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# Systemic application of chlorantraniliprole to cabbage transplants for control of foliar-feeding lepidopteran pests

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ABSTRACT

The diamide insecticide chlorantraniliprole is registered for control of lepidopteran pests in cabbage (*Brassica oleracea* L.). Taking advantage of its root-uptake systemic properties, chlorantraniliprole is labeled for use with a variety of soil application methods in different countries, depending on pests and local practices. We investigated the efficacy of different cabbage transplant application methods using a leaf consumption bioassay. In the laboratory, we compared different transplant water volumes, characterized the effect of transplant plug size when the insecticide is applied by drenching or soaking the seedling tray, and determined the effect of different soil types. At three field sites, we compared the efficacy of chlorantraniliprole applied in transplant water or as a tray drench or tray soak treatment. In the laboratory, transplant water volume did not affect the level or duration of *Trichoplusia ni* (Hübner) mortality caused by chlorantraniliprole. When seedling trays were drenched with insecticide solution, transplant plug size did not affect mortality, but when trays were soaked with an equivalent volume of solution, mortality was higher with small plugs. Transplanting plugs treated by transplant water, drench or soak into different soil types did not affect mortality caused by chlorantraniliprole. In the field, transplant water application was the most effective method at all three locations. Tray soak was the most variable application method. Different application methods can be used to take advantage of the systemic characteristics of chlorantraniliprole. Among the methods tested, transplant water and tray drench resulted in more consistent mortality under variable field conditions.



## 1. Introduction

Cabbage (*Brassica oleracea* L.) is an important crop grown in temperate and tropical regions. In 2009, there were 3,229,146 ha planted worldwide, including 26,510 ha planted in the United States (USDA, 2011). Several lepidopteran pests feed on the leaves of a variety of *Brassica* species and cultivars. These species include diamondback moth *Plutella xylostella* L., cabbage looper *Trichoplusia ni* (Hübner) and Imported cabbageworm *Pieris rapae* (L.). Single or multiple species infestations can cause significant damage to the cabbage crop. For example, it has been shown that high *P. xylostella* infestations that were not controlled can decrease marketable yield by 91% (Ayalew, 2006). Cabbage pest management is difficult because pest species can have multiple generations per year. In North America, *P. xylostella* can have four to twelve generations (Capinera, 2012), *T. ni* can have two to seven generations (Capinera, 2005) and *P. rapae* can have two to eight generations per year (Capinera, 2013). For this reason, depending on weather and pest pressure, cabbage fields in Minnesota, for example, may receive 5–9 insecticide sprays to control lepidopteran pests during a growing season (Hutchison et al., 2001). In areas where cabbage is grown year-round there can be over 20 generations of *P. xylostella* per year (Shelton, 2001). Moreover, in areas where insecticide-resistant populations occur, some growers may spray every two days (Talekar and Shelton, 1993). Insecticide applications reduce these pests decreasing the duration and intensity of plant defoliation and can increase yield (Burkness et al., 2005).

Application of systemic insecticides at the time of transplant can be a practical, effective and environmentally-safer method for control of early-season foliar pests than broadcast sprays. Currently, several neonicotinoid insecticides (i.e. imidacloprid, thiamethoxam, dinotefuran) and one organophosphate insecticide (diazinon) are labeled in the United States for applications in the transplant water at the time of planting (Bayer CropScience, 2007; Syngenta, 2007; Valent U.S.A., 2005; Makhteshim Agan, 2011). The neonicotinoids are labeled for the control of aphids, leafhoppers,

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thrips, leafminers, flea beetles and whiteflies (Bayer CropScience, 2007; Syngenta, 2007; Valent U.S.A., 2005). Diazinon is labeled for the control of root maggots (Makhteshim Agan, 2011). In the past, there has been limited research on controlling lepidopteran pests using transplant treatments in Brassica and other leafy vegetables. The registration of chlorantraniliprole as a soil-applied systemic product for control of lepidopteran pests has opened new possibilities for pest management in cabbage.

Chlorantraniliprole, formulated as Coragen® 20SC for application on Brassica and other vegetables, is an insecticide from the anthranilic diamides chemical class developed by DuPont™ (Lahm et al., 2005, 2007). Chlorantraniliprole works by activating the ryanodine receptors that control calcium release from muscle cells. This releases calcium ions from internal stores into the cytoplasm which causes nearly immediate paralysis and crop protection (E.I. du Pont de Nemours, 2007). The activity on lepidopterans, as well as root uptake and xylem mobility, make chlorantraniliprole an ideal choice for transplant treatments against the major foliar-feeding lepidopteran pests during early establishment of the crop (Lahm et al., 2005, 2007; Cordova et al., 2006). In the US, chlorantraniliprole is currently registered for use with in-furrow spray at planting, transplant water treatment, hill drench at planting, surface band at planting, soil shank injection at planting, drip chemigation or foliar application. The objective of this study is to compare transplant water, seedling tray drench and seedling tray soak application methods in the laboratory and in the field, to better integrate chlorantraniliprole into diverse cropping systems. Transplant water provides delivery of the product to the root zone where it is needed for systemic uptake. This method may be useful in cropping systems and regions where water is already being provided at transplanting. However, it would require additional resources such as machinery, water, time and fuel in systems that do not currently use this method. The tray drench application method would allow for treating a large number of plants at one time by spraying the trays. However, some of the insecticide may be retained by the leaves, which may reduce residual control. The tray soak method would allow treating of a large number of trays as well, if the transplants were already being watered from underneath. However, there may be uneven distribution of the insecticide if the soil moisture in the plugs is uneven.

