conducted to determine the specific effect of microbial insecticides and repellents for control of migratory grasshopper in Fort Collins, Colorado. In an initial trial, both *Beauveria bassiana* and spinosad treated foliage produced significant mortality to grasshoppers at 120 h post-exposure, with some more rapid mortality within 24 h when spinosad was used at a higher rate. Significant mortality from *B. bassiana* was first observed after 72 h, with the high rate (1 lb/100 gal concentration). In a second trial treatment with Bioneem, Trilogy (neem oil), and Garlic Barrier were also included all treatments caused significant mortality at 96 h, with significantly most mortality with *B. bassiana* and spinosad. At 192 h, *B. bassiana* and spinosad produced 100% mortality. In conclusion, *Beauveria bassiana* and Spinosad were effective microbial insecticide for reducing population density of migratory grasshopper in both laboratory bioassays trials. In addition, Bioneem had significant repellent effects on migratory grasshoppers.

**Key words:** The migratory grasshopper, *Melanoplus sanguinipes* (Fabricius) (Orthoptera: Acrididae), microbial insecticides, repellent insecticides

## Introduction

The migratory grasshopper, *Melanoplus sanguinipes* (Fabricius) is an economically important grasshopper distributed throughout North America (Gurney and Brooks, 1959). Methods of control have been predominately limited to the use of insecticide sprays. Unfortunately, applications of insecticides have resulted in large and immediate decreases in certain non-target arthropods (Pfadt *et al*., 1985; Quinn *et al*., 1991). Microbial insecticides and repellents reduce plant injury by migratory grasshopper and other species common to the northern Front Range of in Colorado (Demirel, 1998). One microbial insecticide that has been long considered for use as an insect control agent is *Beauveria bassiana* (Balsamo) Vuillemin (Hyphomycetes: Moniliales) that is being developed as a bioinsecticide of grasshoppers (Inglis *et al*., 1995) and many other types of insects (Anderson *et al*., 1989; Knudsen *et al*., 1990; James and Lighthart, 1994). Many of the dead grasshoppers treated with *B. bassiana* exhibited dark red coloration, a common symptom of

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*B. bassiana* infection (Marcandier and Khachatourians, 1987). Spinosad is a recently developed insecticide produced as fermentation product of by the soil actinomycete *Saccharopolyspora spinosa*. Spinosad has biological activity against a wide range of the insects including Lepidoptera, certain Diptera and Thysanoptera (Berard *et al*., 1994).

In laboratory and field applications of several commercial neem-extract formulations, Zimmerman *et al*. (1993) showed activity against eggs and larvae of elm leaf beetle, *Xanthogaleruca luteola* (Muller). These experiments showed that although neem was slower to display initial effects, it ultimately yielded a level of control comparable to that of many synthetic insecticides. In addition to azadirachtin there are many other biologically active chemical compounds derived from neem seed extracts (Schmutterer, 1990). Neem oil contains a complex array of biologically active compounds known as limonoids (tetranortriterpenoids) of diverse structural types (Ley *et al*., 1993). Pesticides using the azadirachtin-free neem oil fraction have been developed (e.g., Trilogy$^{R}$) for control of certain arthropods and plant pathogens. For example, treatment with neem oil resulted in a reduction of eggs produced and increased incubation time for of the spider mite *Tetranychus urticae* (Koch) (Dimetry *et al*., 1993).

The purpose of this study was to determine the specific effect of microbial insecticides and repellents for control of migratory grasshopper in Fort Collins, Colorado (USA).

## Materials and Methods

*Laboratory Ingestion Trial I, 1997*

Trials were conducted with adult migratory grasshoppers to determine susceptibility to ingestion exposure to *Beauveria bassiana* Strain GHA (BotaniGard WP9702) and spinosad (Conserve SC) in Fort Collins, CO (USA). *Beauveria bassiana* Strain GHA (BotaniGard WP9702, MycoTech Corporation, Butte, MT) and spinosad (Conserve SC, Dow AgroSciences, Indianapolis, IN) were applied to alfalfa leaves with a series of 0.25 times dilutions that were reflecting labeled use rates; BotaniGard WP9702 1 1b/100 gal; BotaniGard WP9702 0.25 1b/100 gal; BotaniGard WP9702 0.0625 1b/100 gal; Conserve SC 0.4170 $mL^{-1}$; Conserve SC 0.1043 $mL^{-1}$; Conserve SC 0.0261 $mL^{-1}$) and a water check. Adult migratory grasshoppers were collected from alfalfa at the Horticulture Research Center and Agricultural Research and Demonstration Center (ARDEC) of Colorado State University northeast of Fort Collins, CO. Grasshoppers were then confined 8 per petri dish (100x15 mm), with 5 petri dishes used per treatment and maintained at room temperature. Alfalfa leaves were dipped in the dilution of the various treatments, allowed to air dry and then placed with grasshoppers. After the originally treated alfalfa foliage was consumed, untreated alfalfa foliage was used to maintain grasshoppers in all treatments. Mortality was assessed at 24 h intervals for six days following exposure. Data from trial was analyzed by analysis of variance (ANOVA) with using the SAS software and means were separated by using Student-Newman-Keuls (SNK) Multiple Comparison Tests (SAS Institute Inc., 1990).

