Protecting Unrooted Cuttings From *Bemisia tabaci* (Hemiptera Aleyrodidae) During Propagation

Peter C. Krauter, Kevin M. Heinz, and Steven Arthurs

Department of Entomology, Texas A&M University, 370 Olsen Blvd., College Station, TX 77843-2475 (p-krauter@tamu.edu; kmheinz@tamu.edu; sathurs@tamu.edu), and *Corresponding author, e-mail: kmheinz@tamu.edu*

Received 10 March 2017; Editorial decision 30 May 2017

Abstract

In North America, the sweetpotato whitefly, *Bemisia tabaci* Genn., is an important pest of greenhouse poinsettia. Growers have limited options to control this pest during propagation of cuttings, which are rooted under mist for several weeks. Early establishment of this pest increases the difficulty of managing the whitefly and retaining high aesthetic standard during the remaining crop production phase. We evaluated two neonicotinoids with translaminar activity, thiamethoxam (Flagship 25WG), and acetamiprid (TriStar 70 WSP), for control of *B. tabaci* pre-infested on unrooted cuttings propagated under mist. In an experimental greenhouse, both materials significantly reduced whitefly populations, providing an average reduction of 87.8% and 61.5% total recovered whitefly stages respectively, compared with controls. In another test, dipping cuttings in thiamethoxam (immersion treatment) did not improve control significantly, when compared with foliar sprays applied at label rate. In a commercial greenhouse operation, immersion treatments of thiamethoxam on pre-infested poinsettia cuttings maintained whiteflies at ≤0.02/plant, compared with up to 0.33/plant in untreated cuttings. Our data suggest that treating unrooted cuttings before or at the start of propagation can be part of an overall strategy for growers to manage whitefly in poinsettia production.

Key words: poinsettia, thiamethoxam, acetamiprid, propagation, whitefly

The propagation of unrooted cuttings under greenhouse mist systems is a well-established method for nursery stock (Couvillon 1988, Newton and Jones 1993). Although mist propagation systems offer a low cost and reliable approach for many plant species, vegetative cuttings in propagation may be susceptible to pests and diseases. Moreover, the shipment of propagative plant material including cuttings provides a pathway for introduction of pests into greenhouses (Hulme 2009, Van Lentena and Navia et al. 2010, Saccaggi and Pieterse 2013). Management of pests early in the production cycle is critical to establishing integrated pest management approaches for many greenhouse pests (Van Lenteren and Woets 1988, Albajes et al. 1999).

In the case of poinsettia (*Euphobia pulcherrima* Willd. Ex Koltz) propagation of unrooted cuttings under a fine mist of water presents environmental and physiological challenges to management of sweetpotato whitefly, *Bemisia tabaci* Genn. Contact insecticides require thorough coverage of both upper and lower sides of the leaves to be effective against *B. tabaci* (Lathief et al. 2008, Liu and Stansly 1995). Residual control from contact insecticides may be limited by the frequent application of mist; moreover, the lack of a developed root system will limit adsorption (uptake efficiency) from many traditional systemic insecticides (Sichaldi et al. 1997). *B. tabaci*, however, are unhindered by the presence of mist and continue to lay eggs and develop on the leaves of the unrooted cuttings. If the cuttings are obtained from infested source plants, or if the propagation areas are subject to new whitefly infestations, the new crop of poinsettias will begin their 6-month crop cycle already infested.

Insecticides with translaminar properties provide alternatives to manage pests on cuttings. Translaminar insecticides are readily absorbed and move internally across leaf tissues, offering a strategy to control whitefly during mist propagation. In Canada and Europe, researchers and growers are experimenting with dipping poinsettia cuttings in biopesticides in order to reduce initial infestations of whiteflies on propagated materials (Buitenhuis et al. 2016; Cuthbertson et al. 2009, 2015). However, the use of insecticides with translaminar activity as dipping treatments against *B. tabaci* on poinsettia has not been reported. The objective of this study was to evaluate neonicotinoid insecticides with translaminar activity as spray and immersion treatments against *B. tabaci* on poinsettia cuttings under mist-propagation.

