AN ABSTRACT OF THE THESIS OF

RALPH E. WHITESIDES for the degree of MASTER OF SCIENCE

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Title: SELECTIVE CONTROL OF CIRSIUM ARVENSE (L.) SCOP. IN MENTHA PIPERITA L. WITH 3, 6-DICHLOROPICOLINIC ACID

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A series of field experiments was conducted during 1975 and 1976 to examine peppermint tolerance and Canada thistle response to Dowco 290 (3, 6-dichloropicolinic acid). Peppermint oil yield and Canada thistle density were considered most important in evaluating experimental results.

Peppermint tolerance to Dowco 290 was studied in weed-free peppermint (cv. Mitcham). Rates of 0.25 lb/A or more reduced peppermint oil yield. Time of application appeared to be less critical than rate of herbicide as oil production decreased with increasing rates. Mint injury was sufficiently severe at high rates to cause yield reductions the year of treatment, but recovery was good and no reduction in oil yield was found 1 year later.

Spring application of Dowco 290 to peppermint (cv. Mitcham and

Todd's Mitcham) infested with Canada thistles resulted in erratic oil yield but good thistle control. Oil yield was difficult to evaluate because of the variability of the peppermint stand. All rates of Dowco 290 tested gave good short-term thistle control and rates of 0.5 lb/A or more gave excellent seasonal control.

There was no advantage to split applications of Dowco 290 (fall plus spring) over a single application in the spring. An excellent combination of good thistle control and high oil yield was obtained from sequential treatments in the spring when 0.125 lb/A was applied 10 weeks prior to harvest and 0.063 lb/A was applied 2 weeks later.

Translocation of Dowco 290 through underground thistle parts was demonstrated by treating parent plants and observing the response in a connected daughter plant. The herbicide was not lethal at rates that translocated to connected plants, but it did cause abnormal floral development.

Dowco 290 was sufficiently active when applied at 0.25 lb/A to control all underground plant parts of test thistles even when treated plant parts were removed as soon as 1 hour after treatment. Root mortality was measured by a modified tetrazolium test.

Seedling Canada thistle plants were slightly more sensitive to Dowco 290 than plants which developed from mature rootstock. After seedling plants had developed a more complex root system, regrowth from rootstock of plants grown from seed and from mature rootstock was similar.

Selective Control of *Cirsium arvense* (L.) Scop. in *Mentha piperita* L. with 3,6-dichloropicolinic Acid

by

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INTRODUCTION

During the 1976 cropping year, the state of Oregon produced 62% of the peppermint oil produced in the United States. The value of the peppermint oil production in 1976 exceeded 35 million dollars (Oregon Crop and Livestock Reporting Service, 1977).

The rapid development of the Oregon peppermint industry in the late 1940's and early 1950's was a result of increasing infestation of verticillium wilt (*Verticillium dahliae*; formerly *V. albo-atrum* or *V. albo-atrum* var. *menthae*) in the muckland soils of Michigan and Indiana. The quantity of peppermint oil produced in Oregon in 1948 was greater than in Indiana, although the acreage in Oregon was smaller. Higher yields were attributed to a more favorable environment and less verticillium wilt. By 1952, the Oregon Essential Oil Growers League had requested an embargo on peppermint roots originating in the Midwest in an effort to stop the rapid spread of verticillium wilt into the western United States (Landing, 1969). The root embargo was an early technique used to prevent establishment and spread of verticillium wilt. Subsequent control methods include the cultural practice of eliminating plowing and cultivating in western Oregon peppermint fields.

Reduced tillage in peppermint fields has localized wilt problems but created other management situations. Mint which is not plowed becomes shallowly rooted and requires careful control of water and fertilizer schedules (MacSwan and Horner, 1965). Weed control to improve yield and oil quality (Ogg, 1972) in non-cultivated peppermint of the Willamette Valley depends heavily on terbacil and diuron for control of many annual grasses and broad-leaves. Control of Canada thistle is inadequate with these herbicides. Infestations of thistles can reduce peppermint yield. Current control methods for Canada thistle include hoeing and spot treatment with unregistered herbicides.

This study was designed to determine the relationship between rate and time of application of Dowco 290 (3,6-dichloropicolinic acid) for effective thistle control and minimal peppermint injury. Field experiments were conducted to measure peppermint oil yields from thistle-free and thistle-infested plots, as well as to monitor thistle stand density prior to and after treatment.

Canada thistles grown in containers were used to examine age response, rapidity of uptake, and translocation of Dowco 290 in Canada thistle.

LITERATURE REVIEW

Peppermint

Peppermint (Mentha piperita L.) is a member of the Labiatae Family, characterized by square stems, opposite leaves, and a bilabiate flower. Landing's review of the literature (1969) suggests that the genus Mentha originated in the Mediterranean Basin and spread to the rest of the world by natural and artificial means. Few seeds develop naturally and propagation for field planting is from rootstock. Peppermint produces stolons and rhizomes, but the term "rootstock" will be used to define both structures for the purposes of this paper. The crop is considered perennial by virtue of the fact that it produces new shoots from rootstock each year. In reality, few plant parts live longer than one year and none more than two years (personal communication, C. E. (Jack) Horner).

Mint grows best in deep, well-drained soils, especially muck soils high in organic matter and prefers a pH range of 6.0 to 7.5 (Green and Erickson, 1960). Michigan, Indiana, Wisconsin, Washington, Idaho, and Oregon are the major producing areas of the United States, accounting for a large part of the world supply of peppermint oil (Martin and Leonard, 1967). The 1976 Annual Summary of the Oregon Crop and Livestock Reporting Service (1977) reports 72,200 acres of peppermint harvested in the United States, 42,000 acres of which were produced in Oregon. Oil production is maximized in areas north of the 40th parallel having sunny days with a minimum of 15 hours daylength and low summer rainfall at harvest time (Green and Erickson, 1960).

Peppermint culture in the Willamette Valley of Oregon differs from other producing areas of the Pacific Northwest or the Midwest in that growers have adopted no-till cropping practices to control verticillium wilt. Two major varieties of peppermint are grown in the Willamette Valley, Mitcham (also known as Black mint, English peppermint, and Black Mitcham), and Todd's Mitcham. Other peppermint varieties are available but are not grown on a large acreage. Mitcham is considered by many to be slightly higher yielding than Todd's Mitcham but is not as resistant to verticillium wilt as is Todd's Mitcham.

The major diseases of peppermint are verticillium wilt caused by the fungus *Verticillium dahliae*, and peppermint rust produced by *Puccinia menthae*. Planting resistant Todd's Mitcham on uninfested soil and eliminating all tillage practices have decreased the spread of wilt. When fields are replanted and have a history of wilt, 5 or more years rotation is recommended unless fields are fumigated before planting (Koepsell and Horner, 1975). Flaming peppermint with a propane burner to destroy crop residue and young shoots in the fall for wilt control and in the spring for rust control, help contain these diseases as they attempt to establish themselves in peppermint fields.

Insect pests include symphilids (Scutigerella immaculata), mint flea beetle (Longitarsus waterhousi), and cutworms (Lepidopterans) (Green and Erickson, 1960). Major control efforts for insect pests center on insecticides.

Elimination of all tillage practices on peppermint grown in the Willamette Valley results in consistent production of "meadow mint" (Landing, 1969) with row mint appearing only in new plantings. Adoption of meadow mint culture under conditions of high fertility and irrigation has provided an ideal habitat for perennial weedy species not readily controlled with herbicides (Wiese and Staniforth, 1973; Donaghy and Stobbe, 1972). Under meadow mint culture, Canada thistle is one of the most aggressive weed species.

Canada Thistle

Canada thistle (Cirsium arvense (L.) Scop.) is a perennial weed introduced from Eurasia and has cosmopolitan distribution in the United States (Hitchcock and Cronquist, 1974). A member of the Compositae Family, Canada thistle is also known as creeping thistle, California thistle, and field thistle. It is found in heavy infestations in the northern half of the United States (Hodgson, 1971).

A mature thistle plant is from two to five feet tall, with leaves that are spiny and serrated or ruffled at the margins. Hodgson (1971) described a number of ecotypes of Canada thistle which have varying degrees of ruffling and spininess on the leaf margins.

Canada thistle flowers have tubular florets with rose-purple to pinkish or occasionally white coloration (Moore, 1975).

Moore (1975) described the plant as dioecious while Hitchcock (1974) referred to it as subdioecious. Lloyd and Myall (1976) classified Canada thistle as neither gynodioecious nor dioecious but intermediate between the two: "Cirsium arvense is perhaps best described as near-dioecious and departing from strict dioecy in a gynodioecious manner." Hodgson (1971) has reported that large quantities of seed are produced annually as long as nothing interferes with pollination. The seeds mature rapidly and 8 to 10 days after the flowers open, seeds are capable of germination. Germination percentage of Canada thistle seeds declines rapidly in the first two years and young seedlings do not become established easily where there is competition from other plants (Amor and Harris, 1975). A copious white pappus allows seed dispersal to take place aerially (Moore, 1975).

Rapid spread of Canada thistle in a localized area is a result of a potent horizontal root system which can give rise to aerial shoots (Moore, 1975). A single Canada thistle plant has been known to spread laterally through the soil 10 to 12 feet in a single season. Lateral roots develop shoots in the spring which become fully developed plants that may flower 7 to 8 weeks after emergence. A single plant can spread over an area 20 feet in diameter in one year (Hodgson, 1971).

According to Amor and Harris (1975), patches of Cirsium arvense maintain a pattern of development where degeneration of the patch takes place behind an advancing front.

Root segments that are broken or cut from extensive root systems can develop new plants and are able to establish new thistle patches. In laboratory experiments, Hamdoun (1972) demonstrated that root fragments less than 0.25 inch long were not able to form shoots. Roots 0.5 inch long or longer, and 0.063 inch in diameter were able to produce shoots as long as they were not taken from immature apical regions. Unless repeated cultivations are done, control of Canada thistle by fragmentation of the root is unlikely. Thistle roots are the storage organ for food reserves and provide the plant with the tenacious ability to regenerate after foliage has been removed. Cropping, cultural, biological, and chemical control methods have been attempted for thistle control.

Canada thistle is a vigorous competitor for light, moisture, and nutrients, and can virtually eliminate stands of less competitive crops like peppermint. Cultural control is based on carbohydrate starvation and depletion of stored root reserves. Cultivations at 21-day intervals when newly emerged shoots are just beginning to transport new reserves to the root, provides the best control (Hodgson, 1971).

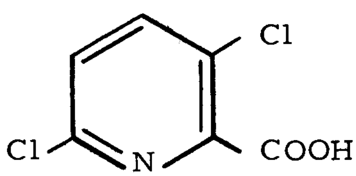
Under meadow mint production in Oregon, the cultivation required in the cultural control method is not possible.

Biological control of Cirsium arvense has been attempted with weevils (Ward, Pienkowski, and Kok, 1974, and Baker, Blackman, Claridge, 1972), lacebugs (Equazie, 1972), and a rust-causing fungus, Puccinia puncti (Peschken and Beecher, 1973). All attempts at bio-control have not given enough thistle control to be practiced in a cropping situation.

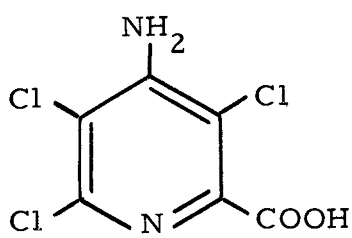
Recommendations for chemical control of Canada thistle include the use of 2,4-D, dicamba, picloram, MCPA, 2,4,6-TBA, and aminotriazole. None of these herbicides are registered in peppermint and all cause phytotoxic responses from peppermint at rates that are effective on Canada thistle (Anonymous, 1976). Preliminary screening experiments indicated that an experimental compound, Dowco 290, may be effective for selective control of Canada thistle in peppermint.

Dowco 290

Dowco 290 is a picolinic acid closely related to picloram. The chemical structures follow:



3,6-dichloropicolinic acid
Dowco 290 (Haagsma, 1975)



4-amino-3,5,6-trichloropicolinic acid
picloram (Anonymous, 1974)

Dowco 290 is a white, odorless crystalline solid with a melting point of 151-152^{o} C. Its vapor pressure is 2×10^{-5} mm Hg at 27^{o} C and its water solubility is 1000 ppm at 27^{o} C (Haagsma, 1975). There are three formulations of Dowco 290 available for research work according to Haagsma (1975):

M-3785 -- contains 2 lbs a.e. (acid equivalent) 2,4-D and 0.5 lb a.e. Dowco 290 per gallon as alkanolamine salts.

M-3786 -- contains 2 lbs a.e. MCPA and 0.5 lb. a.e. Dowco 290 per gallon as alkanolamine salts.

M-3972 -- contains 3 lbs a.e. Dowco 290 per gallon of the monoethanolamine salt.

Dowco 290 was added to formulations containing phenoxy herbicides to improve control of several phenoxy-tolerant weeds in small grains and corn. Dowco 290 is strongly herbicidal to members of the Polygonaceae, Leguminoseae, and Compositae; but the Gramineae and Cruciferae show considerable tolerance (Keys, 1975; Naish, 1975). Dowco 290 induces auxin-type response in growing dicotyledonous plants. It is absorbed by roots and leaves and is rapidly translocated through the plant (Haagsma, 1975).

Research using M-3785 at Oregon State University began in 1972 (Anonymous, 1972-73) on small grains, and screening studies for thistle control in peppermint with M-3972 began in 1973

(Anonymous, 1973-74). Preliminary testing showed little peppermint damage by Dowco 290 at rates that were effective against Canada thistle.

Soil persistence of Dowco 290 is much shorter than picloram. On a loam soil containing 1% organic matter in California, soybeans (sensitive to Dowco 290) could be planted 16 weeks following application of 0.28 lb/A of Dowco 290 with no phytotoxicity observed (Haagsma, 1975). Soil persistence studies at Hyslop Agronomy Farm near Corvallis, Oregon, and at the Pendleton Experiment Station, showed soil persistence of Dowco 290 (0.25 lb a.e /A) to be less than 12 months based on phytotoxic responses of sensitive species (Anonymous, 1975). Zimdahl and Foster (1975) reported that the M-3785 formulation of Dowco 290 gave good short-term control of Canada thistles, but there was apparent recovery of the thistles 4 months after application.

FIELD EXPERIMENTS

Peppermint Tolerance to Dowco 290

Materials and Methods

Field experiments in weed-free peppermint (cv. Mitcham) were established to evaluate the effect of Dowco 290 on green forage (fresh hay) and oil yield. Two experimental sites were selected in the Willamette Valley. The experimental design was a randomized block with six replications and nine treatments. Four rates of Dowco 290: 0.25, 0.50, 1.00, and 2.00 lb a.e./A, were applied 10 weeks and 8 weeks prior to harvest (Appendix Tables 2 and 13). Peppermint oil yield was considered the most important parameter for treatment evaluation in 1975 and was used in 1976 to determine persistence of Dowco 290 effects in the treated plots.

Plot size was 10' by 20' and all spraying was done with a compressed air, bicycle-wheel plot sprayer. The boom was designed to spray an 8-foot width (allowing for 2-foot buffer zones between plots) and was fitted with 8002 flat fan nozzle tips mounted to give double-overlap coverage. Spray pressure of 27 psi delivered a volume of 25 gallons per acre. The peppermint was 5 to 6 inches tall 10 weeks before harvest and 8 to 12 inches tall 8 weeks before harvest.

Peppermint harvest was conducted manually. Foliage was harvested from three square-yard quadrats (27 sq ft) per plot. The mint was cut at ground level using an electric hedge clipper powered by a portable generator. Fresh hay from the clipped quadrats was bulked and placed in a canvas carrying sling and transported to a field scale tared for the sling and mounted on a tripod. Fresh weight was recorded and a 10-lb subsample from each plot was retained for distillation. The 10-lb subsample was placed in a loose-weave burlap bag and fastened securely at the top with twine. The total fresh weight from some plots was less than 10 lb in which case the entire sample was retained.

Bagged samples were taken to the Hyslop Experimental Station and hung in a drying shed exposed to air on all sides. Samples were allowed to dry 2 to 4 weeks before distilling. Four samples were distilled simultaneously in modified pressure cookers (Figure 1). All treatments within a replication were distilled in the same tub to reduce the potential for variation. Samples were placed in preheated tubs and subjected to 26 to 30 psi steam pressure for 30 minutes. Condensation tubes were used to collect the distillate. Temperature at the mouth of the condenser tube was monitored and maintained at 105^{o} F.

Peppermint oil (specific gravity 0.9 g/ml) was collected in a graduated cylinder to assure accurate measurements immediately after distillation. Oil yield per sample was converted to yield per acre using the following formula:

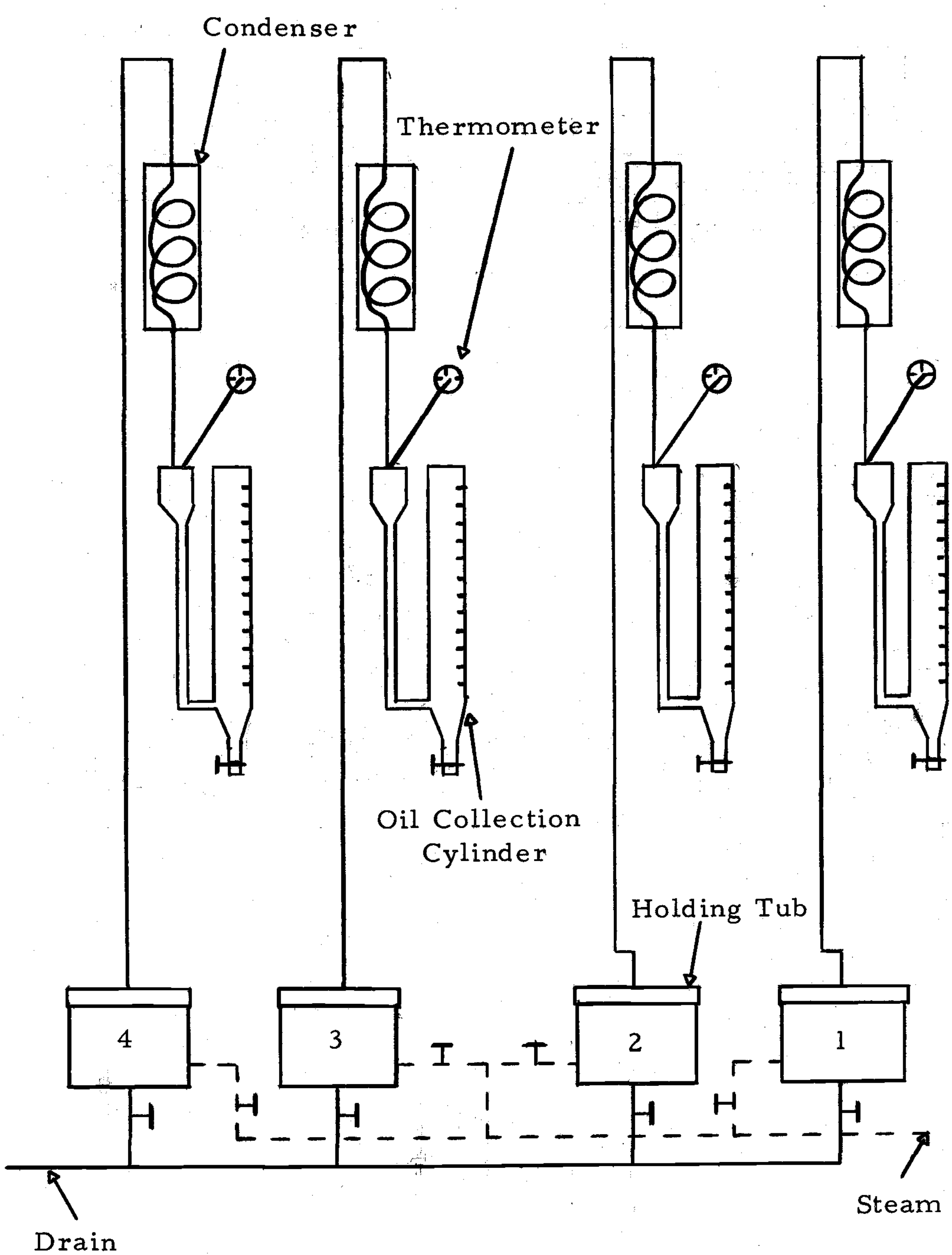


Figure 1. Peppermint still.

$$lb/A = K \times A \times B$$ (Appendix Table 1)

Spent peppermint hay and oil were discarded after distillation and measurement of the oil sample.

Results

Peppermint treated with Dowco 290 at all rates and dates showed morphological changes, although few plants died due to treatment. Treated plants were reddish colored a week after application. After treatment, leaves did not increase in size, became leathery, and were often folded dorsally along the midvein. Different coloration may have resulted from increased concentrations or shifts of pigment concentrations in the leaves as well as a reduction in leaf number and size so more of the red colored stem was visible. Younger leaves, developing after application, frequently grew together at the leaf margins and formed a single leaf which surrounded the stem. Other treated plants had leaves that were wrinkled and warty-textured and grew in a crescent shape which resembled symptoms of verticillium wilt (Figure 2).

Visible peppermint damage at 1.0 and 2.0 lb/A of Dowco 290 was a combination of stunting plant growth and inhibiting new leaf development but did not result in extensive thinning of the peppermint stand. Cupped leaves were still evident in plots treated with 0.5, 1.0, and 2.0 lb/A when evaluated 6 months later. No abnormal

Figure 2. Peppermint response to 0.5 lb/A Dowco 290. Applied June 9, 1975; photograph July 16, 1975.

plants were found in plots treated with 0.25 lb/A Dowco 290.

