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A MANIFOLD FOR INJECTING INSECTICIDES INTO A DRIP IRRIGATION SYSTEM FOR SMALL PLOT RESEARCH TRIALS WITH ROW CROPS

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Abstract

A 10-port manifold was developed for the injection of insecticides into a drip irrigation system for small plot bell pepper research trials. A 179.1 metric ft lb/s positive displacement Aquaflow® electric chemical metering pump was used to transfer liquid chemical treatments from an 18.9 liter polyethylene bottle through a 10-valve manifold that allowed both water and up to 10 separate chemical treatments to mix and flow into the drip irrigation line of each treatment plot. Because very small amounts of insecticides are injected for small-plot trials, a valve and discharge pipe were built into the manifold to allow for the complete rinse of the system between treatments. This system would be suitable for chemigation research trials in most row crop trials using drip irrigation with or without plastic mulch.

Key Words: European corn borer, *Ostrinia nubilalis*, chlorantraniliprole, drip irrigation, chemigation, *Capsicum annuum* L.

Resumen

Un colector de 10 salidas fue desarrollado para la inyección de insecticidas en un sistema de riego por goteo para ensayos de investigación en pequeñas parcelas de pimiento. Se utilizó una bomba eléctrica de dosificación de productos químicos de 0.34 métricas CV de desplazamiento positivo (Aquaflow®), para la transferencia de los tratamientos químicos líquidos de una botella polietilena de 18.9 litros a través de un colector de 10 válvulas que permiten el agua y hasta 10 tratamientos separados de químicos el mezclarse y fluir en la línea de riego por goteo de cada parcela del tratamiento. Debido a que pequeñas cantidades de insecticidas se inyectan para los ensayos de pequeñas parcelas, se construyó una válvula y una tubería de descarga en el colector para permitir la completa limpieza del sistema entre los tratamientos. Este sistema sería adecuado para los ensayos de investigación sobre los químicos distribuidos por un sistema de riego en la mayoría de los ensayos de cultivos sembrados en surcos que utilizan el riego por goteo, con o sin mantillo plástico.

The production of quality vegetables requires timely and adequate water to meet the water requirements of the crop. Drip, or trickle, irrigation in vegetables and other crops has recently become the irrigation system of choice in many areas because of several reasons, including the compatibility and efficiency with plastic mulch row covers (Ross 2004). Depending on location, water savings with this system can amount to as much as 80% as compared with other irrigation methods (Locasio et al. 1981). Drip irrigation uses low water volume, low pressure, requires low energy, and has high application efficiency because it targets water to the root zone for efficient uptake (Ross 2004). Because many row-crop growers already use a drip irrigation system, it would be practical to utilize this system as a method of insecticide application for certain soil and foliar insect pests.

The use of drip irrigation systems to deliver agricultural chemicals began with the injection of plant nutrients through a drip irrigation system in vegetables in the 1970's. The first application of an insecticide through a drip irrigation system was reported by Ghidiu (1980), who injected oxamyl (Vydate® 2L, E.I. DuPont deNemours & Co., Wilmington, Delaware) through a trickle system under black plastic mulch in bell peppers for unsuccessful control of the European corn borer (*Ostrinia nubilalis* Hübner) using pressurized CO_2 and spaghetti hose to inject the mixture directly into the drip lines. Between 1980 and the late 1990's, few drip chemigation trials were reported, partly because insecticides available during these years did not have all of the qualities necessary for drip chemigation, i.e., high solubility and root systemic activity, non-phytotoxicity when root-applied, and effectiveness against specific insect pests.

In the late 1990's, 2 new classes of insecticides were developed that had all of these properties—the neonicotinoids and the anthranilic diamides. These new classes of insecticides were soluble, systemic and effective against specific insect pests at low rates. The neonicotinoids are highly toxic primarily to beetles, aphids, and leafhoppers, and the anthranilic diamides primarily to Lepidopterans (Lahm et al. 2007).