Materials and Methods

Insects and Plants

A laboratory colony of *B. tabaci* B Biotype originating from cotton in Brazos County, TX and reared on eggplant in Plexiglass cages
maintained at 26 °C 14:10 (L:D) h were used in the first two studies. Adult used in trials came from a one-year-old colony and had a sex ratio of 50% male/female. Adults used in the experiments were of unknown age. Poinsettia “Prestige Red” plants were obtained from a local nursery and grown and propagated at Texas A&M University according to guidelines provided by Ecke et al. (2004).

Comparison of Two Insecticides

We compared foliar applications of two neonicotinoid insecticides for B. tabaci protection on unrooted poinsettia cuttings propagated under mist in an experimental greenhouse. Thiamethoxam was applied at a rate of 75 mg active ingredient/liter (Flagship 25WG, Syngenta Crop Protection, Inc. at 0.3 g product/liter or 4 oz/100 gal), and acetamiprid at a rate of 59 mg a.i./liter (TriStar 70 WSP, Cleary Chemical Corporation at a rate of 0.08 g product/liter or 1.13 oz/100 gal, 2 soluble bags). These dilutions were selected based on the label rates of active ingredients that would be applied by growers. Water (RO) was used for an untreated control. To establish infestations for the study, 160 poinsettia plants placed on greenhouse benches under Remay cover were exposed to adult whiteflies released at an average of 2.25 whitefly per cutting on two occasions, 5 days apart. Six days later, cuttings containing whitefly eggs were taken from the source plants and stuck individually into 10-cm diameter pots containing potting media (Sunshine Grow Mix #1, Sungrow Horticulture, Agawam, MA) for rooting. Pots were randomly divided into three treatment groups with each one placed on separate mist benches measuring 1.5 m × 3 m. Benches were covered with a semi-transparent nonwoven polyester fabric (Reemay, Avintiv Old Hickory, TN) fitted over a 1.2 m high PVC frame to maintain humidity. On each bench the 36 potted cuttings were randomized into three groups of 12 plants per the three treatments.

Overhead misting for propagation was provided by Phytro-Mist Brass Nozzles (Phytotronics Inc., Earth City, MO) at 1-m spacing which was programmed to operate for 12 s every 12 min. A decreasing misting cycle intensity was provided to harden the cuttings. Initially the misting cycle operated for 24 h 3 days, followed by operation only during daylight hours (6 a.m. until 8 p.m.) for a further 14 days, and finally operation during only afternoon hours (12 p.m. until 4 p.m.) for a further 8 days. Insecticide treatment applications were made on day 11 of the misting cycle, after the end of the misting period. The three treatments were applied using 1-liter hand held spray bottles, and plants sprayed until runoff. Cuttings under mist were exposed to five additional releases of adult whitefly (at a rate of 1 whitefly per cutting). The study was terminated on day 24 after planting, and number of whiteflies and leaves counted, as noted previously. Environmental conditions monitored with a data-logger (Hobo H8 Series, Onset, Bourne, MA) mounted inside a rain shield revealed an average temperature of 21.3 °C (range 11.8–31.1 °C) during the studies, and 100% RH during misting cycles.

Grower Study

To test the efficacy of cutting treatments under producer conditions, a greenhouse trial was conducted with a local poinsettia grower in Washington County, TX. Approximately 10,000 Prestige Red poinsettia cuttings that contained apparent B. tabaci source populations were used and one half randomly assigned to thiamethoxam treatments via immersion, at the same rate indicated in the previous study. The remaining cuttings were untreated. Following treatments, cuttings were placed in rooting media plugs on 12 benches in a mist propagation house. Whitefly counts were conducted weekly on 60 randomly selected cuttings per treatment (i.e., 10 plants per six replicate benches for each thiamethoxam and control cuttings) for five weeks, until the end of the mist propagation period. Cuttings were replaced but not reused during the study.

Statistical Analysis

Data were analyzed as a randomized complete block design via one-way ANOVA with bench as a statistical block and 10–13 plants per replicate, depending on the study. Means were compared, where appropriate, using Tukey multiple comparison procedures at P < 0.05 with count data transformed via log (n + 1). In the grower study, due to low numbers, whiteflies per bench were totaled over the 30-day propagation period prior to analysis.