Peppermint fresh hay yield response varied at the two locations. Significant hay reduction occurred with all treatments except 0.5 lb/A (8 weeks before harvest) on the Bob Nixon farm. There were no significant differences at the John Harrison farm at any rate except the 2.0 lb/A rate (10 weeks prior to harvest) and 1.0 lb/A (8 weeks before harvest) (Appendix Tables 3, 4, 14, and 15).

Oil yield from treated plots followed the fresh hay yield trend at the Bob Nixon location, with oil yield being reduced from all treatments except the 0.5 lb/A application 8 weeks prior to harvest. At the John Harrison location, all rates caused oil reduction except

0.25 lb/A applied 10 weeks before harvest (Appendix Tables 5-7 and 16-18).

In 1976, peppermint was harvested from plots treated in 1975 with the 1.0 and 2.0 lb/A rates (applied 8 weeks prior to harvest) and the check plots at both locations to evaluate persistence of Dowco 290 effects in peppermint. There were no differences between treated plots and the check at either location in fresh hay or peppermint oil yields (Appendix Tables 8-12 and 19-23).

Discussion

Application of Dowco 290 to weed-free peppermint at rates of 0.25 lb/A or more reduced peppermint oil yields when compared to the check. There was a definite trend toward decreased oil production as rates of Dowco 290 increased (Figure 3). Timing of application appeared to be less critical than rate, although there appeared to be a slight advantage when treatment was made 8 weeks prior to harvest. This advantage could be attributed to more time for new leaf development on plants treated 2 weeks later so that the total number of oil-producing leaves was greater on those plants.

Rates of Dowco 290 which caused serious yield reduction in 1975 did not persist in the soil or in the plant in quantities large enough to cause significant yield reduction in 1976 (Figure 4). Stands of peppermint appeared thinned after treatment with Dowco 290;

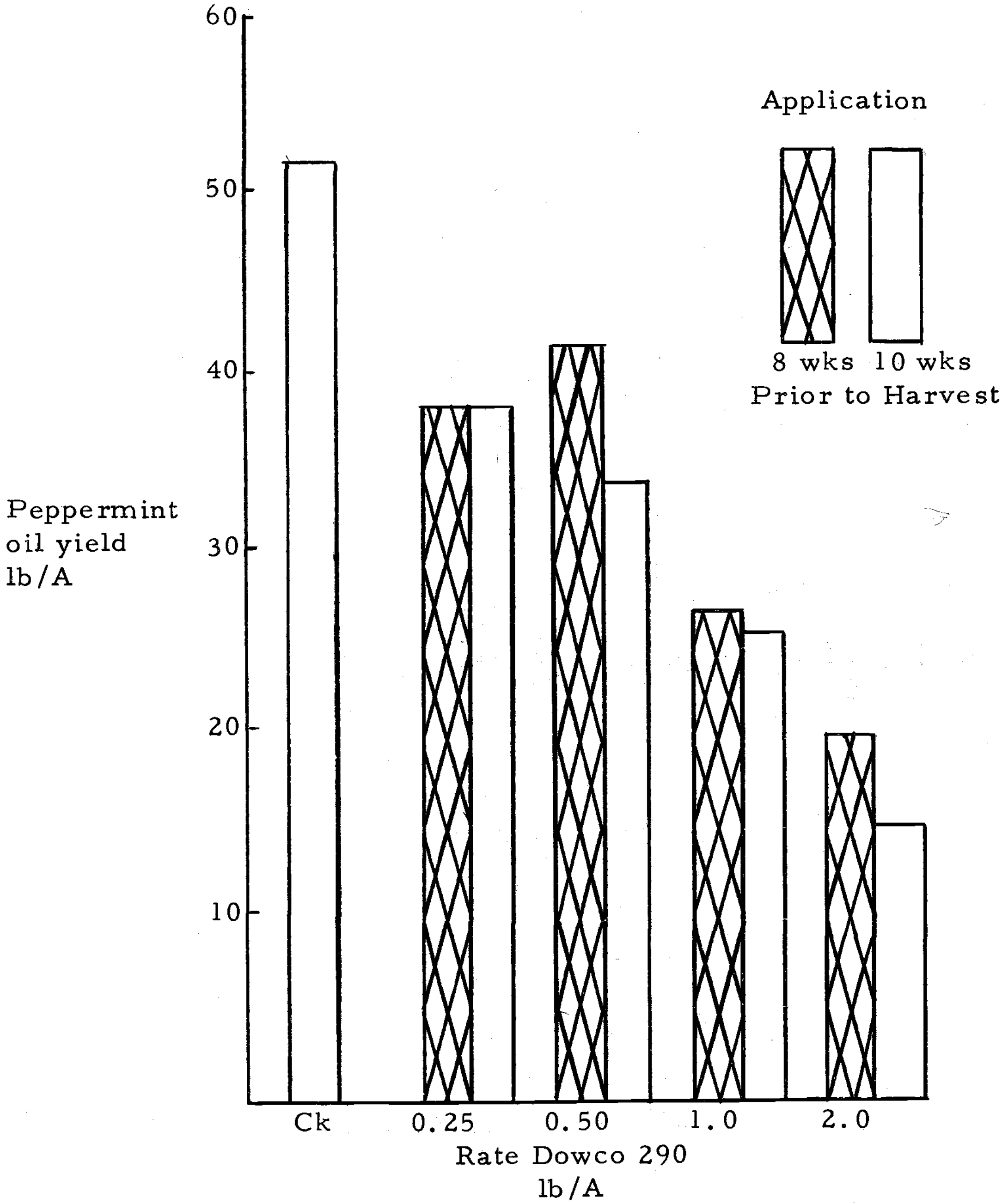


Figure 3. Peppermint oil yield, 1975 - Average of two locations

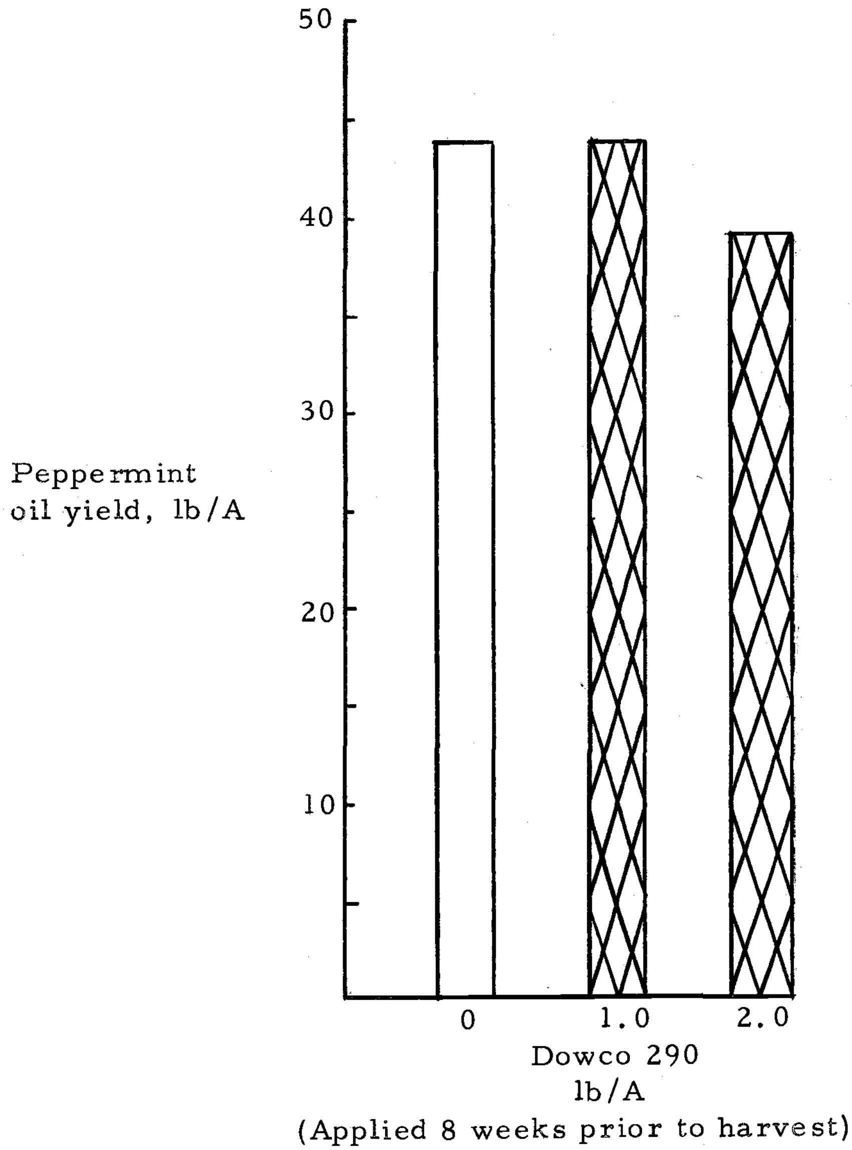


Figure 4. Peppermint oil yield, 1976 - Average of two locations.

however, thinning was apparently a result of fewer leaves and not fewer plants as no yield reduction was observed in 1976 (Figure 5).

Visual evaluation of peppermint treated with Dowco 290 could lead to erroneous conclusions regarding peppermint damage. Suppression of oil yields occurred without any significant depression of hay yield from treated mint. Where mint regrowth is good after treatment, similar quantities of fresh material must be handled to recover a reduced quantity of oil when compared to an untreated check (Appendix Tables 3, 6, 14, and 17). Dowco 290 at all rates and dates tested can cause obvious or subtle damage to peppermint plants resulting in a reduction of oil yield. Peppermint recovery is good and

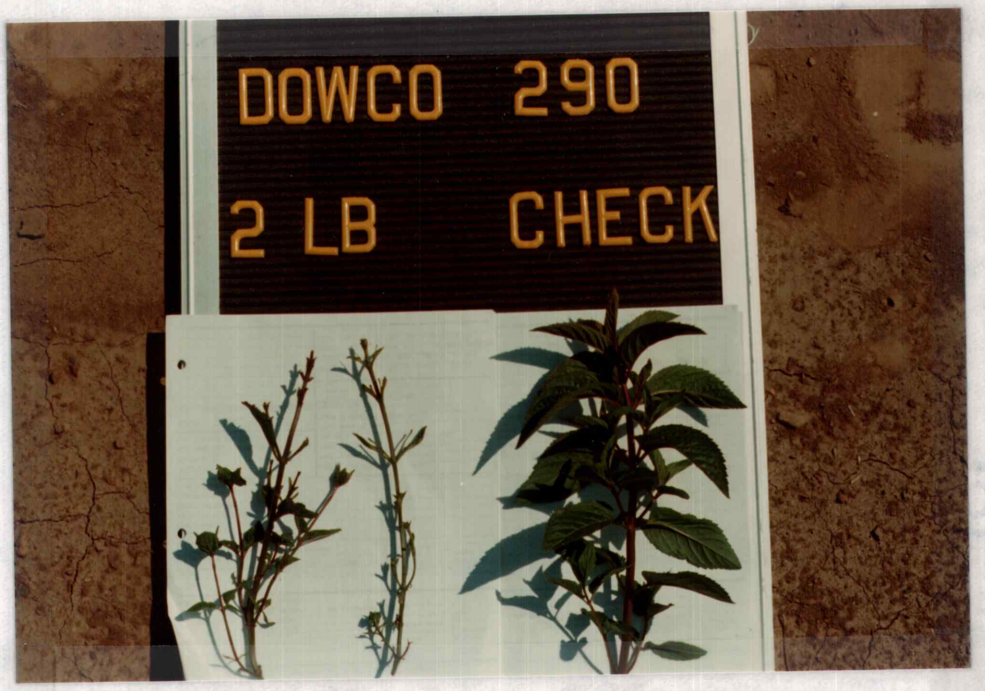


Figure 5. Peppermint response to 2.0 lb/A Dowco 290, 4 weeks after application.

no difference between treated plots and check plots is detectable 1 year after application (Figure 6).

Figure 6. Peppermint response 1 year after treatment with 2.0 lb/A Dowco 290 (left). Check on the right.

Spring Applications of Dowco 290 for Canada Thistle Control

Materials and Methods

Two locations in Willamette Valley peppermint fields with localized dense patches of Canada thistle were selected for spring applications of Dowco 290. Five rates of Dowco 290 were applied 10 and 8 weeks prior to harvest. The mint varieties were Todd's Mitcham and Mitcham at Crowson's and Oakley's, respectively. The experimental design at both locations was a randomized block with four replications.

All applications were made with a compressed air, bicycle-wheel plot sprayer. Plot size was 16' by 20' and two passes with an 8-foot boom were used for application to the plot area. Pertinent data at times of application are recorded in Appendix Tables 24 and 32.

Canada thistle stands were monitored for response from treatment with Dowco 290 by taking stand counts before and after treatment. Two locations in each plot were predetermined and the number of thistles per 9 square feet at each site was counted. A thistle was considered "countable" if it had emerged to the extent that it could be seen without moving any soil. In clusters of thistles, each stem that was distinct at the soil level was counted as an individual plant. After treatment, when counts were made, the same criteria were used. Any plant that was necrotic or chlorotic in some parts but still had plant parts that were green was considered alive and was counted. Counting quadrats were labeled "A" and "B" and were positioned in the plot as shown in Figure 7. If no thistles appeared in the quadrat area at first count, the quadrat was moved to the left or right in order to encompass test thistles. Usually, however, quadrats were located in the center of the plot to avoid any "edge" effect on the Canada thistle plants. Measurements were recorded at each quadrat position during initial counts to enable relocation of the position for future counts.

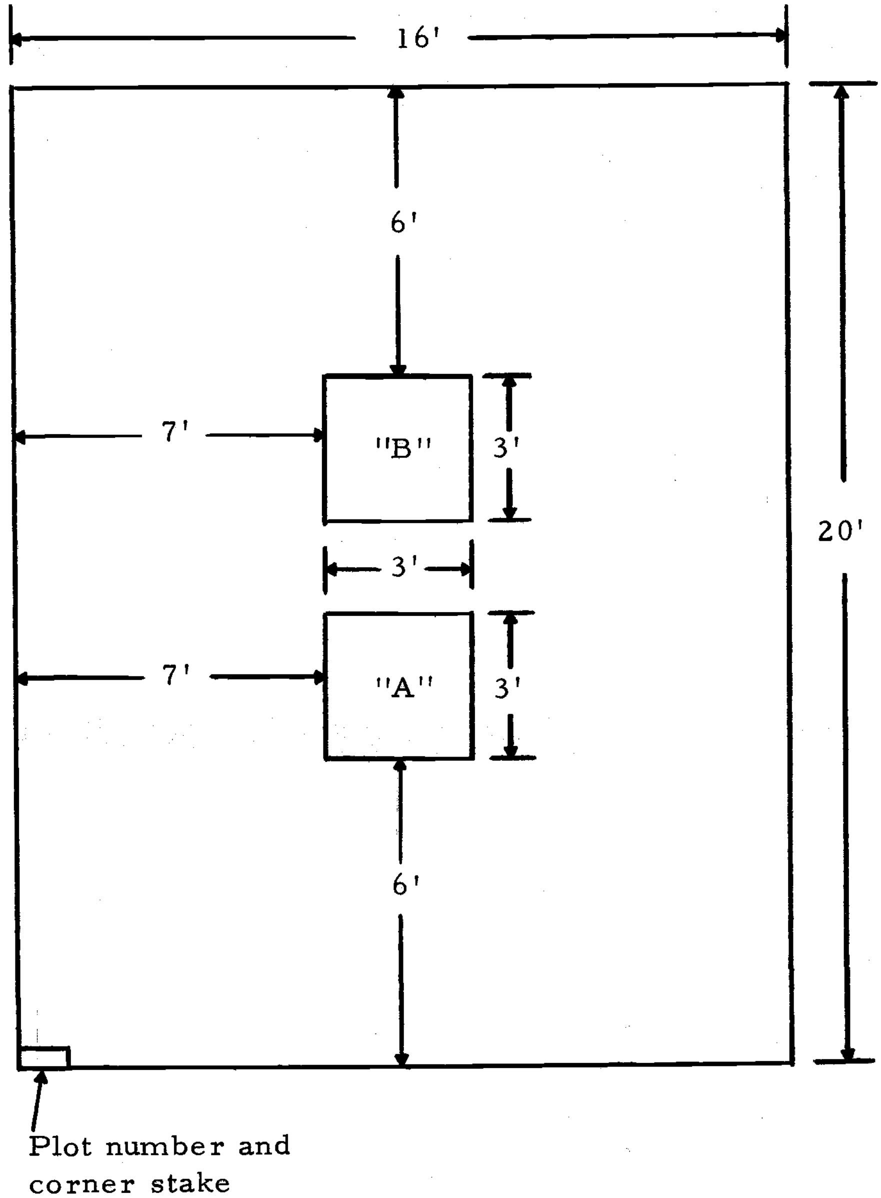


Figure 7. Placement of counting quadrats for Canada thistle densities in 16' by 20' plots.

Harvest and distillation were accomplished as outlined in the Materials and Methods section of the peppermint tolerance study. At harvest, Canada thistle plants were removed from the fresh hay after clipping, but before fresh weight was recorded.

Peppermint oil yield and Canada thistle stand densities were considered the factors most important in assessing the effectiveness of Dowco 290.

Results

Evaluation of spring-applied Dowco 290 for Canada thistle control in peppermint was hampered by loss of two replications of the trial area at the Crowson farm. A portion of the trial area was clipped and windrowed by a swathing machine during normal grower harvest which occurred prior to experimental plot harvest. Enough total treatments were salvaged to harvest and distill a total of two replications.

When statistical comparison was made between treated plots and the check plot, there were no differences in fresh hay or oil yields at either location (Appendix Tables 25-29 and 33-37). At the Crowson farm, the reduced number of replications and the variability of the peppermint stand gave a large coefficient of variation for both fresh hay and oil yields (Appendix Tables 25-29). This variability made it impossible to select treatments that were significantly better than the check, even though treatment means ranged from 23 lb/A to 65 lb/A (Appendix Table 28). Although differences were not significant, trends indicated that lighter rates of Dowco 290 gave higher oil yields from application 10 weeks prior to harvest (Figure 8 and Appendix Table 28). Oil yields were generally greater for applications applied 10 weeks prior to harvest compared to the 8-week application date. There appeared to be no pattern to the fresh hay yields from the Crowson farm (Appendix Table 25). At the Oakley farm, variability was less for fresh hay and oil yields. Average yield differences were smaller and again no significant differences were found between the check plots and the treated plots (Appendix Tables 33-34 and 35-37). Oil yields showed a slight trend for the lighter rates to give higher yields and application 10 weeks prior to harvest gave better overall yields than application 8 weeks before harvest (Figure 8 and Appendix Table 36).

Counts on Canada thistles were completed on four replications at both locations. Canada thistle stands were reduced after application of Dowco 290 at all rates and both timings at both locations (Figure 9). Lighter applications of Dowco 290 gave less control shortly after treatment than did higher rates. Control remained poor from light rates one year later (Appendix Tables 30-31 and 38-39). The decrease in thistle stand seen at both locations between the May and July counting in 1976, was a result of grower-applied herbicides for

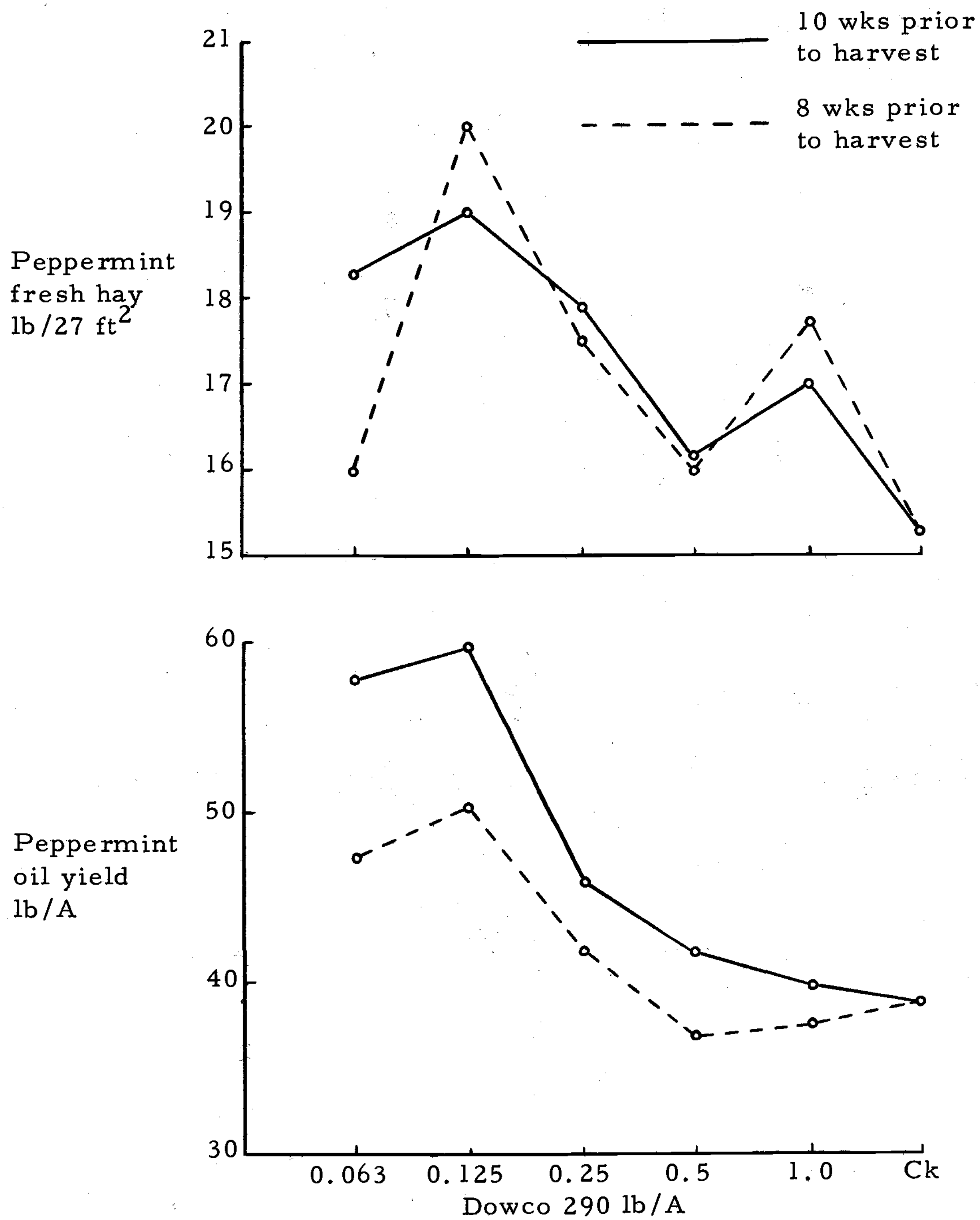


Figure 8. Peppermint fresh hay and oil yields after spring applied Dowco 290, average of two locations.