*Laboratory Ingestion Trial II, 1997*

This study expanded upon that of the previous experiment by including additional treatments in Fort Collins, CO (USA). In addition to *B. bassiana* Strain GHA (BotaniGard WP) and spinosad (Conserve SC), a garlic-derived insecticide/repellent (Garlic Barrier$^{R}$), neem oil (without azadirachtin) pesticide (Trilogy$^{R}$) and neem-derived crude extract (azadirachtin + neem oil) (BioNeem$^{R}$) were included. Treatments were applied at the following concentrations, reflecting labeled use rates:

BotaniGard WP 1 1b/100 gal, Conserve SC 0.0625% concentration (8-fl oz/100 gal), Garlic Barrier 10% concentration (10 gal/100 gal); Trilogy 1.0% concentration (1 gal/100 gal) and BioNeem 2.5 concentration (2.5 gal/100 gal) and a water check as a control treatment. Adult migratory grasshoppers were confined, 8 per petri dish (100x15 mm), with 6 petri dishes used per treatment. Alfalfa leaves were collected from the Horticulture Research Center of Colorado State University northeast of Fort Collins, CO. Treatments involved in dipping alfalfa leaves, allowing them to air-dry and then feeding the leaves to the grasshoppers. After the originally treated foliage was consumed, untreated foliage was used to maintain grasshoppers in all treatments. Mortality was assessed at 24 h intervals for two days and at 48 h during a subsequent interval, for a 192 h total during this study. Data from trial was analyzed by analysis of variance (ANOVA) with using the SAS software and means were separated by using Student-Newman-Keuls (SNK) Multiple Comparison Tests (SAS Institute Inc., 1990).

## Results and Discussion

*Laboratory Ingestion Trial I, 1997*

At 120 h, all *B. bassiana* and spinosad treatments produced significant grasshopper mortality (Table 1). Effects were most rapid with spinosad, which showed mortality effects at the higher rates during the first evaluation. Spinosad at the highest (0.4170 $mL^{-1}$) concentration was caused significant mortality than water check treatments at the 24 h evaluation. At 72 h, all of the spinosad treatments produced significantly greater mortality than untreated check. At 96 h, the high rate of spinosad (0.4170 $mL^{-1}$ concentration) showed 100% mortality. Significant mortality from the high rate of the BotaniGard WP9702 formulation of *B. bassiana* Strain GHA was first observed at the 72 h evaluation. At that time, mortality was 30%. At 96 h, mortality was 57.5% compared to the untreated check. At 120 h (five days), mortality was 95% from *B. bassiana* at the 1 1b/100 gal rate; slightly lower (85%) mortality was observed at this time from both the 0.25 1b/100 gal and 0.0625 1b/100 gal *B. bassiana* rate. At 144 h (six days), all of the *B. bassiana* concentrations showed up to 95% mortality in this trial. Several studies were also conducted its use in control of grasshoppers. Laboratory spray tower trials with *B. bassiana* have been conducted on fourth-instar migratory grasshopper and larvae of the yellow mealworm, *Tenebrio molitor* L. (Marcandier and Khachatourians, 1987; Moore and Erlandson, 1988; Khachatourians, 1992). At 10 days, mortality of grasshoppers treated with *B. bassiana* was 72.5%, significantly higher than the mortality of the yellow mealworms and mortality of both species receiving air and oil treatments (Brinkman *et al*., 1997). This is similar to the laboratory trial results of Marcandier and Khachatourians (1987) who observed, at 14-days post treatment, 90-100% mortality of grasshoppers after being dipped in a distilled water suspension containing $2x10^7$ conidia per milliliter. However, there were no significant differences, compared to the water check, observed at 144 h post exposure in this trial because of high background mortality in the untreated check.