Results

Comparison of Two Insecticides

Insecticide treatment was highly significant (F2,6 = 15.0, P < 0.005). Mean comparisons revealed that both insecticides significantly reduced all the different immature stages of whitefly relative to the control (Table 1). Overall, thiamethoxam-treated plants had a larger reduction, i.e., 87.8% fewer whiteflies stages on plants, compared with 61.5% for acetamiprid. However, the number of whiteflies recovered differed significantly only in the number of eggs. The bench (blocking factor) effect on total whiteflies recovered was not significant (F2,6 = 0.22, P = 0.81).

Comparison of Application Methods

Both application methods of thiamethoxam significantly reduced whitefly infestations relative to controls, but did not differ significantly with respect to each other in reduction of eggs, early, or late instars (Table 2). Overall, plants treated via immersion or spray had a similar reduction, i.e., 91.2% and 91.1% fewer total whiteflies.


Table 1. Evaluation of foliar-applied neonicotinoid insecticides against whiteflies, \textit{B. tabaci}, on propagated poinsettia cuttings under mist

| Treatment   | Total   | Eggs     | First instar | Second + third instars | Fourth instar/pupae |
|-------------|---------|----------|--------------|------------------------|---------------------|
| Control     | 250.9 ± 45.2a | 93.1 ± 11.6a | 55.5 ± 14.0a | 99.1 ± 16.1a | 3.0 ± 0.6a |
| Thiamethoxam | 96.6 ± 21.4b | 48.9 ± 7.4b | 29.2 ± 3.3b | 17.5 ± 3.2b | 1.0 ± 0.4b |
| Acetamiprid | 30.9 ± 5.9c  | 8.3 ± 1.3c  | 17.9 ± 2.3b | 4.4 ± 0.9b  | 0.1 ± 0.1b |

Data are mean ± SEM/whiteflies per cutting from three replicate groups of cuttings; different letters indicate differences according to Tukey’s HSD test at \( P < 0.05 \).

Table 2. Evaluation of thiamethoxam against whiteflies, \textit{B. tabaci}, on propagated poinsettia cuttings under mist according to application method

| Treatment        | Total     | Eggs      | First–third instars | Fourth instar/pupae | Exuvia         |
|------------------|-----------|-----------|---------------------|---------------------|----------------|
| Control          | 107.5 ± 4.8a | 65.5 ± 2.6a | 37.7 ± 5.2a         | 3.3 ± 1.3a          | 1.0 ± 0.1a     |
| Immersion        | 9.4 ± 1.6b  | 7.1 ± 0.7b | 2.3 ± 0.9b          | 0.0 ± 0.0b          | 0.0 ± 0.0b     |
| Foliar spray     | 9.5 ± 5.5b  | 7.5 ± 4.2b | 2.0 ± 1.4b          | 0.0 ± 0.0b          | 0.0 ± 0.0b     |

Data are mean ± SEM/whiteflies per cutting from three replicate groups of cuttings; different letters indicate differences according to Tukey’s HSD test at \( P < 0.05 \).

We investigated whether immersion of cuttings with thiamethoxam would improve control, relative to spraying to drip. We did not observe any differences between these treatments, suggesting that leaf penetration and bioavailability to whiteflies was sufficient via foliar spray. Currently, immersion or dipping is not an approved label use for this pesticide. However, dipping treatments for new cuttings may have logistical benefits. For example, dipping may result in less pesticide waste compare with spraying, while providing optimal coverage of contact insecticides, which is required against whiteflies (Latheef et al. 2008, Liu and Stansly 1995). As the active ingredients of most neonicotinoids move into leaf tissues within 4 h and surface residues will diminish to low levels within a week (Wise et al. 2006), the use of such materials early in propagation may also be compatible with later use of beneficial arthropods that do not feed directly on the crop (Heinz and Parrella 1994), however this would need to be confirmed.

One issue is that some \textit{B. tabaci} biotypes (notably Q) have developed resistance to neonicotinoids and other insecticides, while over-exposure of nonresistant biotypes to pesticides at the propagator may also cause resistance development (Schuster et al. 2010, Castle...
and Prabhaker 2013). This suggests that biotype monitoring may be needed and that insecticides should immediately discontinued if determined ineffective (McKenzie et al. 2012). Moreover, pending legislation may restrict the availability of neonicotinoids in the future, as various risk assessments concerning environmental impacts of this group of insecticides are currently underway (EPA 2017).