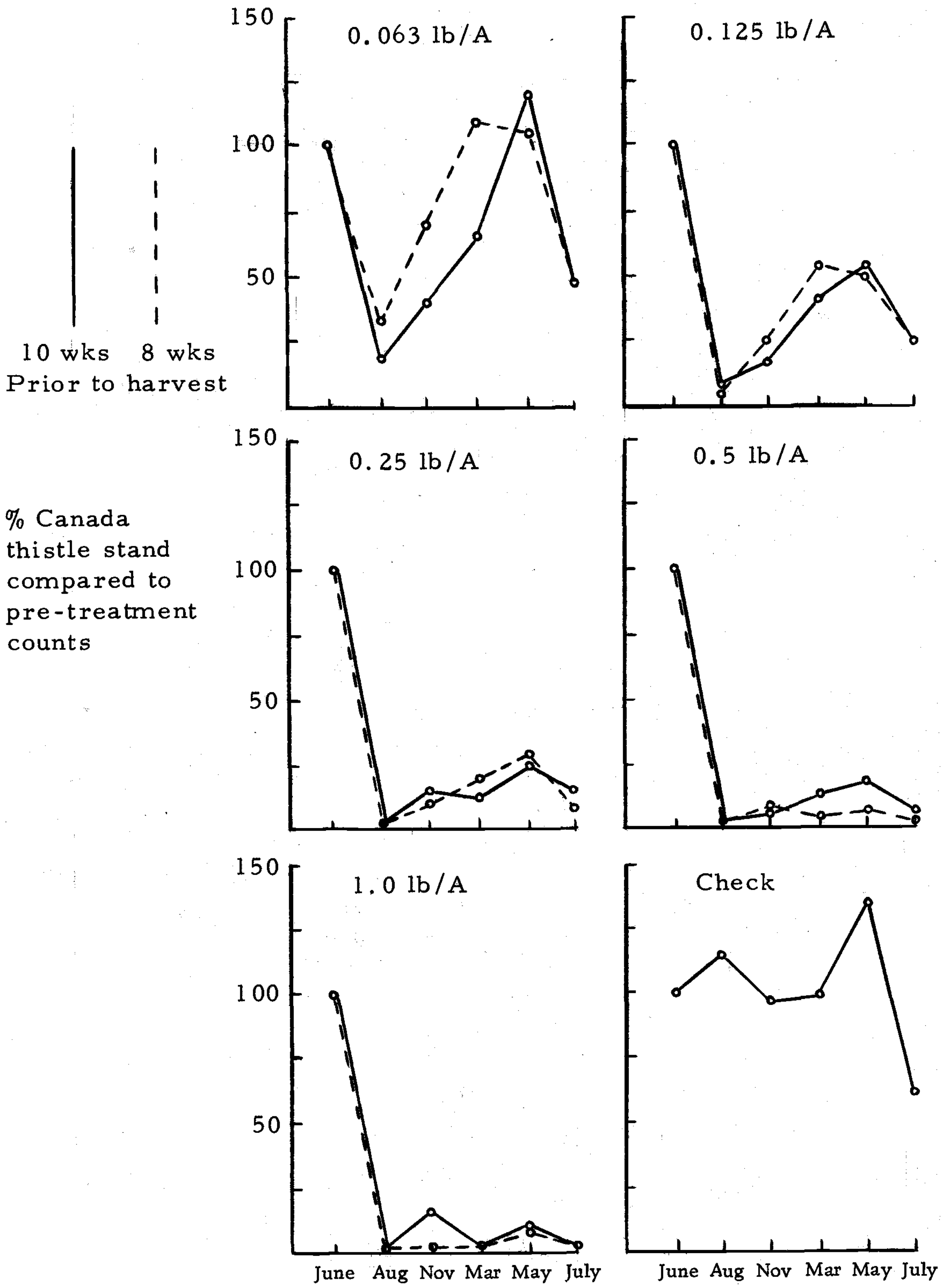


Figure 9. Canada thistle stand following spring applications of Dowco 290, average of two locations.

thistle control in the plot areas. The check plot in all cases had a heavier stand of thistles even after another herbicide had been used than any of the previously treated Dowco 290 plots.

Canada thistle plants treated with Dowco 290 exhibited a dramatic epinastic response shortly after application. Necrotic tissue developed quickly on treated leaves and the appearance of necrosis moved basipetally until all plant parts became desiccated and necrotic. Plants treated with rates of Dowco 290 insufficient to kill the thistles showed epinasty and chlorosis and failed to develop a mature inflorescence. A tight bud was frequently produced; however, it remained small and eventually turned black and became dry.

Discussion

Yield data from spring applications of Dowco 290 showed no differences in fresh hay and oil yields. Differences did not show up in these experiments as a result of the great amount of natural variability of the peppermint trials and the loss of two replications at one location. With the large amount of variability, we cannot conclude statistically that any one treatment was better than another; however, general observations warrant some discussion. There appears to exist a relationship between Canada thistle density, Dowco 290 injury, and peppermint oil yields. When Canada thistle densities decreased as a result of application of Dowco 290, oil yield increased and should continue to increase up to the point where Dowco 290 begins to cause peppermint injury.

Although this study did not clearly define yield differences in peppermint treated in the spring with Dowco 290, it did indicate a Canada thistle stand response to Dowco 290. All rates of Dowco 290 gave good short-term thistle control. Excellent control was obtained at 0.5 lb/A or more (Figure 9). Based upon the peppermint tolerance study (Figure 3), these rates may have caused reduced oil yields from the peppermint which remained in the thistle-infested area.

To conclude that growers would not use Dowco 290 at higher rates for fear of crop damage is not consistent with current cropping practices. Growers frequently use persistent herbicides for spot treatment of thistles, allowing for no selectivity in peppermint.

Good, long-range thistle control can be obtained by applications of Dowco 290 10 weeks prior to harvest at rates of 0.125 lb/A or higher. The highest oil yield in thistle-infested peppermint from a single application of Dowco 290 occurred when 0.125 lb/A was applied 10 weeks prior to harvest. This rate gave excellent short-term and moderate seasonal thistle control and was half the lowest rate tested which caused yield reduction in weed-free peppermint. The lighter the rate of Dowco 290 that will give adequate thistle control, the higher the oil yields will be. This is borne out in the trend for higher oil yields to occur at light rates of Dowco 290 although differences were not statistically significant (Appendix Tables 28 and 36). When Canada thistle densities are very high, rates of Dowco 290 that cause peppermint injury and subsequent crop loss in the treated area may be acceptable for the purpose of thistle control. Areas treated with high rates of Dowco 290 should recover the following year without replanting, as indicated by the peppermint tolerance study (Figure 4).

Split Applications of Dowco 290 for Canada Thistle Control

Materials and Methods

Three locations in thistle-infested Willamette Valley peppermint fields were selected for evaluation of split applications of Dowco 290. Two locations, John Harrison farm (Todd's Mitcham) and Kenneth Holmes farm (Todd's Mitcham), were designated for initial application in the fall followed by a second application the following spring. The Burle Oakley farm (Todd's Mitcham) received both applications in the spring of 1976. Experimental design was a randomized block with four replications at each location.

All applications were made with a compressed air bicycle-wheel plot sprayer. Plot size at the Harrison and Holmes locations was 8' by 25' and at the Oakley farm 20' by 30'. An 8-foot boom was used to make applications to the smaller plots using 8002 nozzle tips set to deliver 25 gpa at 28 psi. A 10-foot boom (same nozzle size, gpa, and psi as the 8-foot boom) was used on the Oakley farm, and two passes were made on each plot to get complete coverage. Application data are recorded in Appendix Tables 40, 48, and 56.

Canada thistle control and peppermint oil yield were again considered the factors of primary importance in treatment evaluation. Canada thistle stand was monitored by taking stand counts from treated plots and comparing with the untreated check. Counts were made on 18 square feet of plot area using square yard quadrats. Quadrat location was predetermined and the position recorded so count areas could be relocated. Each plot had two quadrats designated as "A" and "B." Figure 10 shows the location of quadrats in the 8' by 25' plots, and Figure 11 the location in the 20' by 30' plots.

Peppermint harvest was conducted as outlined in the section on peppermint tolerance. When fresh hay was cut, Canada thistle plants were removed from the hay before fresh weights were recorded.

<u>Results</u>

Application of Dowco 290, split as fall treatments followed by spring treatments, caused no reduction in peppermint fresh hay yields (Appendix Tables 41-42, 49-50). Oil yields from these locations were erratic. No significant oil yield differences were found at the Holmes location, while every treatment at the Harrison site except 1.0 lb/A in the fall gave significant yield increases (Appendix Tables 43-45, 51-53). Reduction in Canada thistle stand occurred at all rates tested

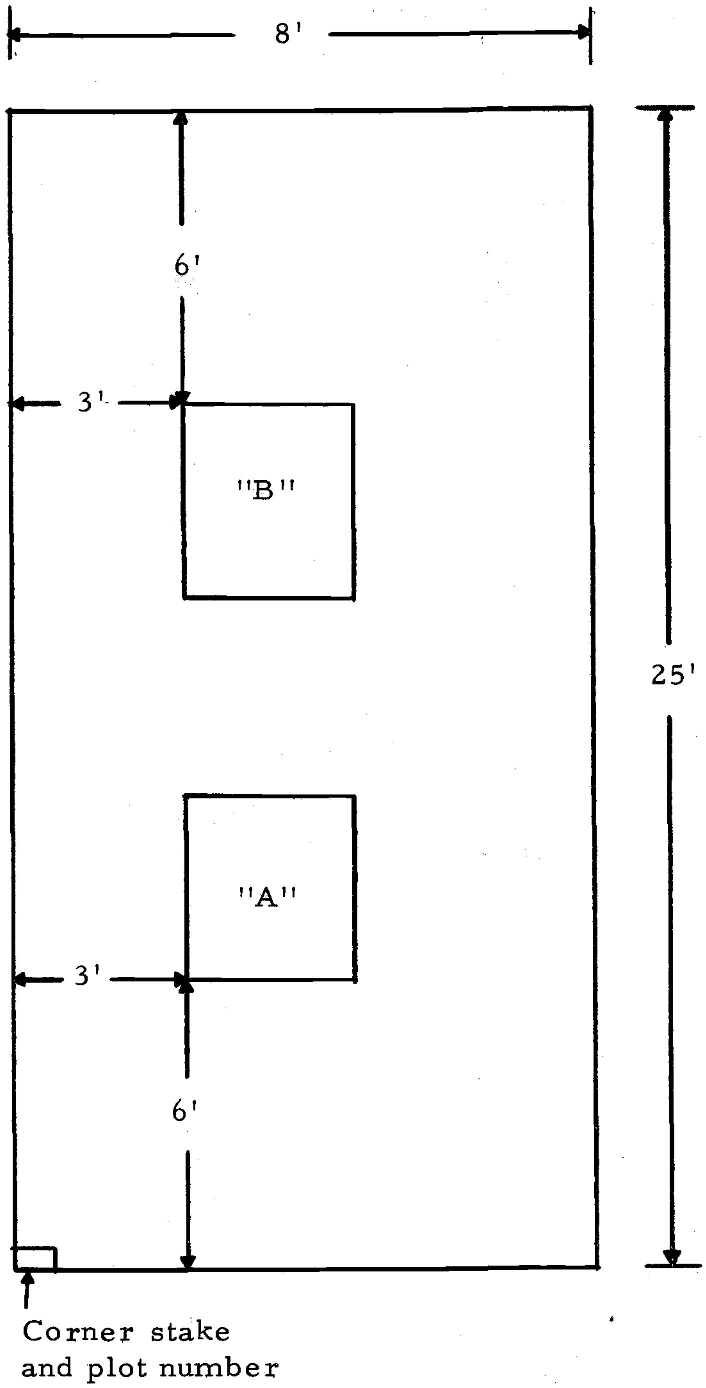


Figure 10. Quadrat location in 8' by 25' plots, split application (fall + spring).

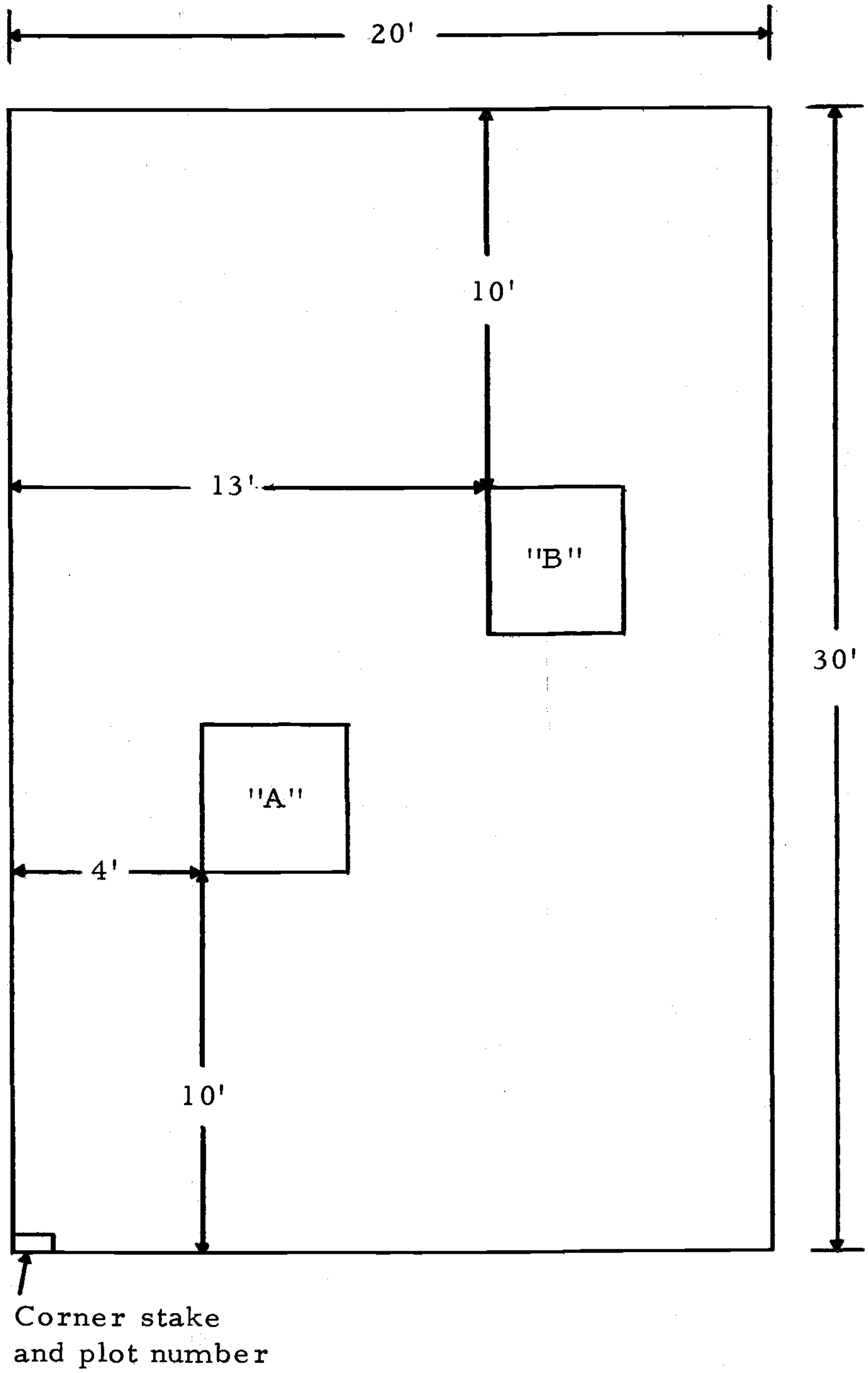


Figure 11. Quadrat location in 20' x 30' plots, split application (spring + spring).

with a minimum stand reduction of 16% and a maximum of 94% (Appendix Tables 46-47, 54-55).

When Dowco 290 was applied as split applications in the spring, highest fresh hay and oil yields were obtained by treating with 0.125 lb/A 10 weeks before harvest followed 2 weeks later with 0.063 lb/A (Figure 12). Thistle control was fair from all treatments and varied from a low of 47% to a high of 79% (Appendix Tables 62-63 and Figure 12). Canada thistle control was slightly better than the split treatment (0.125 + 0.063) when 0.125 lb/A was applied 8 weeks prior to harvest as a single application.

Discussion

Fresh hay, oil yields, and Canada thistle control in all 1976 experiments may have been biased since weather conditions were poor and test plots were harvested early. Many growers indicated they would harvest in late July. Experimental plots were harvested prior to expected grower harvest dates and subsequent changes in the weather allowed many growers 3 to 4 weeks more growing time before harvest. It is uncertain what the response of the peppermint and the Canada thistles would have been if harvest of the test plots had been delayed another 3 weeks.

Increased variability in oil yields from experimental plots also occurred as a result of mildewing of the fresh hay as it was drying at

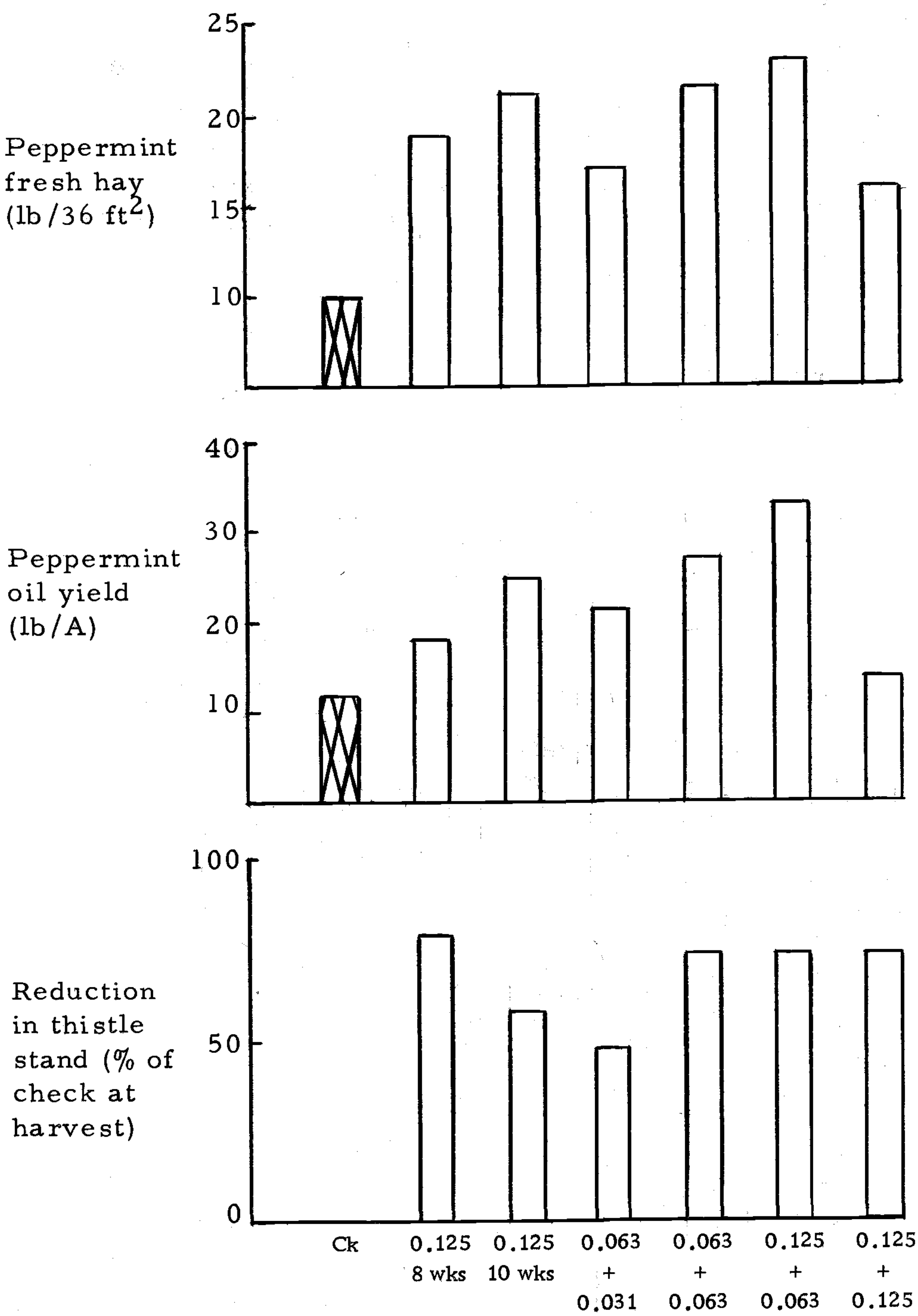


Figure 12. Peppermint and Canada thistle response to split (spring + spring) applications of Dowco 290.

