Effects of Spinosad and Acephate on Western Flower Thrips Inside and Outside a Greenhouse

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SUMMARY. Greenhouse studies were conducted from 1996 to 1998 to determine the efficacy of spinosad, and acephate, against western flower thrips (*Frankliniella occidentalis* Pergande) on transvaal daisy (*Gerbera jamesonii* H. Bolus ex. Hook f). In addition, the number of natural enemies inside and outside the greenhouse was determined. Studies were arranged in a randomized complete-block design with four blocks and four treatments per block. Three rates of spinosad, 50, 100, and 200 $mg{\cdot}L^{-1}$ (ppm), and one rate of acephate, 600 $mg{\cdot}L^{-1}$ were used in all three studies. Plants were artificially inoculated at bloom with 10 adult western flower thrips. The number of live and dead thrips was counted from each plant. In all three studies, both spinosad and acephate controlled thrips. However, there was more variation in the average number of live thrips for acephate than spinosad across years. In all treatments fewer live thrips and more natural enemies were found on plants outside the greenhouse than inside the greenhouse. This suggests that placing plants outdoors allows the natural enemies of thrips to colonize plants and provide supplemental control.

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Most greenhouse crop production systems rely strongly on the use of chemical pesticides to maintain a high-quality crop (Hudson et al., 1996). Western flower thrips (*Frankliniella occidentalis*) are the target of much of these control efforts because of their ability to damage flowers and foliage and to vector tomato spotted wilt and impatiens necrotic spot viruses (Allen and Broadbent, 1986; DeAngelis et al., 1993; Stobbs et al., 1992). Despite repeated insecticide applications, thrips are difficult to control because of their cryptic habit, high reproductive capacity, short development time, and resistance to insecticides (Robb, 1988; Helyer and Brobyn, 1992; Immaraju et al., 1992).

Two regulatory events have focused research on the development and use of reduced-risk pesticides to control greenhouse pests. The Worker Protection Standards directly alters labor practices by putting strict limitations on the reentry of workers into greenhouses after pesticide applications (U.S. Environmental Protection Agency, 1993). The Food Quality Protection Act can potentially eliminate many of the organophosphate and carbamate pesticides routinely used by growers (Sray, 1997). The use of reduced-risk pesticides are encouraged by these regulations because they are less toxic to workers, have shorter residual activity against pests, and are generally less harmful to beneficial insects and mites (Lowery and Isman, 1995; Oetting and Latimer, 1995; Parrella et al., 1983).

In this study, we tested one such material called spinosad. Spinosad is derived from a species of Actinomycete, *Saccharopolyspora spinosa* (Mertz and Yao), that when fermented creates a metabolite (spinosad) which is toxic to various insects. The material kills insects by contact and ingestion (Bret et al., 1997; Thompson et al., 1997). Our objective was to determine the effectiveness of spinosad and acephate in controlling western flower thrips. In addition, we compared the abundance of natural enemies on plants grown inside and outside a greenhouse.

Materials and methods

Trials were conducted from 1996 through 1998 to compare the effectiveness of spinosad with a standard insecticide for controlling western flower thrips. Transvaal daisy (*Gerbera jamesonii*) was used in this study for all three trials. Procedures for obtaining adult western flower thrips, identification, and inoculation have been described in previous studies (Cloyd and Sadof, 1998). The treatments in this study were spinosad (Conserve SC, Dow AgroSciences, Indianapolis, Ind.) applied at three rates, 50, 100, and 200 $mg \cdot L^{-1}$ (6, 11, and 22 fl oz / 100 gal water, respectively) and acephate (Orthene 75SP, Valent U.S.A Corp., Walnut Creek, Calif.) applied at the rate of 600 $mg \cdot L^{-1}$ (10.5 oz / 100 gal water). No adjuvant or spreader sticker was used.