While our results and earlier studies (Buxton and Clarke 1994, Richter 2005) suggest that immersing poinsettia cuttings in conventional insecticides helps control B. tabaci, there are issues of worker exposure and waste disposal. Researchers and growers in other regions are therefore experimenting with biopesticides (soaps, oils, and microbial control agents) used individually and in combination as dipping treatments to manage B. tabaci on new poinsettia cuttings. In Canada, where access to registered pesticides is limited and insecticide resistant whitefly biotypes occur, researchers have reported that mineral oil (0.1%, v/v) and the combination of insecticidal soap (0.5%, v/v) plus a commercial formulation of Beaniaeria bassana were the most effective treatments used to dip poinsettia cuttings (Brownbridge et al. 2014, Buitenhuys et al. 2016). Similar results have been demonstrated in the UK (Cuthbertson et al. 2009, Cuthbertson and Collins 2015). Buitenhuys et al. (2016) noted that dipping cuttings was compatible with biological control agents used later in production, i.e., by ensuring that the density of whiteflies entering the production cycle did not exceed control “capacity” of the parasitoids used. However, the rates of oils and soaps used for dipping were decreased from label rates to avoid issues of phytotoxicity. The transmission of plant diseases is another potential concern for growers using dipping treatments.

In summary, the emergence of insecticide resistant whitefly biotypes, increasing restrictions on insecticide availability, and emergence of effective greenhouse biological control strategies all favor movement to preventative rather than curative strategies (McKenzie et al. 2012, Cuthbertson et al. 2011, Frewin et al. 2014). Treatment of poinsettia cuttings with effective materials will help growers knock down any B. tabaci populations on plants entering the production cycle to a level at which where they can be more easily managed, in order to produce a clean crop.

Acknowledgments

We are grateful to Steve Thompson, Carlos Bogran, and Ellison’s Greenhouses Inc., for technical support and Ecke Ranch, Inc. for donating poinsettia cuttings. Financial support for this research was provided by the USDA-ARS Floricultural and Nursery Research Initiative and the American Floral Endowment to K.M.H.

References Cited

Albajes, R., M. L. Gullino, J. C. van Lenteren, and Y. Elad (eds.) 1999. Integrated pest and disease management in greenhouse crops, Developments in Plant Pathology, vol. 14. Springer Science and Business Media, Dordrecht, the Netherlands.

Brownbridge, M., R. Buitenhuys, T. Saito, A. Brommit, P. Cote, and G. Murphy. 2014. Prevention is better than cure: early-season intervention to control whitefly on poinsettia. Integ. Control Prot. Crop. Temp. Clim. IOBC-WPRS Bull. 102: 23–28.

Buitenhuys, R., M. Brownbridge, A. Brommit, T. Saito, and G. Murphy. 2016. How to start with a clean crop: biopesticide dips reduce populations of Bemisia tabaci (Hemiptera: Aleyrodidae) on greenhouse poinsettia propagative cuttings. Insects. 7: 48.

Buxton, J., and A. Clarke. 1994. Evaluation of pesticide dips to control Bemisia tabaci on poinsettia cuttings. Pestic. Sci. 42: 141–142.

Castle, S. J., and N. Prabhaker. 2013. Monitoring changes in Bemisia tabaci (Hemiptera: Aleyrodidae) susceptibility to neonicotinoid insecticides in Arizona and California. J. Econ. Entomol. 106: 1404–1413.

Couvillon, G. A. 1988. Rooting responses to different treatments. Acta Hortit. 227: 187–196.

Cuthbertson, A. G., L. Blackburn, P. Northing, W. Luo, R. Cannon, and K. Walters. 2009. Leaf dipping as an environmental screening measure to test chemical efficacy against Bemisia tabaci on poinsettia plants. Int. J. Environ. Sci. Technol. 6: 347–352.

Cuthbertson, A. G., L. F. Blackburn, D. P. Eyer, R. J. C. Cannon, and J. Millar. 2011. Bemisia tabaci: the current situation in the UK and the prospect of developing strategies for eradication using entomopathogens. Insect Sci. 18: 1–10.

Cuthbertson, A. G., and D. A. Collins. 2015. Tri-Tek (petroleum horticultural oil) and Beauveria bassiana use in eradication strategies for Bemisia tabaci Mediterranean species in UK glasshouses.” Insects. 6(1): 133–140.