Chlorantraniliprole (Coragen® 20SC, E.I. DuPont de Nemours & Co., Wilmington, Delaware) belongs to the anthranilic diamides class, and is a newly registered insecticide for use in many vegetable crops. During small-plot chemigation research trials for ECB control in bell peppers (*Capsicum annuum* L.), rates of insecticides as low as 88.72 mL/0.4047 ha (3 oz/acre) were to be tested using the manifold described herein, which for test purposes is only 0.6 ml (0.02 oz) per treatment per 30.5 m (100 ft) of row length. Thus it is necessary to thoroughly rinse the manifold between treatments because with such an efficacious material, even minute amounts of residual remaining within the manifold could influence the outcome of the next injected treatment.

We designed a 10-valve manifold for quickly injecting up to 10 separate insecticide treatments into drip-irrigated bell pepper plots. A rinse valve and outlet pipe were added to thoroughly flush the manifold with clean water between treatment injections. The design is inexpensive, easy to construct and use, durable, and dependable for accurate and proper application delivery.

Materials and Methods

Manifold Construction

The manifold was constructed out of 1.27 cm PVC plastic pipe in a rectangular shape, 0.92 m long by 1.22 m wide (Figs. 1 and 2). There were a total of 10 'water' (1.27 cm ball valves) valves, 5 on each side and 10.16 cm apart, to allow water to flow from the manifold into a 1.27 cm sub-main line (Goodall Blueflex) and a total of 10 'treatment' valves, 5 on each side (8.9 cm apart), which connected to the corresponding water valves via a 1.27 cm sub-main to allow each insecticide treatment to merge with one of the 'water' sub-mains via a T-connection. Thus each 'water' valve independently

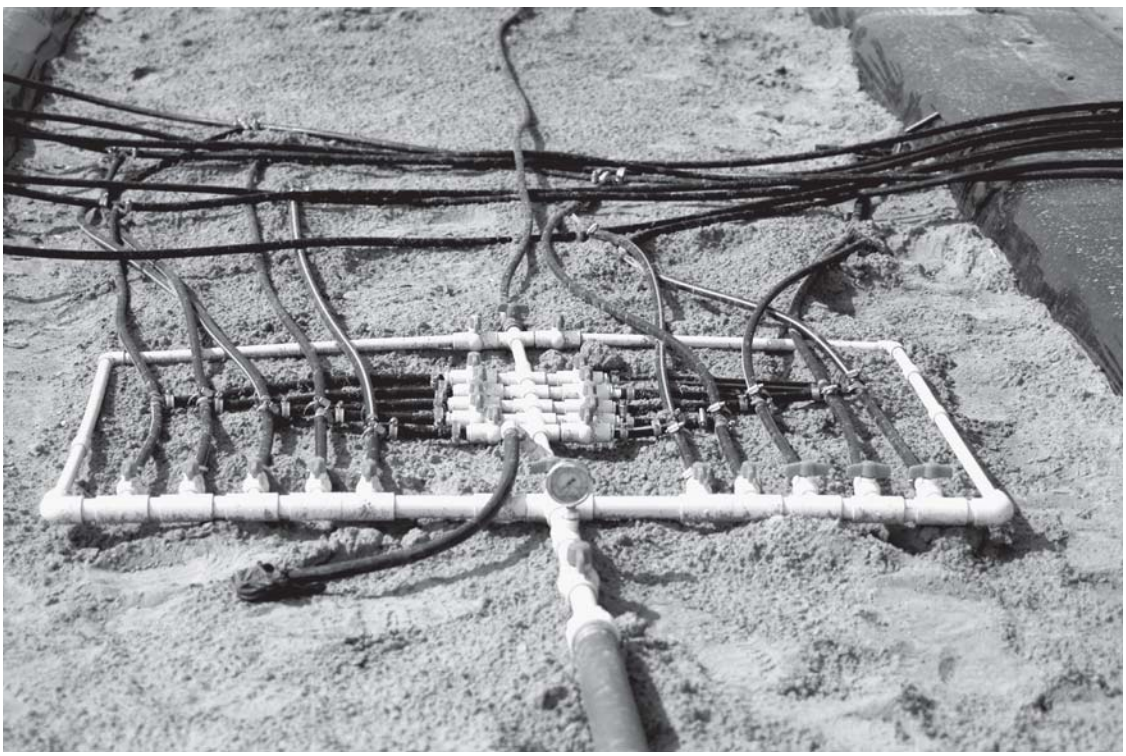

Fig. 1. Injection manifold and pump to deliver drip irrigation treatments to individual plots, 2007, Bridgeton, New Jersey.