Plants were potted into 15.2 cm (6.0 inch) pots in a growing substrate consisting of peat moss (75% to 85%), perlite, and vermiculite, with a pH between 5.5 to 6.5. They were fertilized with 20N–4.4P–16.6K at 200 $mg \cdot L^{-1}$ in a constant liquid feed program. Plants were placed into a greenhouse [20 × 10 m (60 × 30 ft)] on raised benches in a randomized complete block design with four replicate pots per treatment. Each flower was artificially infested with 10 adult western flower thrips. There was only one flower per pot as all other flowers were removed prior to inoculation. The next day, each flower was sprayed to drip with the desired treatment using a 946 mL (32 fl oz) spray bottle. All treatments were mixed in 473 mL (16 fl oz) of deionized water. Temperatures inside the greenhouse during the day ranged from 21 to 24 °C (70 to 75 °F). Data was collected 2 d after treatments had been applied by removing the flower from the plant in each pot and counting the number of live and dead thrips. Effects of treatments on the number of live thrips were analyzed using a randomized complete block design two-way analysis of variance (SAS Institute, 1996). Means were separated using a Fisher's protected least significant difference (LSD) test.

In 1998, the study protocol was modified to compare the number of live thrips and natural enemies inside and outside a greenhouse among the same treatments used in the pesticide efficacy study. After treatments were applied, four plants from each treatment group (16 total plants) were left in a greenhouse (20 × 10 m) and arranged in a randomized complete block design. A second group of 16 plants were similarly arranged outside in a shade house (20 × 10 m) with the doors and sidewalls opened. Data was collected 12 days after treatments by removing the flower from the plant in each pot and counting the number of live and dead thrips, and the number of natural enemies. Data was analyzed for effects of treatment and location on the number of live thrips and natural enemies using a randomized complete block design two-way analysis of variance (ANOVA) (SAS Institute, 1996). All treatment and location means were separated using a Fisher's protected LSD mean separation test. The number of live thrips was compared across treatments for all three trials. Percent control was calculated as the percent of change from the untreated control plants.

Table 1. Mean number of live western flower thrips per plant and percent control among treatments for all three trials.

Treatment	Rate [$mg \cdot L^{-1}$ (ppm)]	Mean live thrips (% of control) 1996	1997	1998	1996–98
Spinosad	50	1.3 (88.9)	0.0 (100)	1.0 (94.7)	0.7 a[z] (94.3)
Spinosad	100	1.0 (91.7)	0.0 (100)	0.0 (100)	0.3 a (97.7)
Spinosad	200	0.7 (94.4)	0.5 (93.1)	2.0 (89.5)	1.0 a (91.4)
Acephate	600	6.0 (50.0)	0.5 (93.1)	9.0 (52.6)	4.7 a (59.8)
Control	0	12.0	7.5	19.0	11.7 b

[z]Means not followed by a common letter are significantly different ($P = 0.05$) as determined by Fisher's protected least significant difference (LSD) test.

Results and discussion

All treatments had significantly fewer live thrips per plant than the control ($F = 9.33$; df = 4, 24; $P = 0.001$) (Table 1). There was no significant difference between spinosad and acephate, the most common pesticide used in greenhouses (Hudson et al., 1996). Despite this finding, variability in the average number of live thrips was greater for acephate than spinosad across the 3 years (Table 1). Consistency of control may be of concern to greenhouse managers that are trying to reduce plant injury and viral transmission. The inconsistency of acephate may be due to the metabolite (methamidophos) de-

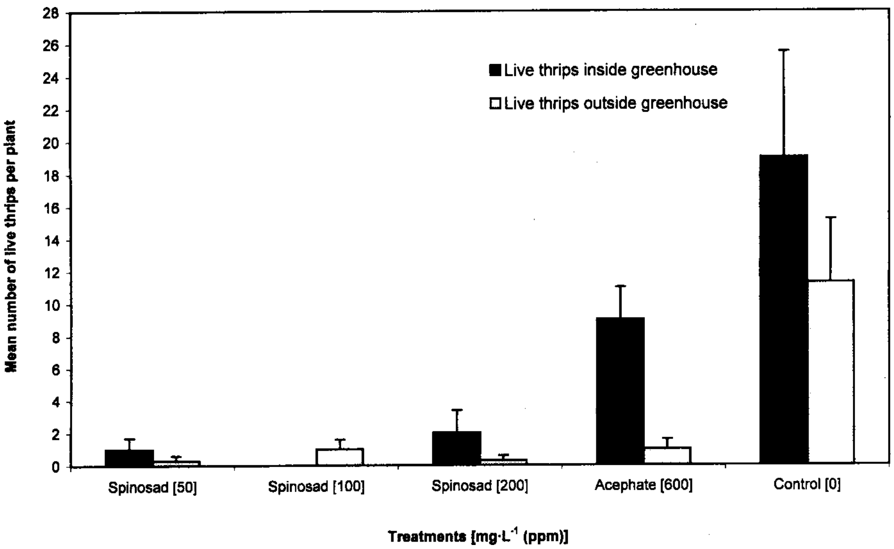

Fig. 1. Mean number of live western flower thrips per plant inside and outside the greenhouse. Vertical bars indicate SE.