EPA (Environmental Protection Agency). 2017. Schedule for Review of Neonicotinoid Pesticides. https://www.epa.gov/pollinator-protection/sched-ule-review-neonicotinoid-pesticides (accessed 28 April 2017).

Ecke, P. III, J. E. Faust, J. Williams, and A. Higgins. 2004. The Ecke. Poinsettia Manual. Ball Publishing, Batavia, Illinois, USA. 287 p.

Elbert, A., M. Haas, B. Springer, W. Thielt, and R. Nauen. 2008. Applied aspects of neonicotinoid uses in crop protection. Pest Manag. Sci. 64: 1099–1105.

Frewin, A. J., C. Scott-Dupree, G. Murphy, and R. Hanner. 2014. Demographic trends in mixed Bemisia tabaci (Hemiptera: Aleyrodidae) cryptic species populations in commercial poinsettia under biological control and insecticide-based management. J. Econ. Entomol. 107: 1150–1155.

Heinz, K. M., and M. P. Parrella. 1994. Poinsettia (Euphorbia pulcherrima Willd Ex Koltz) cultivar-mediated differences in performance of five natural enemies of Bemisia argentifolii Bellows and Perring, n. sp. (Homoptera: Aleyrodidae). Biol. Control. 4: 305–318.

Hulme, P. E. 2009. Trade, transport and trouble: managing invasive species pathways in an era of globalization. J. Appl. Ecol. 46: 10–18.

Latheef, M. A., I. W. Kirk, L. F. Bouse, J. B. Carlton, and W. C. Hoffmann. 2008. Evaluation of aerial delivery systems for spray deposition and efficacy against sweet potato whitefly on cotton. Appl. Ent. Agric. 24: 415–422.

Liu, T. X., and P. A. Stansly. 1995. Deposition and bioassay of insecticides applied by leaf dip and spray tower against Bemisia argentifolii biotypes (Homoptera: Aleyrodidae). Pest Manag. Sci. 44: 317–322.

McKenzie, C. L., J. A. Bethke, F. J. Byrne, J. R. Chamberlin, T. J. Dennehy, A. M. Dickey, D. Gilrein, P. M. Hall, S. Ludwig, R. D. Oetting, L. S. Osborne, L. Schmale, and R. G. Shatters. 2012. Distribution of Bemisia tabaci (Homoptera: Aleyrodidae) biotypes in North America after the Q invasion. J. Econ. Entomol. 105: 753–766.

Navia, D., R. Ochoa, C. Velbourn, and F. Ferragut. 2010. Advective etiophyoid mites: a global review of their impact, pathways, prevention and challenges. Exp. Appl. Acarol. 51: 225–255.

Newton, A. C., and A. C. Jones. 1993. Characterization of microclimate in mist and non-mist propagation systems. J. Hortic. Sci. 68: 421–430.

Richter, E. 2005. Can integrated pesticides improve biological control of Bemisia tabaci in Euphorbia pulcherrima? IOBC-WPRS Bull. 22: 209–212.

Saccaggi, D. L., and W. Pieterse. 2013. Interacting aliens: insects and mites on budwood imported to South Africa. J. Econ. Entomol. 106: 1179–1189.

Schuster, D. J., R. S. Mann, M. Toapanta, R. Cordero, S. Thompson, S. Cymans, A. Shurtleff, and R. F. Morris. 2010. Monitoring neonicotinoid resistance in biotype B of Bemisia tabaci in Florida. Pest Manag. Sci. 66: 186–195.

Sichalbi, F., G. A. Sacchi, M. Trevisan, and A.A.M. Del Re. 1997. Root uptake and xylem translocation of pesticides from different chemical classes. Pestic. Sci. 50: 111–119.

Van Lenteren, J. C., and J. V. Woets. 1988. Biological and integrated pest control in greenhouses. Ann. Rev. Entomol. 33: 239–269.

Wise, J. C., A. B. Coombs, C. Vandervoot, L. J. Gut, J. J. Hoffmann, and M. E. Whalon. 2006. Use of residue profile analysis to identify modes of insecticide activity contributing to control of plum curculio in apples. J. Econ. Entomol. 99: 2055–2064.