Hyslop Farm. When bags were badly affected by mildew and oil yields appeared unreasonably low when compared to the other samples, missing plot techniques were used to supply numbers for statistical analysis. These factors made it very difficult to select the best treatment from split applications of Dowco 290.

When Dowco 290 was applied in the fall, thistle control was good during the winter but was deteriorating at the time spring applications were made. The second application of a light rate was intended to reduce the possibility of mint damage but still control thistles that had survived fall treatments (Figure 13). Yield data showed, however, that split applications in the fall and the spring were not dramatically better than a single spring application of 0.125 lb/A and, in many

Figure 13. Canada thistle control in peppermint 0.50 lb/A November 1975 plus 0.125 lb/A June 1976.

cases, were worse (Figure 14). The expense of the fall application was not justifiable when similar results were obtained in the spring with a single application.

When examined at one location, applications of Dowco 290 split by 2 weeks in the spring gave higher oil yields than single applications. Thistle control was approximately the same (Figure 12). Application of 0.125 lb/A 10 weeks prior to harvest followed by 0.063 lb/A 2 weeks later increased oil yield by 8 lb/A when compared to a single application of 0.125 lb/A applied 10 weeks before harvest. There was a 15 lb/A oil yield increase when the same split application was compared to 0.125 lb/A applied 8 weeks before harvest. Canada thistle control was best, however, when a single application of 0.125 lb/A was applied 8 weeks prior to harvest. The decrease in thistle control by 0.125 lb/A applied 10 weeks before harvest may have resulted from regrowth of injured thistle plants that had not yet regrown in the 8 week plots. The addition of 0.063 lb/A 8 weeks before harvest to a plot treated 2 weeks before with 0.125 lb/A controlled the thistles missed by the earlier application and accounted for increased thistle control (Figure 12).

Variability in the trial areas and harvesting procedures made it impossible to select a treatment that was good and could be repeated with confidence that the results would be similar. A single application of Dowco 290 in the spring, however, appeared better than

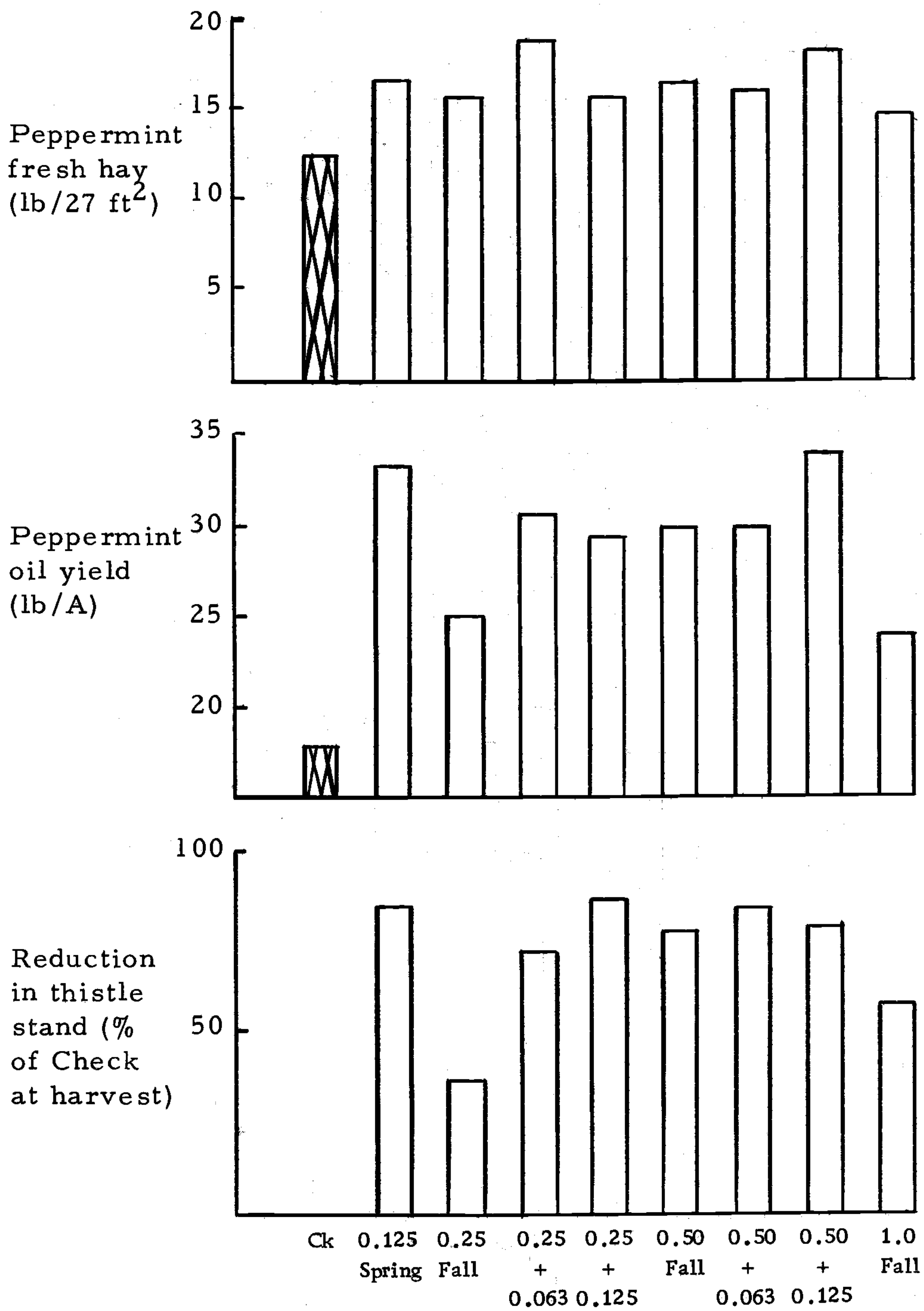


Figure 14. Peppermint and Canada thistle response to split (fall + spring) application of Dowco 290 (average of two locations).

splitting applications between fall and spring. When the spring application was split by 2 weeks and a total of 0.188 lb/A of Dowco 290 was applied, high oil yields and adequate thistle control were achieved. It is not known if a single application of 0.188 lb/A in the spring would give as good control as split application totaling the same rate. This is a question that needs further research and is suggested as a potentially valuable study if Dowco 290 should ever be marketed. The rate for maximizing yield and thistle control appears to be between 0.125 lb/A and 0.25 lb/A (the rate which resulted in yield reduction from Dowco 290 in the mint tolerance study).

CONTAINER EXPERIMENTS

Translocation of Dowco 290 Through Underground Plant Parts of Canada Thistle Plants

Materials and Methods

An experiment was designed to determine the extent of translocation of Dowco 290 through rhizomes of Canada thistle. The study was conducted on a lath-topped platform raised 8 inches from the soil surface, located on the Oregon State University campus. On April 8, 1976, greenhouse soil was prepared by addition of 0.5% (by weight) ground limestone, and 0.175 oz of 13-13-13 fertilizer per container, then thoroughly mixed in a conventional electric powered portable cement mixer. Soil test results before and after addition of lime and fertilizer are recorded in Appendix Table 64. Clean number 10 cans were filled with soil (approximately 105 oz). Canada thistle rhizomes were removed from a waste area (which has had no herbicide treatment for a minimum of 2 years) located 7 miles north of Corvallis near the entrance to the Corvallis city disposal site. Individual plants were located and the soil was removed to recover as long a rhizome from one plant as possible. Rhizomes were returned to the greenhouse and segmented with a razor blade into 6-inch lengths, trimmed of all shoots, and divided into three categories based on diameter. "Large" rhizomes were 0.38 inch diameter or larger, "medium" 0.25-0.37 inch diameter, and "small" 0.25 inch diameter or less. The soil in each can was opened in a narrow furrow with a small spade and the rhizomes were pushed into the soil 1-1.5 inches. The soil was then compacted 0.75 inch with a circular wooden compaction tool. Cans were placed in subirrigation trays in the greenhouse overnight and moved to the outdoor holding racks on April 10, 1976. Irrigation on the raised platforms was done every other day and 1 to 1.5 inches of water was applied with a 25-foot perforated soaker hose. Temperature and rainfall data were recorded (Hyslop Farm, north of the trial area, and the Lewis-Brown Horticultural Farm east of the trial area) from April 1, 1976 through September 20, 1976, and are reported in Appendix Table 65.

Canada thistles grew normally until June 15, 1976, when 30 cans were selected for the translocation study. Thistles for six replications of five treatments each were chosen based on visual evaluation of total leaf area, plant vigor, and the number of shoots which had developed from the rhizome. A minimum of two plants per can was necessary, but where more plants had developed, similar sized plants with equal shoot numbers were used to make up each replicate. Initial rhizome size was also used to determine replicates. The number of plants per can, rhizome size, and the height of the tallest plant at treatment time in each can is recorded in Appendix Table 66. The tallest thistle in each can to be treated was tagged with a red wire and the largest thistles in the check containers were tagged with white wire. All thistles were in the vegetative stage.

Prior to treatment, test plants were returned to the greenhouse and permalite was added to each can 0.75 inch deep to cover the soil. All plant parts were covered with plastic kitchen wrap except the tagged plant which was left exposed. Where permalite had fallen on the leaves of plants to be treated, a soft paintbrush was used to remove the particles. The thistles were placed, three cans at a time, in a single-nozzle tracked greenhouse sprayer. Treatment rates, materials, and climatic data are reported in Appendix Table 67. Immediately after treatment, thistles were moved to a greenhouse room where spray droplets were allowed to dry for 30 minutes. After drying, the plastic wrap was removed and the permalite was brushed from the soil surface and discarded. The thistles were held in the greenhouse for 48 hours after treatment, then moved back to the outdoor holding racks.

Treated plants and check plants were grown to maturity to allow maximum opportunity for lateral translocation from treated shoots and subsequent growth response in connected daughter plants. On September 18, 1976, fresh weights of the tagged plants in each can, and total fresh weight, were measured. All measurements were made on a Mettler scale, accurate to a tenth of a gram. Fresh weights are recorded in Appendix Table 68. Visual ratings of buds and flowers at clipping time are recorded in Appendix Table 73.

Results

Total fresh weight of thistles (expressed as a percentage of the check) was reduced as the rate of Dowco 290 increased (Figure 15). The reduction in total fresh weight can be attributed primarily to reduction in fresh weight of the treated shoot. When fresh weights were taken, the tagged plant in the check container made up 50% of the total fresh weight, but the tagged plant (treated plant) in the 0.125 lb/A container comprised only 31% of the total fresh weight. As rates increased, the contribution toward total fresh weight made by the treated shoot decreased.

When 0.016 lb/A was applied, treated and untreated plants developed to maturity and flowered. Treatment with 0.031 lb/A allowed buds to form on treated plants, but no flowers reached maturity; connected untreated plants developed normal flowers. Application of 0.063 lb/A allowed budding on half the treated plants and no floral development on the others; normal flowers developed on the protected plants. The highest rate tested, 0.125 lb/A resulted in no bud development in treated plants and allowed bud development in connected plants but no mature plants flowered. Plants in the check containers flowered normally.

Discussion

Treatment with Dowco 290 at test rates did not cause a marked

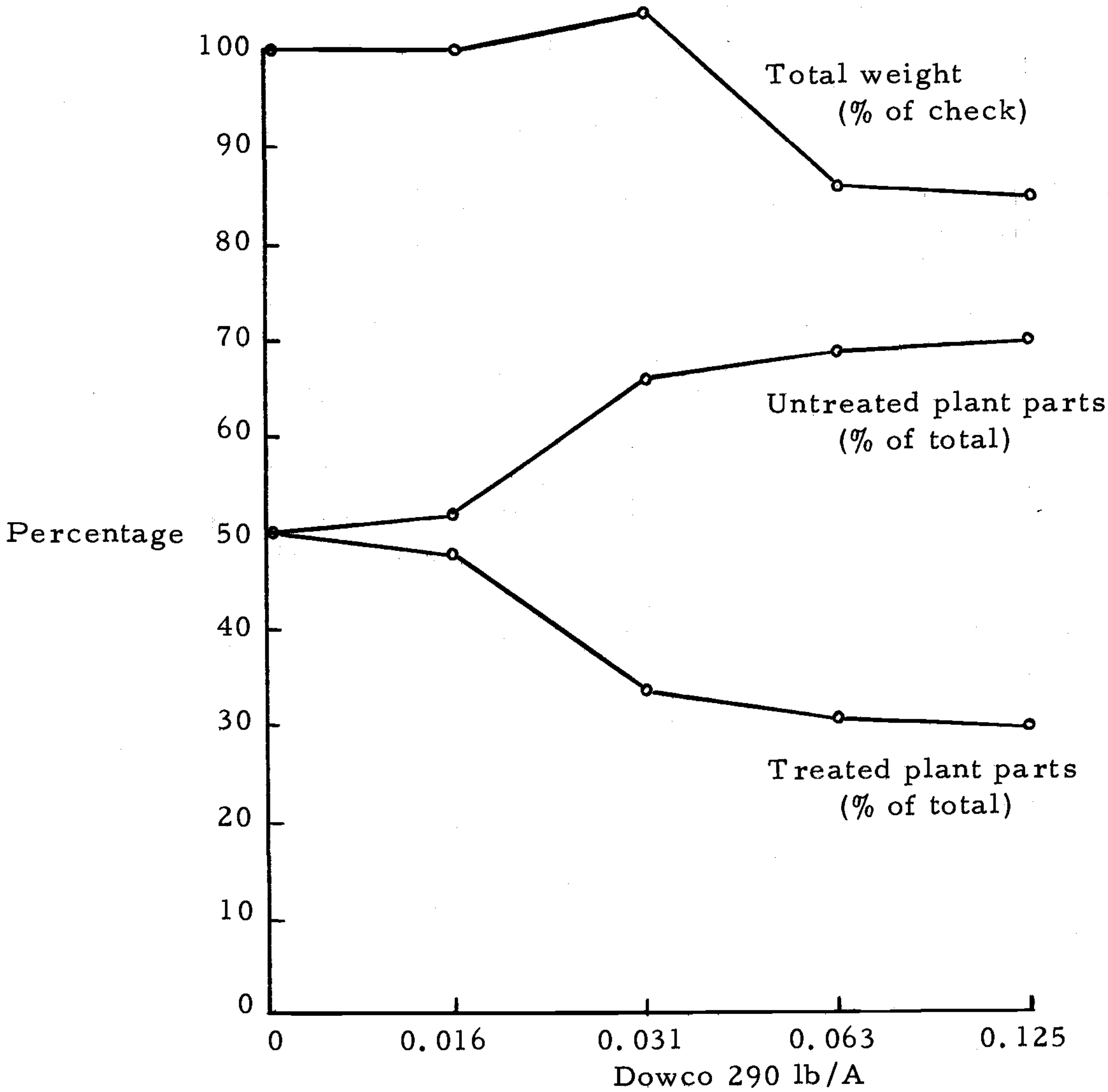


Figure 15. Fresh weight response of Canada thistle plants to Dowco 290 when plants are connected by underground rootstock and only one plant is treated.

reduction in fresh weight of daughter plants connected to treated plants. Sufficient translocation through underground plant parts did occur at the 0.125 lb/A rate to cause a flowering response in daughter plants similar to that from plants treated with 0.031 or 0.063 lb/A (Appendix Table 69). As with picloram (Sharma, Chang, and Vanden Born, 1971), translocation from plants treated with Dowco 290 did occur laterally to connected daughter plants, but the concentration of herbicide that reached daughter plants was much more dilute than the actual treatment rate.

Total fresh weight loss in treated plants was not due to overall stand reduction as a result of translocation between plants, but can be attributed to a reduction in weight of the treated shoot (Figure 15). Fresh weight data did not indicate a significant translocation response from treated to connected untreated plants but visual evaluations of floral development did (Figure 15).

Regrowth from Canada Thistles Treated with Dowco 290

Materials and Methods

An experiment was established to examine the effect of Dowco 290 on regrowth of Canada thistle plants when treated with 0.25 lb/A and clipped at different time intervals. Propagation and handling of test plants was identical to that explained for the translocation study. The statistical design was a randomized block with six replications and nine treatments. Application of Dowco 290 was made with a single-nozzle track-mounted greenhouse sprayer on June 16, 1976, when the thistles were in the early bud stage. An 8001-E TeeJet nozzle tip set to deliver 25 gal/A at 28 psi was used. Relative humidity was 66% with an air temperature of 72° F. After treatment, plants were held in the greenhouse at 72° F day and 60° F night for 48 hours to ensure adequate drying of the herbicide. No attempt was made to protect the soil surface in this experiment. At the end of 48 hours, the plants were moved to the raised platform area. The experimental plants were watered at 2 day intervals with a 25-foot perforated hose that applied 1 to 1.5 inches at each watering.

There were two untreated containers in each replication. One was clipped (clipped check) at the 1-hour timing and the other (unclipped check) remained unclipped. Treatments consisted of clipping at ground level at 1, 4, 8, 16, 32, 64, and 128 hours after application with Dowco 290. Clipping was done with a pair of side-cutting pliers. Fresh weights of clipped thistles were recorded immediately after clipping (Table 1). Thistles were allowed to grow normally until September 15, 1976, when regrowth of treated plants and checks was cut at the soil-surface and fresh weights were recorded (Table 1). The soil was removed from each pot and sieved to recover thistle roots. Segments of roots from each treatment (unless the roots had decomposed) were cut longitudinally and placed in petri dishes for a

Table 1. Fresh weights of clipped thistles in regrowth study.

	Fresh Weight June 16, 1976 (grams)	Regrowth Fresh Weight Sept. 15, 1976 (grams)	% Reduction of Regrowth of the Clipped Check Sept. 15, 1976
Unclipped Check	-	28.22	
Clipped Check (1 hour)	14.17	16.13	0
1 hour	12.17	0	100%
4 hours	11.33	0	100%
8 hours	16.33	0.28	98.3%
16 hours	16.67	0	100%
32 hours	18.83	0	100%
64 hours	17.83	0	100%
128 hours	20.00	0	100%

Average of six replications.

tetrazolium test as adapted from Duffy (1975). A 0.5% solution of 2,3,5-triphenyl tetrazolium chloride and distilled water was added to the dishes until all roots and rhizome parts were covered. The petri dishes were placed in a dark growth chamber at 86^{o} F. After 6 hours, the sections were removed and visually examined for red coloration, indicating live tissues (Appendix Table 70).

Results

When treated thistles were examined 1 hour after treatment, slight epinasty was observed. At 4 hours, epinasty was clearly evident and became more pronounced by 8 hours. Dramatic epinastic response was seen at 16 hours, with stems bent as much as 45 degrees from vertical. Epinasty continued to increase when observed at 32 hours, and by 64 and 128 hours, some stems were prostrate on the soil surface. Although epinasty was very dramatic, actual fresh weight did not reflect any great change from 1 hour to 128 hours (Table 1).

After watering, regrowth occurred in the clipped check cans and continued growth was maintained in the unclipped check. Clipping the check resulted in development of more lateral buds. New shoots found in the clipped check were smaller and more numerous than those in the unclipped check. No regrowth was seen in any of the treated cans at any time except the 8-hour clipping time in the fifth replication. A small plant developed in this can and remained alive, although it was not thrifty in appearance and had some necrotic areas on the leaves until fresh weights of regrowth were taken. Fresh weight of the clipped check averaged 57% of the fresh weight of the unclipped check when regrowth was measured. Clipping alone reduced the total fresh weight of thistles (Table 1) but resulted in larger numbers of smaller thistles. Where thistles were treated with Dowco 290 before clipping, regrowth was reduced 98% when clipped at 8 hours and 100% at all other timings, when compared to the clipped check (Table 1).

The tetrazolium test was used to detect live tissue in roots where regrowth had occurred as well as containers where no regrowth had taken place. Many plants, including roots, had been killed early, so roots were badly decomposed and no tetrazolium test was possible. All thistles with green tissue showing above ground gave a positive root response to tetrazolium. No other cans yielded any sign of living underground thistle tissue (Appendix Table 70).

Discussion

Dowco 290 had sufficient herbicidal activity to kill Canada thistle underground plant parts even when above-ground treated parts were removed as early as 1 hour after treatment. This study was not designed to differentiate between foliar uptake with subsequent translocation to the roots, and soil activity of Dowco 290. Such a study should be undertaken to separate the effects from these two modes of uptake.

Clipping Canada thistles at early bud stage level with the top of the peppermint is not an uncommon practice in the Willamette Valley. Where thistles are treated with Dowco 290 clipping could take place as soon as 1 hour after treatment and excellent thistle control would still result. In non-crop situations Canada thistles could be treated and subsequently mowed to remove thistle debris with good control of regrowth. When weather conditions are not favorable, growers need only be concerned that a short period of time elapse between treatment and precipitation to obtain good thistle control.

Simple clipping of the thistles without treatment for shoot control was not adequate for thistle control. Untreated root segments can rapidly regenerate new plants (Hamdoun, 1972). When plants were treated with 0.25 lb/A of Dowco 290 and clipped, however, minimum thistle control was 98% (when clipped after 8 hours) and all other timings gave 100% control.