*Laboratory Ingestion Trial II,1997*

Effects were most rapidly observed with BotaniGard when produced significant mortality effects at the highest rate during the 24 h evaluation (Table 2). This was significantly different when compared with the BioNeem treatment and untreated water check. At 48 h, grasshoppers exposed to BotaniGard continued to have the highest mortality when compared the other treatments. At 48 h, there were no significant differences among the other treatments. At the 96 h evaluation there was significant mortality from both BotaniGard and Conserve, compared to other

Table 1: Leaf-dip bioassay using microbial insecticides for control of migratory grasshopper on alfalfa

| | | Percent mortality[z] | | | | | |
|---|---|---|---|---|---|---|---|
| Treatment and concentration | | 24 h | 48 h | 72 h | 96 h | 120 h | 144 h |
| BotaniGard WP9702 | 1 1b /100 gal | 7.5b | 12.5bc | 30.0a | 57.5ab | 95.0a | 100.0a |
| BotaniGard WP9702 | 0.25 1b /100 gal | 2.5b | 5.0c | 7.5b | 37.5a | 85.0a | 97.5a |
| BotaniGard WP9702 | 0.0625 1b /100 gal | 5.0b | 7.5bc | 10.0b | 20.0bc | 85.0a | 100.0a |
| Conserve SC | 0.4170 mL $L^{-1}$ | 52.5a | 67.5a | 92.5a | 100.0a | 100.0a | 100.0a |
| Conserve SC | 0.1043 mL $L^{-1}$ | 25.0ab | 45.0ab | 62.5a | 85.0a | 97.5a | 97.5a |
| Conserve SC | 0.0261 mL $L^{-1}$ | 12.5b | 22.5bc | 32.5a | 67.5ab | 82.5a | 87.5a |
| Water Check | | 2.5b | 2.5c | 2.5b | 10.0c | 22.5b | 40.0a |

[z]Numbers within a column not followed by the same letter are significantly different ($p<0.05$) by SNK

Table 2: Leaf-dip bioassay using microbial and repellent insecticides for control of the migratory grasshopper on alfalfa

| | Percent mortality[z] | | | |
|---|---|---|---|---|
| Treatment and concentration | 24 h | 48 h | 96 h | 192 h |
| BotaniGard WP9702 1 1b /100 gal | 16.7a | 45.8a | 89.6a | 100.0a |
| Conserve SC 0.0625% concentration | 2.5ab | 29.2b | 79.2a | 100.0a |
| Garlic barrier 10% concentration | 6.3ab | 10.4bc | 25.0b | 64.6b |
| Trilogy 1.0% concentration | 8.3ab | 14.6bc | 27.1b | 58.3b |
| BioNeem 2.5% concentration | 0.0b | 18.8bc | 22.9b | 87.5a |
| Water check | 2.1b | 2.1c | 18.8b | 50.0b |

[z]Numbers within a column not followed by the same letter are significantly different ($p<0.05$) by SNK

tested treatments. At 192 h, BotaniGard and Conserve produced 100% mortality. Brinkman *et al*. (1997) reported that at 10 days, mortality of grasshoppers treated with *B. bassiana* was 72.5%, a lower infection rate than was noted in this study. BioNeem (neem-derived insecticide) treatment also produced significant mortality at this time. Some early trials showed neem-derived insecticides capable of control of some insect species. For example, *Heliothis virescens* (Fabricius) larvae consumed less food, gained less weight and were less efficient at converting ingested and digested food into biomass (Barnby and Knocke, 1987). Population levels of chrysanthemum leafminer, *Liriomyza trifolii* (Burgess), were significantly reduced by neem-derived insecticides (Parkman and Pienkowski, 1990). Ascher *et al*. (1992) used the commercial azadirachtin-enriched formula Azatin$^{R}$ to successfully reduce nymphal populations of western flower thrips, *Frankliniella occidentalis* (Pergrande). Price and Schuster (1991) conducted field trials using neem and various synthetic insecticides to control population of the *Bemisia tabaci* (Gennadius) on poinsettia. There was no significant difference in grasshopper mortality resulting from exposure to the Garlic Barrier, Trilogy and untreated water check treatments.

The result of *B. bassiana* supported previous study and even caused significant mortality on the migratory grasshopper short period comparing with them. However, the using *B. bassiana* in the field condition was not success comparing with laboratory bioassay (Demirel, 1998). For this reason that the weather condition was very important factor to get a good result from *B. bassiana* treatments in field conditions. Spinosad was an effective as a bio-insecticide for reducing population density of grasshoppers in both laboratory bioassays and field trials (Demirel, 1998). In addition, the spinosad might be easy to apply for migratory grasshopper at home garden and organic farming. In this study also indicated that Bioneem had significant repellent effects on migratory grasshoppers. In addition, Trilogy and Bioneem had significant repellent effects on migratory grasshoppers and reduction of leaf area consumed in laboratory bioassays (Demirel, 1998). The Garlic Barrier did result in good mortality on the migratory grasshopper in laboratory condition. However, the other repellent insecticides of Hot Pepper Wax treatment was the most effective repellent

insecticide for reducing leaf area consumption in the field (Demirel, 1998). In conclusion, using of the microbial and repellent insecticides might be important for control migratory grasshopper in home garden area in Fort Collins, Colorado. As a result, *Beauveria bassiana* and spinosad were effective microbial insecticide for causing mortality on migratory grasshopper in both laboratory bioassays trials. In addition, Bioneem had significant mortality on migratory grasshoppers.

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