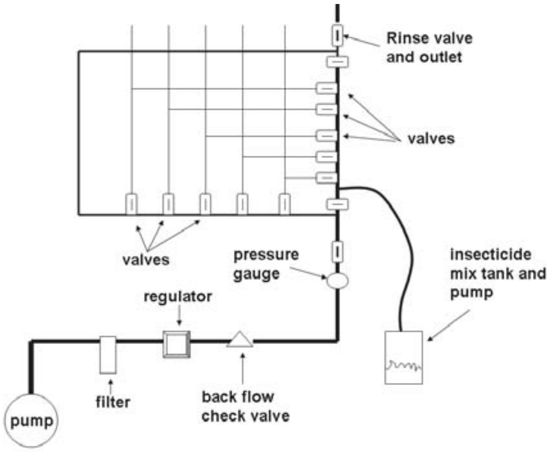

Fig. 2. Schematic of half of the injection manifold and pump to deliver drip irrigation treatments to individual plots, Bridgeton, New Jersey.

merged with a 'treatment' valve which connected to the sub-main tubing that carried the mixture to each individual plot. This system allowed for the injection of up to 10 independent and separate insecticide treatments (materials or rates) into a drip irrigation system. A valve in the center of the manifold, when opened, quickly allowed clean water to flush the entire system. It is critical to thoroughly flush the injection system between treatments to prevent contamination because very small amounts of the test materials could have an impact on results in small-plot field trials.

Field Trial

To determine treatment uniformity, a field trial with drip-irrigated, plastic-mulched bell peppers was established in 2007 at the Rutgers Agricultural Research and Extension Center, Bridgeton, New Jersey. Plots consisted of a single row of 'Paladin' cv. bell peppers (30.5 cm plant spacing) on 15.3 cm raised beds, 15.2 m long and 1.5 m wide, replicated 4 times in a randomized complete block design. Raised beds (91.4 cm wide) were formed on 21 May with a hi-speed bedmaker (Kennco Mfg, Inc., Ruskin, Florida) in a Chillum silt loam field. Following bed making, Eurodrip 8.0 ml irrigation tape (1.6 cm O.D.) with emitters on 30.48 cm spacing (0.95 L/h/30.48 cm at 55.2 kPa) was placed down the center of each plot (5 cm deep) and covered with a 1.25 ml black polyethylene 152.4 cm plastic mulch using a tractor-mounted plastic layer (Kennco Mfg, Inc., Ruskin, Florida). Peppers were transplanted on 23 May using a water-wheel transplanter (Kennco Mfg, Inc., Ruskin, Florida), with a plant spacing of approximately 10.2 cm from the drip tape. A 5.08 cm lay-flat main connected the farm water supply to the 10-valve manifold previously described for distribution to the plots via 1.27 cm sub-main tubing, which connected to the drip tape in each plot. A sand filter, a back-flow prevention unit and a 0.69 bar pressure regulator were connected to the farm water supply outlet.