Effect of Dowco 290 on Newly Emerged Canada Thistles from Seeds and Rootstocks

Materials and Methods

An experiment was conducted to determine if Canada thistle seedlings were more sensitive to Dowco 290 than new shoots developing from established rhizomes. Two groups of Canada thistle plants were grown for this experiment. The first group of plants was propagated from rhizomes as explained in the translocation experiment. A second group of plants originating from seed was also used. Seedling plants were collected on April 20, 1976, from a dense thistle stand in a peppermint field on the John Harrison farm. Each plant was removed from the field in a small plug of soil and transplanted immediately into a number 10 can filled with the greenhouse soil mix previously described in the translocation experiment. Three plants were transplanted to each can. Both groups of plants were moved to the platform growth area and watered every other day with 1 to 1.5 inches of water from a 25-foot perforated hose. After 2 weeks, the seedling plants were thinned to one plant per can.

On July 6, 1976, both groups of plants were moved to the greenhouse and divided into a randomized block design with six rates and six replications (Appendix Table 71). A single-nozzle tracked greenhouse sprayer was used with an 8001-E TeeJet nozzle tip under 28 psi calibrated to deliver 25 gal/A. All plants were held in the greenhouse for 48 hours before being moved outside to the raised platform. After being returned to the platform area, the plants were watered regularly. Visual evaluations were made of all plants starting with the date of treatment and every second day thereafter. Ratings for visual evaluations were based on the percentage of necrotic tissue on the plant compared to the total plant tissue. Check plants were evaluated on the same scale. Fresh weights of above-ground plant parts from rhizomes were taken on August 18, 1976, and on August 19, 1976 for plants from seeds. Cans were returned to the platform area after clipping and regrowth fresh weight was measured on September 15, 1976.

Results

All rates of Dowco 290 caused increased amounts of necrotic tissue on treated Canada thistle plants. As herbicide rates increased, so did the amount of necrotic tissue on seedling plants and plants developing from rootstock (Appendix Table 72). Twenty days after initial evaluations for necrotic tissue began, portions of the check plants were found to be necrotic. Necrosis in the check plants reached a maximum of 10% and was attributed to senescence in the older leaves.

Slightly more necrosis was noted on plants developing from rootstock than from seeds at 0.031 lb/A Dowco 290 but the difference was small. Rates of 0.063 and 0.125 lb/A had more necrotic tissue on the seedling plants than those from rootstock at the end of 40 days. A large difference between seedling plants and rootstock plants was noted at 0.25 and 0.5 lb/A of Dowco 290. As rapidly as 2 days after evaluation began, seedling plants showed more necrotic tissue than comparably sized plants from rootstock. Throughout the 40-day experiment, seedling plants consistently had more dead tissue than did rootstock plants. When the experiment was terminated, seedling plants had as much as 40% more necrotic tissue than did rootstock plants (Appendix Table 72, Figure 16).

Fresh weights taken from treated plants show that seedling plants consistently had a lighter weight at all rates than did rootstock plants. Regrowth after 1 month from clipped plants showed a definite

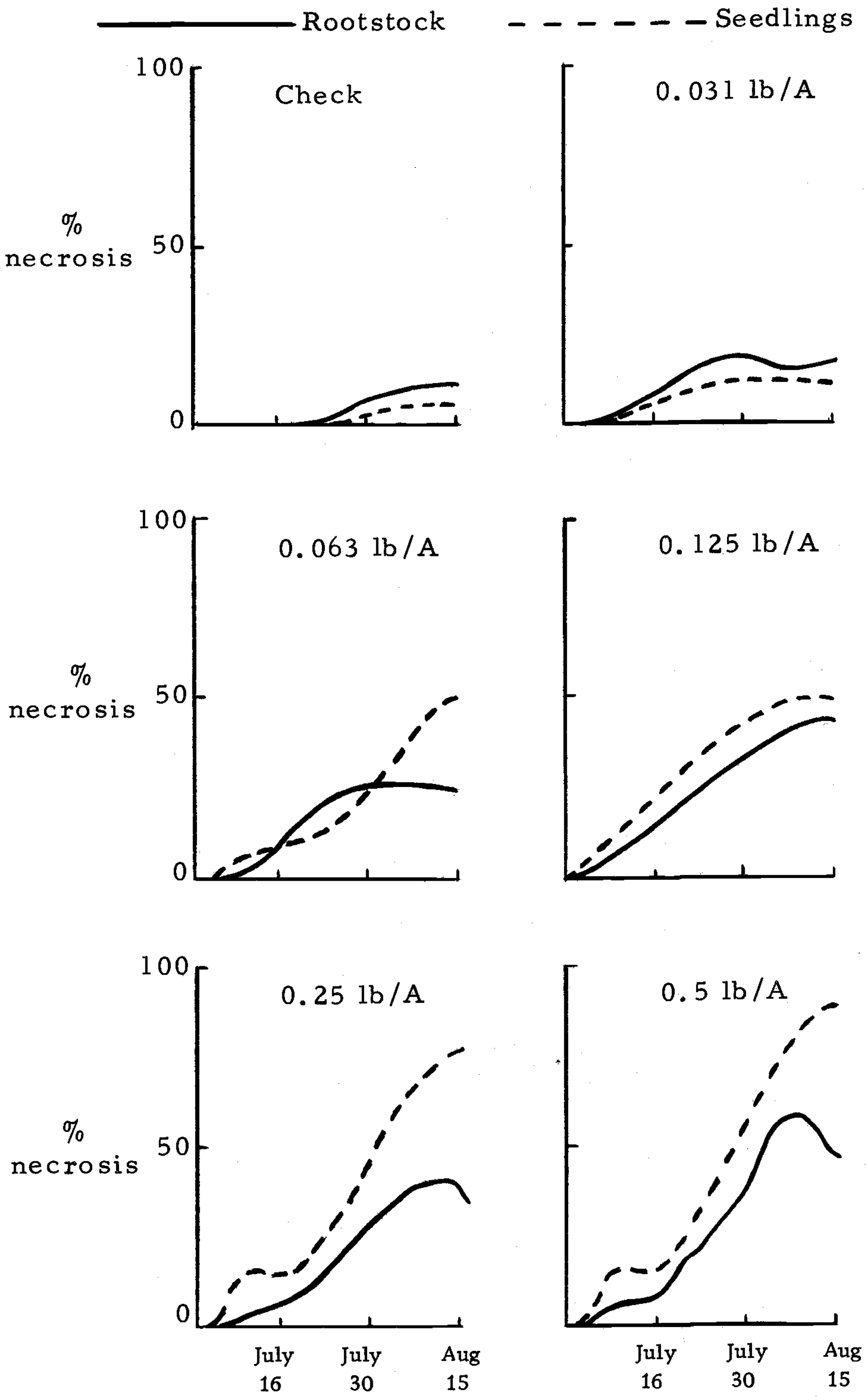


Figure 16. Necrosis of Canada thistle seedlings and plants from rootstock after treatment with Dowco 290.

rate response, but little difference that can be attributed to plant origin (Appendix Table 73, Figure 17).

Discussion

Dowco 290 was slightly more active on Canada thistle plants developing from seed than it was on plants developing from established rootstock. This response was demonstrated by the amount of necrotic tissue seen on treated plants and the fresh weight of plants from both origins when treated with Dowco 290. Regrowth of plants from both groups indicated that the difference between seedlings and plants from rootstock decreased rapidly as both types matured. Within 3 months plants started from seed had root systems that produced regrowth after clipping similar to that from plants established from mature rootstock.

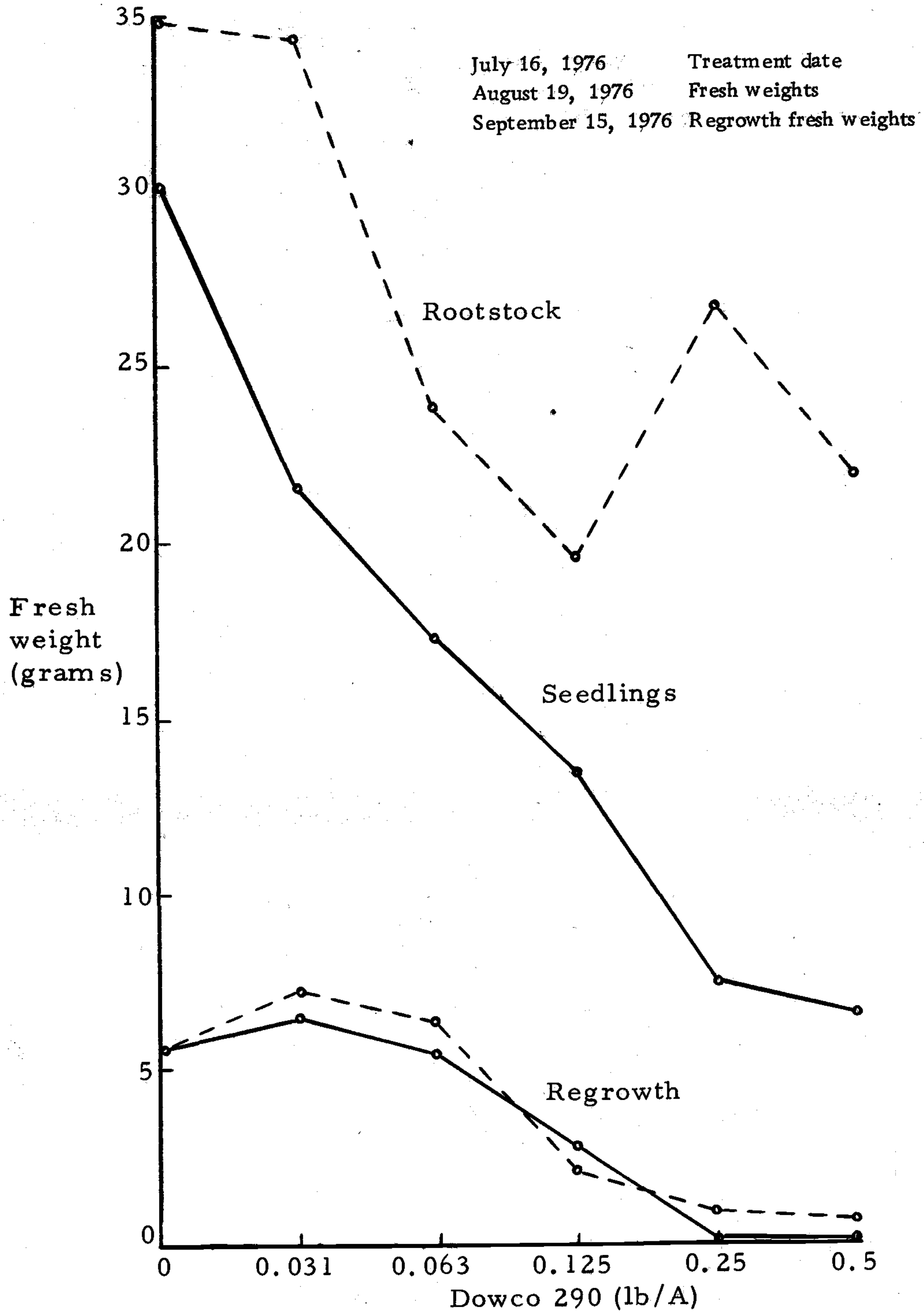


Figure 17. Fresh weight and regrowth fresh weight of seedling grown and rootstock grown Canada thistles.

SUMMARY AND CONCLUSIONS

There is a need for Canada thistle control in peppermint fields. Herbicides registered for peppermint, when used at label rates, are not effective for thistle control. The Dow Chemical Company has developed a compound (Dowco 290) that is extremely active on Canada thistle but is expensive to manufacture and is not marketed in the United States.

Experiments using Dowco 290 in weed-free peppermint fields (cv. Mitcham) of the Willamette Valley indicate that 0.25 lb/A or more Dowco 290 applied in the spring, 8 or 10 weeks before harvest, can cause oil yield reduction. Canada thistle control from spring applications was good when rates of 0.125 lb/A or more were applied. Where thistle stands were very dense rates in excess of 0.25 lb/A Dowco 290 were necessary to obtain good thistle control. Peppermint recovery was good and no differences in yield were detectable 1 year after application of rates as high as 2 lb/A of Dowco 290.

Splitting applications of Dowco 290 between fall and spring and using a higher rate in the fall had little advantage over a single application of 0.125 lb/A in the spring. When spring applications were split and 0.125 lb/A was applied 10 weeks before harvest followed 2 weeks later with 0.063 lb/A, peppermint oil yields were high. It is not known if a single application of 0.188 lb/A in the spring would give as good oil yields as when this total rate was split over a 2-week period. A gross rate between 0.125 lb/A and 0.25 lb/A applied in the spring 10 or 8 weeks before harvest should give good thistle control and high oil yields.

Container experiments using thistles grown from rootstock demonstrated that Dowco 290 can translocate from a treated parent plant to a connected daughter plant. When container grown plants were treated with 0.25 lb/A as a broadcast treatment and then clipped at various time intervals, Dowco 290 controlled regrowth even when the above-ground treated plant parts were removed as soon as 1 hour after application.

Canada thistle plants developing from seed were slightly more sensitive to Dowco 290 than were plants regrowing from rootstock. The difference was small and became insignificant after seedling plants were 3 months old. Regrowth from plants of both origins that were treated and subsequently clipped was not different.

Dowco 290 represents a dramatic answer to the Canada thistle problem of Willamette Valley peppermint growers. There is potential application in other mint producing areas as well as in other crops and non-crop situations. The frustration for growers and researchers is the discovery of a new and effective weed control technique that is not available.

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APPENDICES

Appendix Table 1. Peppermint oil yield conversion formula.

$$lb/A = K \times A \times B$$

where:

$$K = \frac{43560\ ft^2/A}{27\ ft^{2**}/plot} \times \frac{0.9\ g^*/ml}{453.59\ g/lb} = 3.2011\ \frac{plot\ lb}{A\ ml}$$

$$A = \frac{lb\ mint\ hay\ harvested}{plot}$$

$$B = \frac{ml\ oil\ recovered}{lb\ subsample}$$ (NOTE: If sample weight was 10 lb or less, sample = subsample)

* Peppermint oil density = 0.9 g/ml

** 36 ft^2/plot were harvested in Burle Oakley trial (1976) and

$$K = 2.4008\ \frac{plot\ lb}{A\ ml}$$

Appendix Table 2. Peppermint tolerance to Dowco 290, John Harrison Farm, Peoria, Linn County, Oregon, 1975.

Date of Harvest:	August 13, 1975
	July 23, 1976
Date of Distillation:	September 23, 1975
	August 10, 1976

General Information

Crop:	Peppermint, var. Mitcham
Plot Size:	10' x 20'
Soil Type:	Chehalis silty clay loam
	pH 5.6, OM 3.05%
Irrigation:	Sprinkler

Application Data	Treatments 1-4	Treatments 5-8
Date	June 7, 1975	July 3, 1975
Conditions:		
Air temperature	48 F	68 F
Soil temperature	52 F	68 F
Humidity	70%	72%
% Cloud cover	5	100
Wind speed	4-6	5
Wind direction	North	Northeast
Method of Application:	Broadcast	Broadcast
Carrier volume	25 gpa	25 gpa
Nozzle size	8002	8002
Pressure	27 psi	27 psi
Stage of Growth:		
Peppermint	Emerging to 6'' tall*	Emerging to 8'' tall*

* Average height of 20 randomly selected plants.

Appendix Table 3. John Harrison Farm, 1975
Peppermint fresh hay yield - lb/27 ft^2

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	0.25	3.5	11.8	12.4	12.1	12.9	9.9	10.4 NS
June 7, 1975	0.5	6.0	10.2	12.3	8.9	9.1	10.0	9.4 NS
	1.0	5.2	4.2	7.1	10.1	9.7	18.4	9.1 NS
	2.0	3.8	3.6	4.3	4.8	3.4	4.3	4.0 **
Dowco 290	0.25	9.0	10.2	13.6	10.3	13.8	13.2	11.7 NS
July 3, 1975	0.5	9.3	11.0	10.4	13.5	12.4	12.2	11.5 NS
	1.0	7.1	5.0	7.5	8.0	9.2	10.0	7.8 *
	2.0	4.9	7.8	9.4	7.0	9.1	12.0	8.4 NS
Check	-	7.8	12.2	9.1	11.5	10.2	12.0	10.5

* Significantly different from the check at the 1% level.
** Significantly different from the check at the 5% level.
NS = No significant difference

Appendix Table 4. Analysis of variance, John Harrison
Peppermint fresh hay yield - lb/27 ft^2, 1975

Source of Variation	d.f.	SS	MS	F
Replications	5	130.31	26.06	5.81**
Treatments	8	263.00	32.87	7.33**
Replication x Treatments	40	179.50	4.49	
Total	53	572.81		

** Significantly different at the 1% level.
$LSD_{.05}$ = 2.47 lb/27 ft^2
$LSD_{.01}$ = 3.31 lb/27 ft^2
C.V. = 23.0%

Appendix Table 5. John Harrison Farm, 1975
Peppermint oil yield - ml/10 lb sample

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	0.25	6.3	9.3	9.2	13.1	14.1	12.5	10.8
June 7, 1975	0.5	10.1	14.2	11.3	10.7	7.5	16.8	11.8
	1.0	6.2	4.4	6.0	13.2	7.2	7.6	7.4
	2.0	2.9	2.0	3.1	2.4	2.9	3.3	2.9
Dowco 290	0.25	6.4	5.9	7.6	14.4	11.4	8.8	9.1
July 3, 1975	0.5	6.6	10.3	9.6	10.4	11.0	11.0	9.8
	1.0	6.1	5.1	4.7	4.7	8.4	9.5	6.4
	2.0	3.0	6.4	7.0	3.9	7.5	5.6	5.6
Check	-	7.4	11.3	18.6	18.0	18.3	12.1	14.3

Appendix Table 6. John Harrison Farm, 1975
Peppermint oil yield - lb/A

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	0.25	20.2	35.1	36.5	50.7	58.2	40.0	40.1 NS
June 7, 1975	0.5	32.3	46.4	44.5	34.3	24.0	53.8	39.2 *
	1.0	19.8	14.1	19.2	42.7	23.0	44.8	27.3 **
	2.0	9.3	9.3	9.9	7.7	9.3	10.6	9.3 **
Dowco 290	0.25	20.5	19.3	33.1	47.5	50.4	37.2	34.6 **
July 3, 1975	0.5	21.1	36.3	32.0	44.9	43.7	43.0	36.8 *
	1.0	19.5	16.3	15.0	15.0	26.9	30.4	20.5 **
	2.0	9.6	20.5	22.4	12.5	24.0	21.5	18.4 **
Check	-	23.7	44.1	59.5	66.3	59.8	46.5	50.0

* Significantly different from the check at the 5% level.
** Significantly different from the check at the 1% level.
NS = No significant difference.