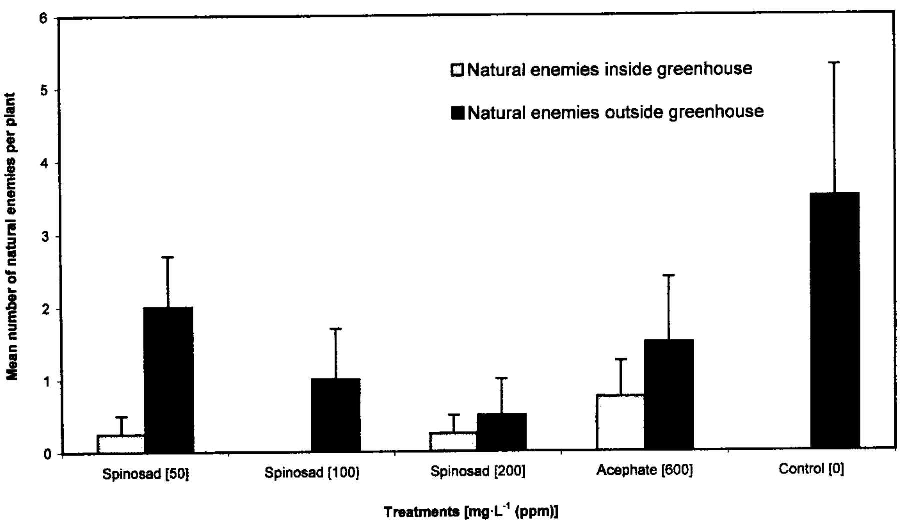

Fig. 2. Mean number of natural enemies per plant inside and outside the greenhouse. Vertical bars indicate SE.

grading more quickly in active tissues such as flowers (Cresswell et al., 1994). In bioassay studies, spinosad has been shown to be effective not only on *F. occidentalis*, but also on other thrips species such as *F. tritici* (Fitch) and *F. bispinosa* (Morgan) (Eger et al., 1998). In addition, greenhouse managers may prefer spinosad because the restricted entry interval (REI) is 4 h compared with acephate, which has a 24-h REI.

Significantly more live thrips were present on plants inside the greenhouse compared to plants located outside the greenhouse (F = 4.48; df = 1, 36; *P* = 0.04) (Fig. 1). Low numbers of live thrips on plants outside the greenhouse may be a result of thrips being exposed to environmental conditions such as wind, rain, and heat, which can cause thrips mortality (Kirk, 1997). Some crops, such as florist's gerberas (*Gerbera jamesonii* H. Bolus ex. Hook f) may not be able to tolerate rain and wind while other crops grown outdoors, such as chrysanthemums (*Dendranthema grandiflora* Tzvelev) and perennials are able to tolerate environmental conditions. Interestingly, significantly more natural enemies were present in the flowers of plants located outside the greenhouse compared with plants located inside the greenhouse (F = 9.37; df = 1, 36; *P* = 0.004) (Fig. 2). However, there was no significant effect of treatment (F = 1.47; df = 4, 36; *P* = 0.22). Despite this, it appears that there may be a dose response for the spinosad treatments with a decline in natural enemies as the rate of spinosad increased (Fig. 2). The natural enemies detected in the open flowers of transvaal daisy plants located inside and outside the greenhouse included green lacewing (*Chrysoperla* sp.), minute pirate bug (*Orius* sp.), and predatory mites. Natural enemies collected from flowers occupy the same habitat as adult thrips. This increases their chances of encountering and feeding on thrips (Chambers et al., 1993), and may have provided some type of supplemental control.

This study has shown that both spinosad and acephate are efficacious against thrips in a commercial situation. Greenhouse managers should consider the presence of natural enemies outdoors when implementing pest management strategies because natural enemies may provide supplemental control of western flower thrips.

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