The insecticide drip-irrigation treatment consisted of chlorantraniliprole (Coragen® 20SC) injected at a rate of 74 g ai/ha (5.0 oz/acre), which was pumped from an 18.9-liter polyethylene mixing bottle using a 0.31 metric hp positive displacement Series 1000 electric chemical metering pump (Aquaflow Inc., Irvine, California) through the 10-valve manifold previously described that allowed both irrigation water and the insecticide treatment solution to mix and flow into the drip irrigation line of each plot. This system is capable of delivering 9 liters of solution per 30 min into the pre-determined sub-main controlled by the valve at the manifold; each sub-main thus mixed only one treatment with the irrigation water which flowed to the selected plots. If electricity is not available, a small portable gas-operated generator with a 110-v output would suffice. The insecticide was injected in a 5.3 liter solution over a period of approximately 12 min. The 74 g ai/ha treatment thus had 3.4 ml of chlorantraniliprole added to 5.3 liters of water, a concentration of 128 ppm. At the time of injection, samples of drip output of plots receiving chlorantraniliprole were collected from drip emitters at the beginning, middle and end of the 15.2 m plots by digging a hole under the emitter and placing a 1000 ml glass beaker directly under the emitter to collect the flow. The emitter output from two replicates was collected from the time of injection through the flush (30 min). The replicates furthest apart (Reps I and IV) were chosen to maximize the distance between samples. The total volume collected was recorded and the %CV (coefficient of variation) per emitter was calculated. The sample was mixed and duplicate 10 mL subsamples were pipetted into vials for analysis. These subsamples were assayed in the laboratory using standard HPLC/UV techniques and average concentrations calculated for each treatment. After the treatment was injected, flushed and all samples collected, the injection manifold and the treatment bottle were rinsed with approximately 7.6 liter of clean water to ensure the system was free of contamination. All plots were irrigated for approximately 30 min before and following the injection treatment.

Field trial data were subjected to a two-way factor of analyses of variance (SAS Institute 1990). Means separations were determined by application of Tukey's Highly Significant Difference Test (SAS Institute 1990).

Results and Discussion

Simultaneous injection of compounds across multiple randomized replications is critical for efficient, cost-effective conduct of small plot

TABLE 1. AVERAGE VOLUME OF SOLUTION AND CONCENTRATION OF CORAGEN® 20SC COLLECTED FROM THE DRIP LINE EMITTERS AT THE BEGINNING, MIDDLE AND END OF A ROW OF IRRIGATED PEPPERS, BRIDGETON, NEW JERSEY, 2007.

Emitter Location	Replicates	Total Emitter Volume (mLs)	Percent Recovery per Emitter
Beginning	1, 4	685 a	89 a
Middle	1, 4	700 a	92 a
End	1, 4	695 a	81 a

Averages followed by the same letter(s) within a column are not significantly different. F= 3.2705; df = 2,5; P < 0.1763

studies. Reduced application time enables more treatment applications per unit of time, which allows for greater flexibility in protocol design. The 10-valve manifold system used in this study allows for multiple replicates of each treatment to be applied at one time. Water flow drives compound movement in the injection process and through the soil root zone. Therefore, uniform water distribution through the drip irrigation system is necessary to ensure uniform compound distribution. The water applied during the chemigation event was collected from individual emitters for two drip tapes to assess water delivery using the manifold. The collected water volume ranged from 670 to 710 mL (Table 1) corresponding to a CV of 2.4%. Eurotape drip tape normally has a CV of <2% (Eurotape, 2007). Considering the small sample size, this CV is acceptable. Uniform compound distribution was also obtained with an average of 88% recovery of chlorntraniliprole per emitter in rep 1 and 86% recovery in rep 4 (Table 1). This study demonstrates that the 10-valve manifold small plot injection system can be used to uniformly deliver compounds through the drip tape. An advantage of this manifold is that the injection system mimics commercial application systems by mixing the compound with the irrigation water. The application of chlorantraniliprole through a drip irrigation system using this manifold and pump designed for small plot work resulted in uniform application of the compound. An important feature was the addition of a valve and rinse line to quickly flush the system, which is critical with treatments such as chlorantraniliprole because the amounts used are very precise (3.4 ml per treatment/50 row meter of drip line). If more than one treatment is applied, it is important to thoroughly and quickly rinse the manifold to prevent treatment cross-contamination from traces of residues. Tubing connected to the valve would allow the rinseate to be collected into containers, or to drain some distance from the plots.

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