Appendix Table 7. Analysis of variance, John Harrison
Peppermint oil yield - lb/A, 1975

Source of Variation	d.f.	SS	MS	F
Replications	5	1,983.23	396.65	4.94 **
Treatments	8	7,851.58	981.45	12.23 **
Replication x Treatments	40	3,210.89	80.27	
Total	53	13,045.70		

** Significantly different at the 1% level

$LSD_{.05}$ = 10.45 lb/A
$LSD_{.01}$ = 13.99 lb/A
C.V. = 29.7%

Appendix Table 8. John Harrison Farm, 1976
Peppermint fresh hay yield - lb/27 ft^2

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	1.0	17.0	23.4	22.5	23.0	27.0	23.6	22.7 NS
July 3, 1975	2.0	18.2	22.6	18.2	20.7	22.3	21.2	20.5 NS
Check	-	18.3	18.5	21.1	21.9	25.6	19.8	20.9

NS = No significant difference

Appendix Table 9. Analysis of Variance, John Harrison
Peppermint fresh hay yield - lb/27 ft^2, 1976

Source of Variation	d.f.	SS	MS	F
Replications	5	78.98	15.80	5.44 NS
Treatments	2	17.14	8.57	2.95 NS
Replication x Treatments	10	29.02	2.90	
Total	17	125.15		

NS = No significant difference
C.V. = 7.96%

Appendix Table 10. John Harrison Farm, 1976
Peppermint oil yield - ml/10 lb sample

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	1.0	9.6	7.4	6.4	8.0	7.1	8.5	7.8
July 3, 1975	2.0	5.1	8.6	6.9	9.4	7.5	8.5	7.7
Check	-	11.0	7.2	9.4	8.2	9.0	8.5	8.9

Appendix Table 11. John Harrison Farm, 1976
Peppermint oil yield - lb/A

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	1.0	52.1	55.4	46.0	58.9	61.4	64.2	56.3 NS
July 3, 1975	2.0	27.4	62.2	40.1	62.1	53.5	57.7	50.5 NS
Check	-	63.0	42.6	63.5	57.5	73.8	53.9	59.1

NS = No significant difference

Appendix Table 12. Analysis of variance, John Harrison
Peppermint oil yield - lbs/A, 1976

Source of Variation	d.f.	SS	MS	F
Replications	5	540.78	108.16	0.90 NS
Treatments	2	229.02	114.51	0.95 NS
Replication x Treatments	10	1,205.49	120.55	
Total	17	1,975.29		

NS = No significant difference
C.V. = 19.9%

Appendix Table 13. Peppermint tolerance to Dowco 290, Bob Nixon Farm, 1975

Date of Harvest: August 5, 1975
July 27, 1976

Date of Distillation: September 22, 1975
August 10, 1976

General Information

Crop: Peppermint, var. Mitcham
Plot Size: 10' x 20'
Soil Type: Malabon clay loam
pH 6.6, OM 4.39%
Irrigation: Sprinkler

Application Data	Treatments 1-4	Treaments 5-8
Date	June 4, 1975	June 20, 1975
Conditions:		
Air temperature	82 F	58 F
Soil temperature	82 F	60 F
Humidity	62%	86%
% Cloud cover	0	100
Wind speed	0	0
Method of Application:	Broadcast	Broadcast
Carrier volume	25 gpa	25 gpa
Nozzle size	8002	8002
Pressure	27 psi	27 psi
Stage of Growth:		
Peppermint	Emerging to 5" tall*	Emerging to 12" tall*

* Average height of 20 randomly selected plants

Appendix Table 14. Bob Nixon Farm, 1975
Peppermint fresh hay yield - lb/27 ft^2

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	0.25	14.7	22.8	18.6	15.1	20.8	17.4	18.2 *
June 4, 1975	0.5	15.8	18.5	18.5	16.2	17.6	15.5	17.0 **
	1.0	14.2	17.0	15.0	15.6	15.3	13.2	15.1 **
	2.0	15.0	13.5	13.8	11.7	14.8	12.0	13.5 **
Dowco 290	0.25	17.8	19.1	18.2	16.3	18.2	18.6	18.0 *
June 20, 1975	0.5	19.8	18.0	19.0	16.5	20.7	15.6	18.3 NS
	1.0	17.6	17.6	17.3	16.2	18.3	14.7	17.0 **
	2.0	15.0	15.7	15.2	10.4	15.8	14.8	14.5 **
Check	-	18.9	19.7	19.2	20.1	22.0	19.0	19.8

* Significantly different from the check at the 5% level
** Significantly different from the check at the 1% level
NS = No significant difference

Appendix Table 15. Analysis of variance, Bob Nixon Farm
Peppermint fresh hay yield - lb/27 ft^2, 1975

Source of Variation	d.f.	SS	MS	F
Replications	5	62.69	12.54	6.72 **
Treatments	8	206.61	25.83	13.86 **
Replications x Treatments	40	74.52	1.86	
Total	53	343.82		

** Significantly different at the 1% level

$LSD_{.05}$ = 1.59 lb/27 ft^2

$LSD_{.01}$ = 2.13 lb/27 ft^2

C.V. = 8.1%

Appendix Table 16. Bob Nixon Farm, 1975
Peppermint oil yield - ml/10 lb sample

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	0.25	3.0	6.7	7.3	6.5	7.5	4.6	5.9
June 4, 1975	0.5	3.2	5.6	5.4	5.6	5.9	4.9	5.1
	1.0	4.4	4.8	7.1	3.1	7.3	3.7	5.1
	2.0	3.0	3.7	5.5	5.0	6.1	5.4	4.8
Dowco 290	0.25	5.7	7.2	5.7	12.3	5.0	-	7.2
June 20, 1975	0.5	5.0	7.8	7.5	9.3	10.4	6.3	7.7
	1.0	5.2	6.9	6.1	7.3	5.8	4.7	6.0
	2.0	4.5	4.7	3.3	5.7	5.2	5.3	4.8
Check	-	5.5	9.3	8.6	8.5	10.0	8.6	8.4

Appendix Table 17. Bob Nixon Farm, 1975
Peppermint oil yield - lb/A

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	0.25	14.1	48.9	43.5	31.4	49.9	25.6	35.6 **
June 4, 1975	0.5	16.2	33.2	32.0	29.0	33.2	24.3	28.0 **
	1.0	20.0	26.1	34.1	15.5	35.8	15.6	24.5 **
	2.0	14.4	16.0	24.3	18.7	28.9	20.7	20.5 **
Dowco 290	0.25	32.5	44.0	33.2	64.2	29.1	-	40.6 **
June 20, 1975	0.5	31.7	44.9	45.6	49.1	68.9	31.5	45.3 NS
	1.0	29.3	38.9	33.8	37.9	34.0	22.1	32.7 **
	2.0	21.6	23.6	16.1	19.0	26.3	25.1	21.9 **
Check	-	33.3	58.6	52.9	54.7	70.4	52.3	53.7

** Significantly different from the check at the 1% level
NS = No significant difference

Appendix Table 18. Analysis of variance, Bob Nixon Farm, 1975
Peppermint oil yield - lb/A

Source of Variation	d.f.	SS	MS	F
Replications	5	2,011.71	402.34	6.10 **
Treatments	8	6,121.65	765.21	11.60 **
Replications x Treatments	40	2,638.64	65.97	
Total	53	10,772.00		

** Significantly different at the 1% level

$LSD_{.05}$ = 9.48 lb/A

$LSD_{.01}$ = 12.68 lb/A

C.V. = 23.9%

Appendix Table 19. Bob Nixon Farm, 1976
Peppermint fresh hay yield - lb/27 ft^2

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	1.0	22.3	18.7	21.6	21.5	21.4	22.3	21.3 NS
June 20, 1975	2.0	16.8	17.5	24.5	17.8	19.6	20.5	19.5 NS
Check	-	17.9	23.6	21.4	15.2	20.6	20.5	19.9

NS = No significant difference

Appendix Table 20. Analysis of variance, Bob Nixon Farm
Peppermint fresh hay yield - lb/27 ft^2, 1976

Source of Variation	d.f.	SS	MS	F
Replications	5	35.57	7.11	1.26 NS
Treatments	2	11.30	5.65	1.00 NS
Replication x Treatments	10	56.38	5.64	
Total	17	103.25		

NS = No significant difference

C.V. = 11.8%

Appendix Table 21. Bob Nixon Farm, 1976
Peppermint oil yield - ml/10 lb sample

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	1.0	3.5	4.0	3.8	2.4	7.0	4.7	4.2
June 20, 1975	2.0	4.5	4.0	1.7	3.0	8.7	4.0	4.3
Check	-	5.2	5.8	2.0	5.0	3.6	3.2	4.3

Appendix Table 22. Bob Nixon Farm, 1976
Peppermint oil yield - lb/A

Treatment	Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
Dowco 290	1.0	24.9	23.9	26.2	16.5	48.0	33.5	28.8 NS
June 20, 1975	2.0	24.2	22.3	13.3	17.1	54.6	26.3	26.3 NS
Check	-	29.8	43.7	19.9	24.3	23.7	21.0	27.1

NS = No significant difference

Appendix Table 23. Analysis of variance, Bob Nixon Farm, 1976
Peppermint oil yield - lb/A

Source of Variation	d.f.	SS	MS	F
Replications	5	1,042.43	208.49	2.06 NS
Treatments	2	20.25	10.13	0.10 NS
Replication x Treatments	10	1,011.80	101.18	
Total	17	2,074.48		

NS = No significant difference
C.V. = 36.7%

Appendix Table 24. Spring applications of Dowco 290 for Canada thistle control, DeVaughn Crowson Farm, Monroe, Lane County, Oregon, 1975

Date of Harvest: August 5, 1975
Date of Distillation: September 19, 1975

General Information

Crop: Peppermint, var Todd's Mitcham
Plot Size: 16' x 20'
Soil Type: Newberg gravelly sandy loam
pH 6.6, OM 2.62%
Irrigation: Sprinkler

Application Data	Treatments 1-5	Treatments 6-10
Date	May 27, 1975	June 10, 1975
Conditions:		
Air temperature	68 F	85 F
Soil temperature	75 F	83 F
Humidity	78%	35%
% Cloud cover	0	0
Wind speed	0-5 mph	0-5 mph
Wind direction	Northeast	Northeast
Method of Application:	Broadcast	Broadcast
Carrier volume	25 gpa	25 gpa
Nozzle size	8002	8002
Pressure	27 psi	27 psi
Stage of Growth:		
Peppermint	Emerging to 5" tall*	Emerging to 12" tall*
Canada thistle	Emerging to 15" tall	Emerging to 32" tall* in the bud

* Average height of 20 randomly selected plants

Appendix Table 25. DeVaughn Crowson Farm, 1975
Peppermint fresh hay yield - lb/27 ft^2

Treatment	Rate lb a.e./A	R1	R2	Avg
<u>May 27, 1975</u>				
Dowco 290	0.063	22.5	17.4	20.0
	0.125	22.2	18.9	20.6
	0.25	17.1	17.4	17.3
	0.5	14.2	16.9	15.6
	1.0	12.1	16.2	14.2
<u>June 10, 1975</u>				
Dowco 290	0.063	16.8	16.4	16.6
	0.125	24.0	16.5	20.3
	0.25	22.9	13.0	18.0
	0.5	12.6	14.2	13.4
	1.0	20.8	16.4	18.6
Check	-	14.1	15.2	14.7

Appendix Table 26. Analysis of variance, DeVaughn Crowson, 1975
Peppermint fresh hay yield - lb/27 ft^2

Source of Variation	d.f.	SS	MS	F
Replications	1	19.67	19.67	1.97 NS
Treatments	10	127.86	12.79	1.28 NS
Replications x Treatments	10	99.65	9.97	
Total	21	247.18		

NS = No significant difference
C.V. = 58.0%

Appendix Table 27. DeVaughn Crowson Farm, 1975
Peppermint oil yield - ml/10 lb sample

Treatment	Rate lb a.e./A	R1	R2	Avg
May 27, 1975				
Dowco 290	0.063	9.8	10.8	10.3
	0.125	10.7	6.7	8.7
	0.25	8.4	4.5	6.5
	0.5	8.0	5.0	6.5
	1.0	6.3	6.3	6.3
June 10, 1975				
Dowco 290	0.063	6.2	8.0	7.1
	0.125	6.3	6.0	6.2
	0.25	7.7	5.2	6.5
	0.5	4.1	6.6	5.4
	1.0	6.6	2.3	4.5
Check	-	4.0	8.7	6.4

Appendix Table 28. DeVaughn Crowson Farm, 1975
Peppermint oil yield - lb/A

Treatment	Rate lb a.e./A	R1	R2	Avg
May 27, 1975				
Dowco 290	0.063	70.6	60.2	65.4
	0.125	76.0	40.5	58.3
	0.25	46.0	25.1	35.5
	0.5	36.4	27.0	31.7
	1.0	24.4	32.7	28.5
June 10, 1975				
Dowco 290	0.063	33.3	42.0	37.7
	0.125	48.4	31.7	40.0
	0.25	56.7	21.6	39.2
	0.5	16.5	30.0	23.3
	1.0	43.9	12.1	28.0
Check	-	18.1	42.3	30.2

Appendix Table 29. Analysis of variance, DeVaughn Crowson
Peppermint oil yield - lb/A, 1975

Source of Variation	d.f.	SS	MS	F
Replications	1	502.09	502.09	2.32 NS
Treatments	10	3,359.72	335.97	1.55 NS
Replications x Treatments	10	2,162.00	216.20	
Total	21	6,023.82		

NS = No significant difference
C.V. = 38.7%

Appendix Table 30. DeVaughn Crowson Farm, 1975
Average* number of thistles/9 ft^2

Treatment	Rate lb a.e./A	June 5, 1975	July 30, 1975	Nov. 18, 1975	March 25, 1976	May 22, 1976	July 21, 1976
May 27, 1975							
Dowco 290	0.063	9.1	1.2	4.1	5.3	13.5	5.1
	0.125	7.6	0.4	1.0	4.3	6.0	2.4
	0.25	7.8	0.0	0.1	0.5	2.0	1.3
	0.5	13.6	0.3	0.5	1.1	2.9	0.3
	1.0	11.6	0.0	0.0	0.0	1.4	0.3
June 10, 1975							
Dowco 290	0.063	15.5	6.6	13.3	17.0	16.6	6.9
	0.125	10.9	0.0	2.0	5.4	5.3	1.6
	0.25	15.4	0.1	0.4	1.1	2.5	1.1
	0.5	13.4	0.0	0.0	0.0	0.1	0.0
	1.0	15.4	0.0	0.3	0.4	0.1	0.3
Check	-	13.1	19.0	12.5	13.4	15.3	7.6

* Average of four replications

Appendix Table 31. DeVaughn Crowson Farm, 1975
Thistle stand compared to pretreatment counts* - expressed as a percentage

Treatment	Rate lb a.e./A	June 5, 1975	July 30, 1975	Nov. 18, 1975	March 25, 1976	May 22, 1976	July 21, 1976
May 27, 1975							
Dowco 290	0.063	100	13	45	58	148	56
	0.125	100	5	13	57	79	32
	0.25	100	0	1	6	26	17
	0.5	100	2	4	8	21	2
	1.0	100	0	0	0	12	3
June 10, 1975							
Dowco 290	0.063	100	43	86	110	107	45
	0.125	100	0	18	50	49	15
	0.25	100	1	3	7	16	7
	0.5	100	0	0	0	1	0
	1.0	100	0	2	3	1	2
Check	-	100	145	95	102	117	58

* Average of four replications

Appendix Table 32. Spring applications of Dowco 290 for Canada thistle control, Burle Oakley Farm, Lebanon, Linn County, Oregon, 1975

Date of Harvest: August 15, 1975
Date of Distillation: September 18, 1975

General Information

Crop: Peppermint, var. Mitcham
Plot Size: 16' x 20'
Soil Type: Newberg silt loam
pH 5.6, OM 5.74%
Irrigation: Sprinkler

Application Data	Treatments 1-5	Treatments 6-10
Date	May 26, 1975	June 9, 1975
Conditions:		
Air temperature	80 F	70 F
Soil temperature	70 F	80 F
Humidity	58%	48%
% Cloud cover	0	0
Wind speed	0-5 mph	3-5 mph
Wind direction	Southwest	Northwest
Method of Application:	Broadcast	Broadcast
Carrier volume	25 gpa	25 gpa
Nozzle size	8002	8002
Pressure	27 psi	27 psi
Stage of Growth:		
Peppermint	Emerging to 6" tall*	Emerging to 7" tall*
Canada thistles	Emerging to 8" tall*	Emerging to 27" tall* in the bud

* Average height of 20 randomly selected plants

Appendix Table 33. Burle Oakley Farm, 1975
Peppermint fresh hay yield - lb/27 ft^2

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
May 26, 1975						
Dowco 290	0.063	13.3	17.1	21.4	14.4	16.6
	0.125	16.3	23.4	18.1	12.7	17.6
	0.25	15.2	17.6	25.6	15.0	18.4
	0.5	14.0	14.3	18.4	20.3	16.8
	1.0	19.6	18.8	17.2	21.3	19.2
June 9, 1975						
Dowco 290	0.063	8.4	20.3	16.7	13.0	14.9
	0.125	15.9	18.3	29.8	16.4	20.1
	0.25	15.4	18.5	18.5	15.1	16.9
	0.5	19.7	20.1	16.0	17.5	18.3
	1.0	18.2	15.8	18.6	15.0	16.9
Check	-	14.3	13.3	22.5	13.6	15.9

Appendix Table 34. Analysis of variance, Burle Oakley
Peppermint fresh hay yield - lb/27 ft^2, 1975

Source of Variation	d.f.	SS	MS	F
Replications	3	156.32	52.11	4.62 **
Treatments	10	91.11	9.11	0.81 NS
Replications x Treatments	30	338.37	11.28	
Total	43	585.81		

** = Significantly different at the 1% level
NS = No significant difference
$LSD_{.05}$ = 4.85 lb/27 ft^2
$LSD_{.01}$ = 6.53 lb/27 ft^2
C.V. = 19.3%

Appendix Table 35. Burle Oakley Farm, 1975
Peppermint oil yield - ml/10 lb sample

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
May 25, 1975						
Dowco 290	0.063	10.3	11.6	7.2	10.4	9.9
	0.125	11.6	8.5	11.1	13.8	11.3
	0.25	11.4	6.9	8.6	13.0	10.0
	0.5	12.9	12.8	4.7	10.2	10.2
	1.0	7.3	9.2	9.4	7.3	8.3
June 9, 1975						
Dowco 290	0.063	13.9	10.9	11.8	12.8	10.6
	0.125	11.6	9.2	6.8	12.5	10.0
	0.25	6.3	10.3	7.1	10.0	8.4
	0.5	11.0	6.4	8.7	8.9	8.8
	1.0	11.5	6.6	6.0	11.0	8.8
Check	-	11.6	10.3	9.5	5.9	9.3

Appendix Table 36. Burle Oakley Farm, 1975
Peppermint oil yield - lb/A

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
May 25, 1975						
Dowco 290	0.063	43.9	63.5	49.3	47.9	51.2
	0.125	60.5	63.7	64.3	56.1	61.2
	0.25	55.5	38.9	70.5	62.4	56.8
	0.5	58.2	58.6	27.7	66.3	52.7
	1.0	45.8	55.4	51.8	49.8	50.7
June 9, 1975						
Dowco 290	0.063	41.8	70.8	63.1	53.3	57.3
	0.125	59.0	53.9	64.9	65.6	60.9
	0.25	31.1	61.0	42.0	48.3	45.6
	0.5	69.4	41.2	44.6	49.9	51.2
	1.0	67.0	33.4	35.7	52.8	47.2
Check	-	53.1	43.9	68.4	25.7	47.8

Appendix Table 37. Analysis of variance, Burle Oakley
Peppermint oil yield - lb/A, 1975

Source of Variation	d.f.	SS	MS	F
Replications	3	2,770.91	92.36	0.01 NS
Treatments	10	1,151.62	115.16	0.70 NS
Replications x Treatments	30	4,932.04	164.40	
Total	43	6,086.43		

NS = No significant difference
C.V. = 24.2%

Appendix Table 38. Burle Oakley Farm, 1975
Average* number of thistles/9 ft^2

Treatment	Rate lb a.e./A	June 9, 1975	Aug. 8, 1975	Nov. 8, 1975	Mar. 23, 1976	May 19, 1976	July 19, 1976
May 26, 1975							
Dowco 290	0.063	21.8	5.0	7.1	15.0	19.6	7.9
	0.125	12.4	1.3	2.3	2.8	3.6	2.0
	0.25	18.0	0.5	4.9	3.5	4.6	2.4
	0.5	17.1	0.1	1.5	3.0	2.4	2.3
	1.0	13.6	0.3	4.0	0.8	0.8	0.4
June 9, 1975							
Dowco 290	0.063	16.1	3.0	7.6	17.5	16.6	7.5
	0.125	20.4	2.3	5.4	11.8	10.6	6.6
	0.25	16.1	0.1	2.5	5.0	6.3	1.6
	0.5	21.8	0.0	3.6	2.1	2.8	2.4
	1.0	16.8	0.1	0.4	1.0	2.3	0.9
Check	-	16.6	13.8	16.3	15.9	24.8	9.5

* Average of four replications

Appendix Table 39. Burle Oakley Farm, 1975-1976
Thistle stand compared to pretreatment counts* - expressed as a percentage

Treatment	Rate lb a.e./A	June 9, 1975	Aug. 8, 1975	Nov. 8, 1975	Mar. 23, 1976	May 19, 1976	July 19, 1976
May 26, 1975							
Dowco 290	0.063	100	23	33	69	90	36
	0.125	100	10	19	23	29	16
	0.25	100	3	27	19	26	13
	0.5	100	1	9	18	14	13
	1.0	100	2	29	6	6	3
June 9, 1975							
Dowco 290	0.063	100	19	47	109	103	47
	0.125	100	11	26	58	52	32
	0.25	100	1	16	31	39	10
	0.5	100	0	17	10	13	11
	1.0	100	1	2	6	14	5
Check	-	100	83	98	96	149	57

* Average of four replications

Appendix Table 40. Split applications of Dowco 290 for Canada thistle control, John Harrison Farm, 1976

Date of Harvest: July 23, 1976
Date of Distillation: August 30, 1976

General Information

Crop: Todd's Mitcham peppermint
Plot Size: 8' x 25'
Soil Type: Chehalis silty clay loam pH 5.6, OM 3.05%
Irrigation: Sprinkler

Application Data	Treatments 1-9	Treatments 4-14
Date	November 9, 1976	May 26, 1976
Conditions:		
Air temperature	41 F	82 F
Soil temperature	42 F	82 F
Humidity	90%	46%
% Cloud cover	100	0
Wind speed	Calm	0-3 mph
Wind direction	--	Southwest
Method of Application:	Broadcast	Broadcast
Carrier volume	25 gpa	25 gpa
Nozzle size	8002	8002
Pressure	28 psi	28 psi
Stage of Growth:		
Peppermint	1-2" tall*	12" tall*
Canada thistles	2-6" tall	Emerging to 16" tall

* Average of 20 randomly selected plants

Appendix Table 41. John Harrison Farm, 1976
Peppermint fresh hay - lb/27 ft^2

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
Nov. 9, 1975						
Dowco 290	0.25	17.5	18.9	13.2	15.6	16.3
	0.50	20.4	15.3	16.5	15.0	16.8
	1.0	7.0	18.3	10.9	12.6	12.2
Nov. 9, 1975 + May 26, 1976						
Dowco 290	0.25 + 0.063	19.9	18.9	13.9	14.6	16.8
	0.5 + 0.063	6.5	19.5	11.7	16.2	13.5
	0.25 + 0.125	15.0	14.8	17.5	9.7	14.3
	0.5 + 0.125	22.7	22.3	11.5	16.2	18.2*
May 26, 1976						
Dowco 290	0.063	16.4	19.6	15.7	12.9	16.2
	0.125	13.5	19.7	11.8	17.8	15.7
Check	-	12.6	16.0	19.0	4.2	13.0

Appendix Table 42. ANOVA, Harrison Farm
Fresh hay, 1976

Source of Variation	d.f.	SS	MS	F
Replications	3	167.66	55.89	4.78 **
Treatments	9	206.30	22.92	1.96 NS
Replications x Treatments	27	315.93	11.70	
Total	39	689.89		

** Significantly different from the check at the 1% level
NS = No significant difference
$LSD_{.05}$ = 4.96 lb/27 ft^2
$LSD_{.01}$ = 5.98 lb/27 ft^2
C.V. = 22.76%

Appendix Table 43. John Harrison Farm, 1976
Peppermint oil yield - ml/10 lb sample

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
November 9, 1975						
Dowco 290	0.25	4.3	4.9	6.4	6.1	5.4
	0.50	4.6	5.9	7.1	9.9	6.9
	1.00	0.6	3.7	10.3	4.4	4.8
November 9, 1975 + May 26, 1976						
Dowco 290	0.25 + 0.063	5.7	8.4	6.4	7.8	7.1
	0.50 + 0.063	0.1	5.5	7.1	6.2	4.7
	0.25 + 0.125	5.4	3.8	5.3	9.8	6.1
	0.50 + 0.125	4.9	5.8	7.8	8.2	6.7
May 26, 1976						
Dowco 290	0.063	4.7	5.8	7.1	7.6	6.3
	0.125	3.6	7.3	6.8	8.4	6.5
Check	-	2.8	4.3	2.8	3.0	3.2

Appendix Table 44. John Harrison Farm, 1976
Peppermint oil yield - lb/A

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
Nov. 9, 1975						
Dowco 290	0.25	24.0	29.6	26.9	31.8	28.1 *
	0.50	30.0	28.8	37.5	47.4	35.9 **
	1.0	17.8	21.7	35.9	17.7	23.3
Nov. 9, 1975 + May 26, 1976						
Dowco 290	0.25 + 0.063	36.3	50.8	28.5	42.0	39.4 **
	0.50 + 0.063	23.7	34.2	26.6	32.2	29.2 *
	0.25 + 0.125	25.9	18.0	29.7	31.4	26.3 *
	0.50 + 0.125	35.5	41.4	28.6	42.5	37.0 **
May 26, 1976						
Dowco 290	0.063	24.6	36.4	35.7	31.3	32.0 **
	0.125	15.6	45.9	25.7	47.7	33.7 **
Check	-	11.3	22.0	17.0	9.6	15.0

* Significantly different from the check at the 5% level.
** Significantly different from the check at the 1% level.