## 2. Methods

### 2.1. Soil application methods

In this study, we refer to the transplant water application method when the insecticide is mixed in the water applied during the transplanting of the cabbage seedlings. The treated water is added to the transplant hole immediately prior to placing the seedling. In the field, this is accomplished by mixing the insecticide with the transplant water that is delivered by the same machine that conducts the transplanting. In the laboratory, we used 50 or 200 ml of water, a volume similar to that commonly applied mechanically in the field. The method of tray soak consists of preparing an insecticide solution, pouring it in a pan, and setting the transplant seedling tray in the pan until all the solution is absorbed. Tray drench consists of preparing an insecticide solution and spraying it over the transplant tray. In this study we adjusted the volume of water so that the solution saturates the potting medium but does not run off the tray.

### 2.2. Insects

*T. ni* used in the laboratory bioassays were obtained as eggs from Chesapeake Perl Inc. (Newark, DE) and larvae were reared on artificial insect diet (#F9772, Bioserv, Frenchtown, NJ) until the late 2nd instar. Cabbage loopers were maintained in a growth chamber with controlled environmental conditions (28 ± 1 °C, 50% RH, and 16:8 L:D) for the laboratory assays and the Delaware field trial. Insects for California and Texas field trials were shipped from the Delaware site as 1st instar larvae and held until the 2nd instar for testing.

### 2.3. Bioassays

Plants for the laboratory trials and the Delaware field trial were grown in-house from seed. Plants for the California (Westside Transplant, Firebaugh, CA) and Texas (Speedling, Alamo, TX) trials were grown commercially. See description of individual trials for the varieties tested. Treatments applied to cabbage plants in laboratory and field experiments were evaluated in laboratory feeding bioassays using leaf samples collected from treated plants at defined days after treatment. At each collection date, leaves from the middle canopy of each plant were removed, cut into approximately 3 × 4 cm rectangular sections, and placed in 16-cell plastic bioassay trays (Clear Pack, Franklin Park, IL). Prior to adding the leaf sections, each cell unit had been provided with approximately 2 ml agar (Bioserv, Frenchtown, NJ). The addition of agar helps maintain moisture to keep the leaf sections turgid for the duration of the assay. Bioassays were conducted by placing one late 2nd instar cabbage looper larva into each cell unit containing a leaf section. Trays with leaf sections and larvae were sealed with transparent snap-on plastic lids (Brisar Delvco Packaging Services, Philadelphia, PA). Test units were maintained in a growth chamber at 24 ± 1 °C, 70% RH and 16:8 L:D for all laboratory assays and the Delaware field trial. The units were maintained in rooms at 21–27 and 27 °C in California and Texas, respectively. Evaluations of larval mortality were conducted four days after transferring the larvae into the tray cells. Larvae were considered dead if immobile when prodded with fine forceps or unable to flip over when placed on their back.

### 2.4. Transplant water – effect of water volume

The objective of this experiment was to determine the effect of varying the transplant water volume used to apply a constant amount of insecticide. Cabbage seeds of the cultivar 'Stonehead'(Chriseed, Mount Vernon, WA) were planted into Redi-Earth® media (Sun Gro, Bellevue, MD) in 3.2 cm wide pots (~22 $cm^3$ per cell) (International Container Corp., Severn, MD). At the 4-leaf stage (ca. 5 weeks old), rooted seedlings with soil plugs were transplanted into 20.3 cm diameter azalea pots (Dillen, Middlefield, Ohio) containing heat-pasteurized Matapeake soil (Elkton, MD 23% sand, 55% silt, 22% clay). Chlorantraniliprole 200 g $L^{-1}$ was applied formulated as Coragen® 20SC (DuPont Crop Protection, Newark, DE). The treatments consisted of 1 mg chlorantraniliprole per transplant delivered in either 50 ml of water (low volume, concentrated solution) or 200 ml of water (high volume, dilute solution), manually poured into the transplant hole. We applied 1 mg chlorantraniliprole per plant because previous research indicated when this dose is used with transplant water, *T. ni* mortality decreases within 30 days, which allows comparisons between water volume treatments within a realistic time frame. In addition, this dose per plant is within the registered range for commercial application to cabbage. The range of labeled application doses is calculated by dividing the minimal and maximal use rate by the number of seedlings per unit of area. The seedling plug was placed in the transplant hole with the treatment solution and covered with soil. Each pot received approximately 10 g of Osmocote® 19-6-12 fertilizer