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The Benefits of Insecticide Use: Carrots

Carrot Weevil

Carrot Weevil Damage

Carrot Rust Fly Damage

Spreading Naphthalene Flakes to Control Carrot Rust Fly (1930s-1940s)

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Key Points

- Carrot weevils can damage up to 80% of the carrots in a field.
- Processors will not accept carrots with more than 1% damage by carrot weevil.
- Carrot rust flies cause about 20% loss on organic carrot farms in Washington.
- Prior to the introduction of synthetic chemicals, carrot growers spread about a ton of naphthalene flakes (moth balls) to control rust fly.

Technical Summary

Carrots are grown on 85,000 acres with a production volume of 2.9 billion pounds worth $500 million. Insects are erratic pests in most carrot fields. The three states with the highest usage of insecticides on carrots are Michigan, Texas and Washington. In these states insecticides are used on 77-100% of the carrot acres and it is estimated that carrot yields would decline by 30-50% without insecticide use [10]. Carrot fields in these three states have entrenched major insect pests which are not a problem in the other major producing states: Washington (carrot rust fly), Texas and Michigan (carrot weevil). In California 20% of carrot acres are treated with insecticides primarily for leafhoppers and cutworms and production would decline by 15% without this use [10][20]. Insecticide costs in California carrots are about $51/A, which represents about 1% of the cost of growing carrots [17]. In Washington and Texas, insecticide costs are $10-11/A representing 1% of the cost of producing carrots [18][19].

Carrot Weevil

The carrot weevil is native to northeast North America and was first described in Pennsylvania in 1842. The first damage reported on carrots was from Washington, DC in 1922. Reports from Illinois and Ohio indicated up to 90% of the carrots in some fields were damaged [4]. Although carrot growers rotated their fields, they found this to be not an effective control of the carrot weevil [6]. Early control was achieved using baits of apple pomace and calcium arsenate. Research demonstrated that three applications of 50 pounds of apple pomace plus calcium arsenate (95-5) reduced carrot weevil damage by 90% [4]. With the development of DDT and other chlorinated hydrocarbons, carrot weevil control shifted to using these effective long residual materials in preventive programs [5]. Three applications of DDT reduced carrot weevil damage by 98% [6]. Methyl parathion applications later became the standard.

Carrot weevils overwinter as adults in and near fields where carrots were grown the previous year emerging in April and May. Weed species also serve as hosts of the carrot weevil. Although the weevils have wings, they seldom fly and instead, they walk to nearby carrot fields. The adults feed directly on the leaves of carrots. Eggs are deposited in small cavities which the females chew in the stems, crowns, or exposed roots of the plant. Larvae hatch out and crawl down to the carrot roots. Each female can lay up to 200 eggs. The economic damage is done by the larva that tunnels in the root of the plant [21]. After entering the carrot, the larva blocks the tunnel entrance with its frass. The tunnels eventually become filled with frass and the epidermal cells over the tunnel die and become dark brown.

The carrot weevil female needs only one mating to fertilize its total egg complement and a single male can fertilize at least four females without sperm depletion [21]. Mating lasts about an hour. Once egglaying starts, it reaches its maximum of eight eggs per day. Adult carrot weevils are long-lived surviving up to 392 days [21]. Larvae feed for two to four weeks and tunnel extensively throughout the upper third of the roots, damaging 80% or more of the carrots in untreated fields [1]. The presence of larvae, frass, and feeding damage in the root are of major concern to carrot processors because of stringent FDA quality control in processed food. Processors are unwilling to accept carrots that have more than 1% damage or if they find one live larva in a sample. Before the development of effective insecticidal controls, shipments of carrots from south Texas were rejected at processing plants because of carrot weevil damage [2].

Crop rotation is effective if a carrot field is set remotely from fields previously in carrots. However, it is almost impossible to isolate carrot fields from a source of carrot weevil in areas of intense carrot cultivation [21]. No resistance or tolerance of carrot varieties to carrot weevils has been documented [21].

Most of the work done on biological control of carrot weevil has been done on the parasitoids of this species. The percentage egg mortality caused by parasitoids has been estimated at 49% in Michigan [21]. However, even with parasitism rates as high as 80%, sufficient carrot weevil larvae survived to damage carrots above a commercially acceptable level [21].

The current recommendation for carrot weevil control is to spray in the spring or early summer, as soon as the adults become active [3].

Carrot Rust Fly

The most important pest of carrots in Washington State is the carrot rust fly. The insect was first found in 1908 in the Puget Sound area. Economic damage to carrots was not reported until 1928 [8]. The carrot rust fly is native to Europe where it was recognized as early as 1794. The insect was first noted in Canada in 1885 and in the US in 1893.How the insect reached the Northwest is not known.

The adult female lays its eggs in the soil at the base of the carrot. Six to ten days later the larva hatches and feeds on the carrot, rendering the carrot impossible to market [7]. The larvae feed for about a month. Carrot rust flies obtain their common name from the rust colored frass that they deposit in the feeding tunnels on the carrot. In Washington State there are generally three generations of the fly per year. Damaged plants are wilted or stunted. 100% of the plants in a field can be damaged. Individual carrots can yield as many as 100 maggots each.

In the period preceding the appearance of the rust fly in the U.S., carrots had no serious insect pests. After the introduction of the insect, rust fly became the chief factor limiting the growing of carrots. In some sections of New York, where carrots had been grown intensively, they were abandoned as a commercial crop [12]. The constant increase in the rust fly was due to a lack of natural enemies [12]. In New York in the 1920s carrot growers began to plant later and harvest earlier to avoid multiple generations of the fly. However, this practice limited the yield and size of harvested carrots.

An early treatment for carrot rust fly was to apply crude naphthalene flakes, broadcast on the soil surface to deter the fly from laying eggs in the carrot field. 250 pounds of flakes were applied per acre. Due to the volatility of naphthalene flakes, three applications were made providing 99% control of the fly. The use of 1.25 tons of naphthalene flakes resulted in carrot yield increases of 37 tons per acre [12]. However, carrots could not be used for at least one month after application because they retained the flavor and odor of naphthalene [9]. Cube, derris and lead arsenate provided no control [11]. Periodic outbreaks were common until the development of chlorinated hydrocarbon insecticides in the early 1950s. In the 1960s organophoshates became the standard treatment with diazinon reducing infestations from 99% to 2% [13].

Because the carrot rust fly is a weak flyer and will not infest fields from a long distance, crop rotation can be a highly effective strategy. To be effective, the new carrot field must be situated at a sufficient distance (1000 meters) from an old field, to discourage relocation of the carrot rust fly. This makes rotation impractical for small acreage farmers [7].

Carrot rust fly causes about a 15-20% annual loss in yield on organic farms in Washington [15]. To avoid carrot rust fly damage, organic growers can delay planting or harvest early. However, this results in a limited growing season. Floating row covers are used as a physical barrier, excluding the insect from feeding or laying eggs on the crop. However, the covers must be undamaged and anchored securely. All this takes time and labor, plus there is the expense of replacing the covers every two to three years [14]. The row covers are cost prohibitive when applied to larger plantings.

Researchers in Washington tested the intercropping of carrots with a cover crop to reduce carrot rust fly damage. Cover crops may prevent carrot rust fly adults from finding carrots when they lay their eggs. However, there was no significant differences in rust fly damage in the plots with and without cover crops [15]. Researchers have tested the release of parasitic nematodes at a rate of 200 million juveniles per acre. Although the nematodes did provide some control of carrot rust fly, they did not reduce the infestation below economically acceptable levels [16].

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