Appendix Table 45. ANOVA, Harrison Farm
Mint oil, 1976

Source of Variation	d.f.	SS	MS	F
Replications	3	507.87	169.29	2.91 NS
Treatments	9	1,919.05	213.23	3.66 **
Replications x Treatment	27	1,455.04	58.20	
Total	39	3,881.96		

** Significantly different from the check at the 1% level
NS = No significant difference
$LSD_{.05}$ = 11.07 lb/A
$LSD_{.01}$ = 14.95 lb/A
C.V. = 25.45%

Appendix Table 46. John Harrison Farm, 1976
Canada thistle densities

Treatment	Rate lb a.e./A	Thistles/9 ft^2* Mar. 23, 1976	May 18, 1976	July 16, 1976
Nov. 9, 1975				
Dowco 290	0.25	3.6	10.9	11.1
	0.50	0.6	3.6	4.9
	1.0	1.8	7.4	7.0
Nov. 9, 1975 + May 26, 1976				
Dowco 290	0.25 + 0.063	3.0	11.1	4.3
	0.50 + 0.063	1.8	17.1	5.0
	0.25 + 0.125	3.3	16.8	4.9
	0.50 + 0.125	1.0	10.6	1.5
May 26, 1976				
Dowco 290	0.063	31.0	37.5	10.4
	0.125	24.0	27.0	1.6
Check	-	30.8	56.0	26.0

* Average of two 9 ft^2 quadrats and four replications

Appendix Table 47. John Harrison Farm, 1976
Canada thistle densities - percentage

Treatment	Rate lb a.e./A	Reduction in Thistle Stand - % of Check *		
		Mar. 23, 1976	May 18, 1976	July 16, 1976
Nov. 9, 1975				
Dowco 290	0.25	88	81	57
	0.50	98	94	81
	1.00	94	87	73
Nov. 9, 1975 + May 26, 1976				
Dowco 290	0.25 + 0.063	90	80	84
	0.50 + 0.063	94	69	81
	0.25 + 0.125	89	70	81
	0.50 + 0.125	97	80	94
May 26, 1976				
Dowco 290	0.063	0	33	60
	0.125	22	52	94
Check	-	0	0	0

* Average of four replications

Appendix Table 48. Split applications of Dowco 290 for Canada thistle control, Kenneth L. Holmes Farm, 1976

Date of Harvest: July 30, 1976
Date of Distillation: September 3, 1976

General Information

Crop: Todd's Mitcham peppermint (planted fall of 1974)
Plot Size: 8' x 25'
Soil Type: Willamette silt loam pH 5.7, OM 2.09%
Irrigation: Sprinkler

Application Data	Treatments 1-9	Treatments 4-14	Treatment 11
Date	Nov. 11, 1975	May 12, 1976	May 26, 1976
Conditions:			
Air temperature	55 F	84 F	78 F
Soil temperature	50 F	90 F	80 F
Humidity	80%	34%	54%
% Cloud cover	90	0	0
Wind speed	4-8 mph	5-8 mph	2-4 mph
Wind direction	South	North	South
Method of Application:	Broadcast	Broadcast	Broadcast
Carrier volume	25 gpa	25 gpa	25 gpa
Nozzle size	8002	8002	8002
Pressure	28 psi	28 psi	28 psi
Stage of Growth:			
Peppermint	2-3" tall*	Emerging (just burned)	Emerging to 6" tall
Canada thistle	3-6" tall	Emerging to 7" tall	Emerging to 14" tall

* Average of 20 randomly selected plants

Appendix Table 49. Kenneth Holmes Farm, 1976
Peppermint fresh hay yield - lb/27 ft^2

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
Nov. 11, 1975						
Dowco 290	0.25	13.7	19.5	10.5	16.4	15.0
	0.50	15.3	12.2	19.9	16.2	15.9
	1.0	14.9	18.3	22.1	13.5	17.2
Nov. 11, 1975 + May 12, 1976						
Dowco 290	0.25 + 0.063	19.6	18.5	23.6	20.7	20.6
	0.50 + 0.063	20.3	20.0	16.8	17.4	18.6
	0.25 + 0.125	19.4	13.4	15.5	19.6	17.0
	0.50 + 0.125	18.1	18.1	16.8	19.8	18.2
May 12, 1976						
Dowco 290	0.125	15.5	17.2	17.0	18.2	17.0
Check	-	10.8	5.7	19.5	10.1	11.5

Appendix Table 50. ANOVA, Holmes Farm
Fresh hay, 1976

Source of Variation	d.f.	SS	MS	F
Replications	3	40.61	13.54	0.68 NS
Treatments	8	206.10	25.78	1.29 NS
Replication x Treatments	24	479.81	19.99	
Total	35	726.63		

NS = No significant difference
C.V. = 27.39%

Appendix Table 51. Kenneth Holmes Farm
Peppermint oil yield - ml/10 lb sample, 1976

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
Nov. 11, 1975						
Dowco 290	0.25	4.6	3.7	4.5	5.6	4.6
	0.50	2.7	9.3	3.7	4.3	5.0
	1.00	2.9	7.4	3.0	4.7	4.5
Nov. 11, 1975 + May 12, 1976						
Dowco 290	0.25 + 0.063	3.5	3.3	2.8	4.0	3.4
	0.50 + 0.063	6.7	2.6	4.8	6.8	5.2
	0.25 + 0.125	3.7	6.7	5.7	7.8	6.0
	0.50 + 0.125	7.7	3.1	6.2	4.7	5.4
May 12, 1976						
Dowco 290	0.125	7.6	7.9	4.2	4.6	6.1
Check	-	3.8	5.1	4.3	8.0	5.3

Appendix Table 52. Kenneth Holmes Farm, 1976
Peppermint oil yields - lb/A

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
Nov. 11, 1975						
Dowco 290	0.25	20.2	23.1	15.1	29.3	21.9
	0.50	13.2	36.2	23.5	22.2	23.8
	1.00	13.8	43.2	21.2	20.3	24.6
Nov. 11, 1975 + May 12, 1976						
Dowco 290	0.25 + 0.063	22.0	19.5	21.1	26.5	22.3
	0.50 + 0.063	43.5	16.6	25.8	37.9	31.0
	0.25 + 0.125	23.0	28.7	28.2	48.9	32.2
	0.50 + 0.125	44.6	18.0	33.2	29.8	31.4
May 12, 1976						
Dowco 290	0.125	37.6	43.5	22.8	26.7	32.7
Check	-	13.1	16.3	26.8	25.7	20.5

Appendix Table 53. ANOVA, Holmes Farm
Mint oil, 1976

Source of Variation	d.f.	SS	MS	F
Replications	3	149.92	49.97	0.51 NS
Treatments	8	799.19	99.90	1.02 NS
Replications x Treatments	24	2,347.24	97.80	
Total	35	3,296.35		

NS = No significant difference
C.V. = 37.04%

Appendix Table 54. Kenneth Holmes Farm, 1976
Canada thistle densities

Treatment	Rate lb a.e./A	Thistles/9 ft²* Mar. 24, 1976	May 15, 1976	July 24, 1976
Nov. 11, 1975				
Dowco 290	0.25	1.1	15.2	12.9
	0.50	0.2	2.3	3.8
	1.00	0.0	10.1	9.3
Nov. 11, 1975 + May 12, 1976				
Dowco 290	0.25 + 0.063	1.9	14.6	6.3
	0.50 + 0.063	0.3	2.1	1.9
	0.25 + 0.125	0.4	6.5	1.1
	0.50 + 0.125	0.5	12.6	5.7
May 12, 1976				
Dowco 290	0.063	11.0	17.8	8.8
	0.125	5.4	19.2	3.9
Check	-	15.8	24.1	15.4

* Average of two 9 ft^2 quadrats and five replications

Appendix Table 55. Kenneth Holmes Farm, 1976
Canada thistle densities - percentage

Treatment	Rate lb a.e./A	Reduction in Thistle Stand - % of Check *		
		Mar. 24, 1976	May 15, 1976	July 24, 1976
Nov. 11, 1975				
Dowco 290	0.25	93	37	16
	0.50	99	90	75
	1.00	100	58	40
Nov. 11, 1975 + May 12, 1976				
Dowco 290	0.25 + 0.063	88	39	59
	0.50 + 0.063	98	91	88
	0.25 + 0.125	97	73	93
	0.50 + 0.125	97	48	63
May 12, 1976				
Dowco 290	0.063	30	26	43
	0.125	66	20	75
Check	-	0	0	0

* Average of five replications

Appendix Table 56. Split applications of Dowco 290 for Canada thistle control, Burle Oakley Farm, 1976

Date of Harvest: July 27, 1976
Date of Distillation: September 2, 1976

General Information

Crop: Peppermint, var. Mitcham
Plot Size: 20' x 30'
Soil Type: Newberg silt loam
pH 5.6, OM 5.74%
Irrigation: Sprinkler

Application Data	Treatments 1, 3-6	Treatments 2-6
Date	May 20, 1976	June 2, 1976
Conditions:		
Air temperature	70 F	68 F
Soil temperature	76 F	69 F
Humidity	50%	66%
% Cloud cover	0	25
Wind speed	6-9 mph	4-6 mph
Wind direction	Northwest	Northwest
Method of Application:	Broadcast	Broadcast
Carrier volume	25 gpa	25 gpa
Nozzle size	8002	8002
Pressure	27 psi	28 psi
Stage of Growth:		
Peppermint	Emerging to 4" tall*	Emerging to 6" tall*
Canada thistle	Emerging to 17" tall*	Emerging to 20" tall*

* Average of 10 randomly selected plants

Appendix Table 57. Burle Oakley Farm, 1976
Peppermint fresh hay yield - lb/36 ft^2

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
<u>May 20, 1976</u>						
Dowco 290	0.125	22.5	22.9	18.6	19.8	21.0 **
<u>June 2, 1976</u>						
Dowco 290	0.125	19.7	19.6	14.9	20.5	18.7 **
<u>May 20, 1976 +</u>						
<u>June 2, 1976</u>						
Dowco 290	0.063 + 0.063	18.7	22.9	19.8	24.1	21.4 **
	0.125 + 0.063	12.0	27.7	23.2	28.3	22.8 **
	0.125 + 0.125	14.5	16.7	14.5	21.2	16.7 *
	0.063 + 0.031	13.2	24.6	12.5	18.5	17.2 *
Check	-	3.6	5.5	16.5	15.1	10.2

Appendix Table 58. ANOVA, Oakley Farm, 1976
Fresh hay

Source of Variation	d.f.	SS	MS	F
Replications	3	164.61	54.87	3.16 *
Treatments	6	426.28	71.05	4.10 **
Replication x Treatments	18	312.19	17.34	
Total	27	903.08		

* Significantly different from the check at the 5% level
** Significantly different from the check at the 1% level
$LSD_{.05}$ = 6.19 lb/36 ft^2
$LSD_{.01}$ = 8.48 lb/36 ft^2
C.V. = 22.79%

Appendix Table 59. Burle Oakley Farm, 1976
Peppermint oil yield - ml/10 lb sample

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
May 20, 1976						
Dowco 290	0.125	5.3	3.7	4.7	6.0	4.9
June 2, 1976						
Dowco 290	0.125	3.4	2.2	3.7	6.3	3.9
May 20, 1976 + June 2, 1976						
Dowco 290	0.063 + 0.063	5.8	4.5	6.6	4.3	5.3
	0.125 + 0.063	5.7	3.9	7.4	7.1	6.0
	0.125 + 0.125	3.6	3.5	2.3	4.0	3.4
	0.063 + 0.031	5.4	4.9	5.7	5.2	5.3
Check	-	2.7	3.7	4.0	4.8	3.8

Appendix Table 60. Burle Oakley Farm, 1976
Peppermint oil yield - lb/A

Treatment	Rate lb a.e./A	R1	R2	R3	R4	Avg
May 20, 1976						
Dowco 290	0.125	28.6	20.3	21.0	28.5	24.6 *
June 2, 1976						
Dowco 290	0.125	16.1	10.3	13.2	31.0	17.7
May 20, 1976 + June 2, 1976						
Dowco 290	0.063 + 0.063	26.0	24.7	31.3	24.9	26.7 **
	0.125 + 0.063	16.4	25.9	41.2	48.2	32.9 **
	0.125 + 0.125	12.5	14.0	8.0	20.3	13.7
	0.063 + 0.031	17.1	28.9	17.1	23.0	21.5
Check	-	6.5	8.9	15.8	17.4	12.2

* = Significantly different from the check at the 5% level.
** = Significantly different from the check at the 1% level.

Appendix Table 61. ANOVA, Oakley Farm, 1976
Mint oil

Source of Variation	d.f.	SS	MS	F
Replications	3	412.26	137.42	3.04 NS
Treatments	6	1,321.25	220.21	4.87 **
Replications x Treatments	18	814.65	45.26	
Total	27	2,548.15		

** Significantly different from the check at the 1% level
NS = No significant difference
$LSD_{.05}$ = 9.99 lb/A
$LSD_{.01}$ = 13.69 lb/A
C.V. = 31.55%

Appendix Table 62. Burle Oakley Farm, 1976
Canada thistle densities

Treatment	Rate lb a.e./A	Thistles/9 ft^2 May 20, 1976	Thistles/9 ft^2 July 19, 1976
May 20, 1976			
Dowco 290	0.125	27	8
June 2, 1976			
Dowco 290	0.125	32	4
May 20, 1976 + June 2, 1976			
Dowco 290	0.063 + 0.063	25	5
	0.125 + 0.063	27	5
	0.125 + 0.125	30	5
	0.063 + 0.031	30	10
Check	-	27	19

* Average of two 9 ft^2 quadrats and four replications

Appendix Table 63. Burle Oakley Farm, 1976
Canada thistle densities - perçentage

Treatment	Rate lb a.e./A	Reduction in Thistle Stand - % of Check* May 20, 1976	July 16, 1976
May 20, 1976			
Dowco 290	0.125	0	58
June 2, 1976			
Dowco 290	0.125	0	79
May 20, 1976 + June 2, 1976			
Dowco 290	0.063 + 0.063	7	74
	0.125 + 0.063	0	74
	0.125 + 0.125	0	74
	0.063 + 0.031	0	47
Check	-	0	0

* Average of four replications

Appendix Table 64. Greenhouse soil mix

	pH	P (ppm)	K (ppm)	Ca (mg/100g)	Mg (mg/100g)	Na (mg/100g)	B (ppm)	Salts Mhos/cm	Total N
Without lime and fertilizer	5.6	15	140	10.3	4.3	-	0.11	0.63	0.05
With lime and fertilizer	7.3	22	198	23	4.9	0.33	0.10	1.41	0.05

Appendix Table 65. Temperature and moisture data (average of two locations) - April 1, 1976 - September 20, 1976

Date	April			Pan	May			Pan	June			Pan
	High °F	Low °F	Precip. (in.)	Evap.* (in.)	High °F	Low °F	Precip. (in.)	Evap. (in.)	High °F	Low °F	Precip. (in.)	Evap. (in.)
1	48	31	T	-	75.5	43.5	0	0.20	59	37	0.10	0.05
2	49	31	T	0.07	76.5	46.5	0.06	0.17	57	35	0.055	0.10
3	59.5	34.5	0	0.14	63	40.5	T	0.10	62	34.5	T	0.23
4	66	33	0	0.14	65	48	0	0.18	63	40.5	0	0.17
5	67	39	0	0.14	62	44	0.02	0.08	65.5	41	0	0.23
6	52	41	0.075	0.05	60	36.5	0.055	0.11	66	49.5	0.04	0.10
7	64	46	0.005	0.01	70	45	0	0.20	67	42	0.02	0.11
8	62.5	45	0.085	0.05	78.5	49.5	0	0.20	62	48	0	0.06
9	61	33	0.16	0.05	80.5	46.5	0	0.21	67.5	46	0	0.11
10	62	44	T	0.02	84.5	51.5	0.045	0.21	75.5	49.5	0	0.26
11	56.5	38.5	0.08	0.06	60.5	41.5	0.05	0.10	63	51.5	0.005	0.11
12	62.5	44.5	0.08	0.15	67	43.5	0	0.18	57.5	50.5	0.06	0.02
13	55	41.5	0.015	0.07	78	45	0	0.22	62.5	34	T	0.16
14	58	31.5	T	0.11	72	36.5	0	0.21	66.5	45	0.045	0.31
15	54	33.5	0.155	0.08	63	38.5	0	0.19	78	46	0	0.38
16	49.5	40.5	0.005	0.08	80.5	43.5	0	0.23	70.5	54	0.015	0.04
17	52.5	39.5	0.04	0.06	61.5	34.5	0	0.11	67.5	47	0	0.14
18	49	33.5	0.075	0.02	61	33.5	0	0.15	82.5	54.5	0	0.21
19	54.5	42	0.09	0.06	66	44.5	0.005	0.15	89.5	54.5	0	0.35
20	52.5	45.5	0.33	0.05	60.5	33	0.01	0.08	76	45.5	0	0.25
21	55	33.5	T	0.12	67.5	37.5	0	0.17	70	45	0	0.26
22	56	42	0.11	0.10	74	43.5	0	0.21	70	43.5	0	0.16
23	53.5	32	0.01	0.06	65.5	48.5	0.04	0.12	70	41	0	0.16
24	53	43.5	0.235	0.06	64	48	0.095	0.09	75	52	0.15	0.24
25	55.5	37	0.03	0.10	62.5	36.5	0.005	0.08	74	39.5	0	0.31
26	54	37	0.205	0.10	67.5	38	0	0.15	67.4	45.5	0	0.25
27	58.5	41	T	0.12	84	49	0.15	0.21	79	41.5	0	0.28
28	70.5	45.5	0	0.23	61.5	35.5	0.02	0.19	85	50	0	0.28
29	65	39.5	0	0.10	55	34.5	0.04	0.07	88	56	0	0.21
30	71.5	43	0	0.10	55	44	0.065	0.04	74	44.5	0	0.31
31					52.5	44.5	0.435	0.08				
	56.7	38.8	1.785	2.59	67.7	42.1	1.095	4.69	70.4	45.5	0.49	5.85

Appendix Table 65 (continued)

Date	July			Pan Evap. (in.)*	August			Pan Evap. (in.)	September			Pan Evap. (in.)
	High °F	Low °F	Precip. (in.)		High °F	Low °F	Precip. (in.)		High °F	Low °F	Precip. (in.)	
1	63.5	49.5	0.265	0.12	83	56	0	0.25	91	51	0	0.24
2	69	41	0.005	0.16	75.5	59	0	0.11	77	45.5	0	0.25
3	79.5	53.5	0	0.24	80.5	55.6	0	0.21	78	51	0	0.24
4	72	56.5	0.115	0.14	79.5	57.5	0.005	0.29	84	49	0	0.25
5	77.5	53.5	0	0.19	66.5	58	0	0.08	82.5	51	0	0.19
6	85	51	0.10	0.28	70	56	T	0.09	74	43	0.230	0.10
7	80	57.5	0.01	0.21	68.5	57	0.115	0.10	69.5	43	0.235	0.14
8	72	55.5	0.34	0.10	65.5	53.5	0.025	0.07	71.5	50.5	0	0.22
9	74	55	0	0.18	74	50	0.13	0.20	82	50.5	0	0.39
10	73.5	49.5	0	0.21	77.5	52.5	0	0.23	88	46.5	0	0.27
11	73.5	56.5	0.025	0.14	82.5	54.5	0	0.21	89.5	50.0	0	0.25
12	68	49.5	0.015	0.07	87	52	0	0.24	68.5	54.5	T	0.13
13	73	46.5	0	0.21	81.5	56.5	T	0.27	72	45	0.005	0.11
14	80	49.5	0	0.29	61.5	56	0.125	0.09	76	52	0.66	0.26
15	82.5	52.5	0	0.33	69	52.5	0.63	0.12	67.5	49.5	0.005	0.02
16	93	51.5	0	0.32	63.5	49.5	0.065	0.10	77	56.5	0	0.20
17	89	47	0	0.31	62	49	0.345	-	66	57	0.055	0.03
18	80.5	48.5	0	0.27	75	49	0	0.16	65	54.5	0	0.06
19	81	46	0	0.28	80	48	0	0.23	72.5	47	0	0.19
20	82	57	0	0.27	75	56	0	0.15	87.5	55.5	0	0.24
21	73.5	47	0	0.24	80.5	50.5	0	0.25				
22	78.5	47.5	0	0.25	84	49	0	0.23				
23	86.5	53.5	0	0.27	77.5	49.5	0	0.19				
24	91	54.5	0	0.28	79.5	55.5	0	0.22				
25	88	61	0	0.34	78.5	54.5	0.415	0.14				
26	89.5	54.5	0	0.33	69	43.5	0.03	0.21				
27	81	49	0	0.30	74	46.5	0	0.16				
28	85.5	51.5	0	0.40	82.5	56	0	0.24				
29	93	53	0	0.37	85	56	0	0.25				
30	83.5	59	0	0.27	90.5	54	0	0.23				
31	77	45	0	0.25	90.5	57	0	0.28				
	79.9	51.7	0.875	7.63	76.4	53.1	1.885	5.79	77.0	50.1	1.17	3.78

* Data collected at one location only

Total precipitation April 1, 1976 - September 20, 1976 = 7.38 in.

Appendix Table 66. Canada thistle data for rhizome translocation study.

Container No.	Height of Tallest Plant (cm)	Plants Per Can	Rhizome Size
101	5	2	Sm
102	8	2	Sm
103	9	2	Sm
104	11	3	Sm
105	13	2	Sm
201	15	3	M
202	9	3	M
203	11	3	M
204	16	3	M
205	12	3	M
301	16	2	M
302	10	2	M
303	16	2	M
304	11	3	M
305	15	2	M
401	15	2	M
402	13	2	M
403	11	2	M
404	12	2	M
405	13	2	M
501	10	3	M
502	9	4	M
503	12	3	M
504	9	4	M
505	15	3	M
601	14	3	M
602	9	3	M
603	16	3	M
604	9	4	M
605	14	3	M

Appendix Table 67. Greenhouse herbicide application data - Translocation study

Date: June 15, 1976

Rate: (lb a.e./A) - 0.016, 0.031, 0.063, 0.125, 0.00

Nozzle Tip: 8001-E

Psi: 28

Gal/A: 25

Relative Humidity: 66%

Air Temperature: 78° F

Sprayer: Single-nozzle tracked greenhouse

Appendix Table 68. Weights and percentages of total plants, treated plants, and connected (protected) plants

Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg
	% Treated Shoot Weight is of Total Plant Weight						
0.016	37	63	57	57	30	48	48.7
0.031	32	43	35	33	21	38	33.7
0.063	16	27	30	28	31	54	31.0
0.125	69	8	37	20	30	21	30.8
Check	51	57	45	67	50	30	50.0
Fresh wt. of tagged plants -- Wt. in grams -- September 18, 1976							
0.016	11.0	22.9	20.8	23.6	12.0	19.5	18.3
0.031	9.6	15.9	15.4	16.4	7.7	12.0	12.8
0.063	4.5	9.7	9.8	11.1	7.7	17.2	10.0
0.125	12.3	3.1	13.3	5.7	10.1	10.7	9.2
Check	19.5	20.4	17.8	20.3	19.5	14.0	18.6
Total fresh weight -- wt. in grams							
0.016	29.8	36.6	36.2	41.7	39.5	40.9	37.5
0.031	29.9	37.3	44.4	49.0	36.9	32.0	38.3
0.063	28.0	35.5	32.4	39.1	24.7	32.1	32.0
0.125	17.8	39.0	35.5	28.5	33.7	37.8	32.1
Check	37.9	35.5	39.9	30.1	39.1	46.9	38.2
Total fresh wt. as a % of Check							
0.016	78.6	103.1	90.7	138.5	101.0	87.2	99.9
0.031	78.9	105.0	111.3	162.8	94.4	68.2	103.5
0.063	73.9	100	81.2	129.9	63.1	68.4	86.1
0.125	47.0	109.9	89.0	94.7	86.2	80.6	84.6
Check	100	100	100	100	100	100	100

Appendix Table 69. Visual ratings of flowers*

Rate lb a.e./A	R1	R2	R3	R4	R5	R6	Avg**
Treated Shoots							
0.016	B	F	F	F	F	F	F
0.031	N	B	B	B	N	B	B
0.063	N	N	B	B	N	B	BN
0.125	N	N	B	N	N	B	N
Check	F	F	F	F	F	F	F
Untreated Shoots							
0.016	F	F	F	F	F	F	F
0.031	F	F	F	F	F	F	F
0.063	F	F	F	F	F	B	F
0.125	N	B	B	B	B	F	B
Check	F	N	F	N	F	F	F

* N = No flowers; B = Bud but no flowers; F = Flowers

** Four or more of one mark used to indicate average

Appendix Table 70. Regrowth study - Root response to tetrazolium

Time	R1	R2	R3	R4	R5	R6
1 hour	-	-	-	-	-	-
4 hours	-	-	-	-	-	-
8 hours	-	-	-	-	+	-
16 hours	-	-	-	-	-	-
32 hours	-	-	-	-	-	-
64 hours	-	-	-	-	-	-
128 hours	-	-	-	-	-	-
Clipped check	+	+	+	+	+	+
Unclipped check	+	+	+	+	+	+

+ = Live tissue detected

- = No live tissue detected

Appendix Table 71. Sensitivity study - Origin, height, and growth stage of Canada thistles when treated with Dowco 290

Can Number	Rate lb a.e./A	Height (inches)	Root Size	Inflorescence
101	0.125	8	Seed	Tight bud
102	0.5	5.5	Seed	Pre-bud
103	Check	10	Seed	Tight bud
104	0.063	5.25	Seed	Pre-bud
105	0.25	7	Seed	Bud
106	0.031	8	Seed	Tight bud
107	0.125	13.75	Small	Bud
108	0.5	17	Small	Loose, lax bud
109	Check	14	Small	Bud
110	0.063	13	Short	Bud
111	0.25	12	Small	Bud
112	0.031	12.5	Small	Bud
201	0.063	3.5	Seed	Pre-bud
202	0.125	4	Seed	Pre-bud
203	0.031	2	Seed	Pre-bud
204	0.25	4.75	Seed	Bud
205	0.5	7.75	Seed	Pre-bud
206	Check	8.5	Seed	Pre-bud
207	0.063	14.5	Large	Lax bud
208	0.125	12	Large	Bud
209	0.031	15.5	Large	Bud
210	0.25	13	Large	Bud
211	0.5	8	Large	Tight bud
212	Check	14.5	Large	Bud
301	0.031	2	Seed	Tight bud
302	0.125	1.25	Seed	Pre-bud
303	0.063	3.75	Seed	Pre-bud
304	Check	3.5	Seed	Pre-bud
305	0.5	2.5	Seed	Pre-bud
306	0.25	1.5	Seed	Pre-bud
307	0.031	10	Small	Bud
308	0.125	6.5	Small	Pre-bud
309	0.063	8	Small	Bud
310	Check	9	Small	Bud
311	0.5	8.5	Small	Tight bud
312	0.25	8.5	Small	Tight bud

Appendix Table 71 (continued)

Can Number	Rate lb a.e./A	Height (inches)	Root Size	Inflorescence
401	0.063	6	Seed	Pre-bud
402	0.25	3.75	Seed	Pre-bud
403	0.031	5.75	Seed	Tight bud
404	0.5	3.0	Seed	Pre-bud
405	Check	4.5	Seed	Pre-bud
406	0.125	5.5	Seed	Bud
407	0.063	9.5	Small	Bud
408	0.25	14	Small	Tight bud
409	0.031	14.5	Small	Bud
410	0.5	14	Small	Bud
411	Check	10	Small	Bud
412	0.125	16.5	Small	Lax bud
501	0.5	6	Seed	Pre-bud
502	0.063	4.5	Seed	Pre-bud
503	0.25	5.5	Seed	Pre-bud
504	Check	5	Seed	Pre-bud
505	0.125	4	Seed	Pre-bud
506	0.031	3.5	Seed	Pre-bud
507	0.5	12.5	Medium	Bud
508	0.063	12.5	Medium	Bud
509	0.25	14	Medium	Lax bud
510	Check	12.5	Medium	Bud
511	0.125	11.5	Medium	Bud
512	0.031	13	Medium	Bud
601	0.25	5.5	Seed	Pre-bud
602	Check	5	Seed	Pre-bud
603	0.031	6	Seed	Pre-bud
604	0.125	6.75	Seed	Pre-bud
605	0.063	8	Seed	Tight bud
606	0.5	8.75	Seed	Tight bud
607	0.25	7.5	Small	Pre-bud
608	Check	5	Small	Pre-bud
609	0.031	10	Small	Bud
610	0.125	7	Short	Pre-bud
611	0.063	6	Small	Pre-bud
612	0.5	7	Short	Tight bud

Appendix Table 72. Sensitivity study -- Necrotic tissue as a percentage of total plant tissue

Rate	Rootstock							Seedlings						
lb a.e/A	R1	R2	R3	R4	R5	R6	Avg	R1	R2	R3	R4	R5	R6	Avg
July 10, 1976														
0.031	0	0	0	0	0	0	0	5	0	0	0	0	0	0.8
0.063	0	0	0	5	0	10	2.5	5	10	20	5	0	10	8.3
0.125	5	5	10	5	15	0	6.7	15	5	40	15	10	5	15.0
0.25	5	10	9	9	10	5	5.0	15	15	60	40	35	15	30.0
0.5	15	5	15	0	15	15	10.8	10	5	55	10	5	80	27.5
Check	0	0	5	0	0	0	0.8	0	0	0	0	0	0	0
July 12, 1976														
0.031	0	0	0	0	0	0	0	0	0	5	0	5	0	1.7
0.063	0	0	0	5	0	0	0.8	0	0	5	5	5	0	2.5
0.125	5	5	0	5	10	0	4.2	10	5	15	0	5	0	5.8
0.25	0	5	0	0	5	5	2.5	0	5	25	15	25	5	12.5
0.5	10	0	10	0	0	0	3.3	5	0	20	10	5	80	20.0
Check	0	0	0	0	0	0	0	0	0	0	0	5	0	0.8
July 14, 1976														
0.031	0	0	0	0	0	0	0	0	0	10	0	0	0	1.7
0.063	15	0	0	10	0	20	7.5	0	0	25	10	0	10	7.5
0.125	5	5	0	15	15	0	6.7	15	0	40	30	5	0	15.0
0.25	5	20	0	0	10	5	6.7	10	5	50	5	25	10	17.5
0.5	25	5	5	0	15	15	10.8	5	5	40	5	5	85	24.2
Check	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July 16, 1976														
0.031	0	0	0	0	0	0	0	0	0	5	0	0	0	0.8
0.063	5	0	0	5	0	0	1.7	0	5	20	0	0	15	6.7
0.125	10	10	0	15	15	5	9.2	20	10	30	5	5	0	11.7
0.25	0	15	0	5	25	5	8.3	10	0	35	10	15	5	12.5
0.5	30	5	15	5	5	35	15.8	20	5	40	5	0	85	25.8
Check	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July 18, 1976														
0.031	0	5	0	0	5	5	2.5	0	0	5	5	0	0	1.7
0.063	15	0	0	10	5	15	7.5	5	0	20	5	15	15	10.0
0.125	5	15	0	20	30	20	15.0	30	0	40	5	10	0	14.2
0.25	5	15	15	5	20	10	11.7	20	0	20	10	30	5	14.2
0.5	40	20	15	15	15	40	24.2	35	10	65	15	10	80	35.8
Check	0	0	0	0	0	5	0.8	0	0	0	0	0	0	0

Appendix Table 72 (continued)

Rate lb a.e./A	Rootstock R1	R2	R3	R4	R5	R6	Avg	Seedlings R1	R2	R3	R4	R5	R6	Avg
July 20, 1976														
0.031	0	25	0	0	0	0	4.2	0	0	15	10	5	5	5.8
0.063	15	5	0	15	5	40	15.0	5	5	10	5	5	15	7.5
0.125	10	25	0	40	20	30	20.8	25	10	40	10	15	5	17.5
0.25	10	40	20	10	45	0	20.8	20	5	30	30	45	15	24.2
0.5	45	45	25	15	20	50	33.3	15	5	60	30	10	90	32.5
Check	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July 22, 1976														
0.031	0	15	5	0	0	0	3.3	0	0	20	5	5	5	5.8
0.063	30	5	0	15	0	20	11.7	5	5	15	5	10	5	7.5
0.125	30	30	0	25	40	25	25.0	30	15	65	5	20	5	23.3
0.25	10	50	15	10	55	20	26.7	15	10	50	20	60	10	27.5
0.5	55	40	35	20	40	40	38.3	25	5	85	10	15	90	38.3
Check	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July 24, 1976														
0.031	5	20	5	0	5	10	7.5	0	0	15	5	10	5	5.8
0.063	20	5	5	15	40	25	18.3	10	15	35	10	25	10	17.5
0.125	25	25	0	30	45	25	25.0	25	20	80	15	20	5	24.2
0.25	15	35	10	5	65	30	26.7	35	20	60	15	65	30	37.5
0.5	50	25	20	20	50	35	33.3	20	20	90	30	30	85	45.8
Check	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July 26, 1976														
0.031	5	5	5	5	5	5	5.0	10	5	20	10	10	10	10.8
0.063	25	15	5	15	5	10	12.5	10	15	35	30	25	15	21.7
0.125	10	30	0	35	40	25	23.3	20	20	80	20	35	10	30.8
0.25	15	40	25	10	50	15	25.8	45	35	45	35	75	35	45.0
0.5	35	45	35	25	60	40	40.0	30	15	100	40	25	90	50.0
Check	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
July 28, 1976														
0.031	15	35	5	0	5	15	12.5	0	5	15	10	15	10	9.2
0.063	30	15	5	40	15	30	22.5	10	15	20	30	40	20	22.5
0.125	20	30	0	20	40	35	24.2	30	25	80	15	35	15	33.3
0.25	30	40	35	25	60	10	33.3	45	30	45	35	75	30	43.3
0.5	45	45	25	20	50	40	37.5	30	25	100	65	50	90	60.0
Check	0	10	0	5	5	0	3.3	5	0	0	0	0	0	0.8

Appendix Table 72 (continued)

Rate lb a.e./A	Rootstock R1	R2	R3	R4	R5	R6	Avg	Seedlings R1	R2	R3	R4	R5	R6	Avg
July 30, 1976														
0.031	10	20	15	10	15	30	16.7	10	5	10	15	15	15	11.7
0.063	40	15	10	40	15	50	28.3	15	15	15	30	20	20	19.2
0.125	40	35	10	35	75	45	40.0	30	30	80	20	30	20	35.0
0.25	35	40	35	25	75	25	39.2	25	40	60	65	75	50	52.5
0.5	75	55	40	30	70	40	51.7	25	45	100	75	50	90	64.2
Check	0	5	5	0	5	5	3.3	0	0	0	0	5	0	0.8
August 1, 1976														
0.031	10	30	20	20	20	45	24.2	10	0	30	20	15	15	15.0
0.063	40	15	10	40	40	55	33.3	20	35	10	30	25	40	26.7
0.125	40	50	15	70	40	60	45.8	35	55	100	20	30	35	45.8
0.25	30	80	60	25	70	15	46.7	55	50	70	40	75	50	56.7
0.5	70	75	65	40	85	45	63.3	40	55	100	95	60	90	73.3
Check	0	10	5	5	10	5	5.8	5	0	0	0	0	0	0.8
August 3, 1976														
0.031	15	25	15	15	10	35	19.2	10	5	25	15	15	20	15.0
0.063	25	30	20	30	30	40	29.2	15	30	15	25	20	15	20.0
0.125	30	45	15	40	10	50	31.7	40	35	100	20	35	30	43.3
0.25	20	45	60	25	75	10	39.2	70	45	50	40	75	50	55.0
0.5	55	60	55	45	85	35	55.8	35	35	100	100	45	95	68.3
Check	10	10	5	5	5	5	6.7	0	0	0	0	10	5	2.5
August 5, 1976														
0.031	15	20	10	15	10	30	16.7	25	5	30	15	15	25	19.2
0.063	25	20	20	25	40	40	28.3	20	35	45	25	40	20	30.8
0.125	35	40	20	55	45	65	43.3	30	50	100	25	30	40	45.8
0.25	30	55	50	20	75	45	45.8	55	50	55	45	75	60	56.7
0.5	55	60	60	40	85	50	58.3	45	45	100	100	80	95	77.5
Check	5	10	5	5	10	5	6.7	5	0	5	5	5	5	4.2
August 7, 1976														
0.031	15	15	10	5	15	30	15.0	15	5	25	10	10	25	15.0
0.063	30	25	5	25	10	40	22.5	20	45	65	25	30	20	34.2
0.125	45	40	15	45	35	60	40.0	40	55	100	15	25	35	45.0
0.25	35	45	45	20	85	10	40.0	65	70	85	65	80	50	69.2
0.5	60	75	60	45	90	35	60.8	50	75	100	100	65	95	80.8
Check	5	15	10	5	5	5	7.5	5	5	5	5	5	5	5.0

Appendix Table 72 (continued)

Rate	Rootstock							Seedlings						
lb a.e./A	R1	R2	R3	R4	R5	R6	Avg	R1	R2	R3	R4	R5	R6	Avg
August 9, 1976														
0.031	15	20	20	15	10	55	22.5	15	10	10	20	10	25	15.0
0.063	20	20	10	30	30	45	25.8	20	45	75	20	25	35	36.7
0.125	30	30	15	25	45	90	39.2	40	40	100	30	30	65	50.8
0.25	40	45	45	15	75	20	40.0	80	85	50	40	90	75	70.0
0.5	70	75	60	35	85	50	62.5	35	95	100	100	85	95	85.0
Check	10	10	5	5	5	5	6.7	5	5	5	5	5	5	5.0
August 11, 1976														
0.031	15	25	10	15	15	35	19.2	5	5	25	10	10	25	13.3
0.063	15	20	10	25	20	25	19.2	20	35	70	15	25	30	32.5
0.125	25	30	15	25	20	70	30.8	30	30	100	25	15	40	40.0
0.25	40	35	40	25	35	15	31.7	55	90	65	50	50	55	60.8
0.5	35	45	40	25	85	30	43.3	30	100	100	100	85	85	83.3
Check	5	10	10	10	10	10	9.2	10	5	5	15	10	15	10.0
August 13, 1976														
0.031	10	30	20	10	30	55	25.8	20	10	15	15	15	25	16.7
0.063	20	25	15	30	20	35	24.2	30	80	90	20	55	30	50.8
0.125	35	35	25	25	25	80	37.5	40	55	100	40	35	35	50.8
0.25	30	45	45	25	40	25	35.0	65	95	85	60	70	70	70.8
0.5	45	55	45	40	90	25	50.0	45	100	100	100	85	90	86.7
Check	10	15	15	10	15	15	13.3	15	10	15	10	10	5	10.8

Appendix Table 73. Sensitivity study -- Seedlings vs. rootstock, fresh weights

Rate lb a.e./A	Fresh Weight (grams) Rootstock - August 18, 1976							Seedlings - August 19, 1976						
	R1	R2	R3	R4	R5	R6	Avg	R1	R2	R3	R4	R5	R6	Avg
0.031	32.6	39.1	33.3	44.2	29.8	26.9	34.3	30.3	25.4	3.1	26.5	19.5	23.9	21.5
0.063	16.1	35.2	27.4	18.2	36.5	9.9	23.9	25.3	13.1	3.5	28.3	12.3	20.7	17.2
0.125	12.5	21.3	31.1	23.7	14.8	13.5	19.5	19.5	10.2	0.2	12.3	15.2	23.0	13.4
0.25	34.0	32.6	33.0	32.5	17.8	9.6	26.6	16.8	4.7	1.0	6.3	5.4	9.6	7.3
0.5	16.5	35.5	23.1	25.0	21.3	9.9	21.9	17.1	6.1	0.8	2.3	4.5	7.3	6.4
Check	29.3	47.6	33.7	40.2	40.1	17.6	34.8	29.2	37.1	12.1	22.4	31.7	47.9	30.1

Rate lb a.e./A	Regrowth Fresh Weight (grams) Rootstock - September 15, 1976							Seedlings - September 15, 1976						
	R1	R2	R3	R4	R5	R6	Avg	R1	R2	R3	R4	R5	R6	Avg
0.031	5.7	8.7	6.3	7.0	9.7	5.3	7.12	5.1	8.8	1.1	1.2	7.0	9.2	6.40
0.063	9.8	7.1	6.3	5.1	6.7	3.3	6.38	3.5	4.6	0.0	8.2	9.7	6.0	5.33
0.125	1.4	2.4	5.4	1.2	1.0	0.0	2.05	1.5	3.4	0.0	7.4	3.6	0.0	2.65
0.25	0.0	0.0	1.8	2.1	0.0	1.3	0.87	0.0	0.0	0.0	0.0	0.0	0.0	0.00
0.5	4.1	0.0	0.0	0.0	0.0	0.0	0.68	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Check	4.8	5.5	4.7	6.1	7.5	4.4	5.50	5.8	4.6	3.9	4.8	5.9	8.2	5.53