INSTRUCTION MANUAL FOR INTEGRATED PEST MANAGEMENT IN ONIONS AND CARROTS

D. J. Madder

and

F. L. McEwen

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TABLE OF CONTENTS

PAGE

GENERAL INTRODUCTION

The primary aim of a pest management program is to protect crops from significant damage with a minimum use of pesticide. This is accomplished through the use of cultural and biological control methods augmented by pesticide treatments. When an economic threshold has been exceeded, pesticide treatments are timed to maximize their efficiency. This results in benefits to the grower of reductions in labor, fuel and pesticide costs. The program also results in a significant reduction in environmental contamination with pesticides and a reduction in pesticide residues in produce. A further advantage to both growers and consumers is an increase in the time a pesticide can be used before resistance to the pesticide develops.

This manual describes the techniques used in the integrated pest management program in onions and carrots in the Bradford, Ontario region. This includes the Holland, Bradford, Colbar, Keswick and Cookstown Marshes (Figs. I-V). A monthly schedule for the pest management program is included in Table I. Fact-sheets concerning related topics are included at the back of the manual.

INTEGRATED PEST MANAGEMENT IN ONIONS

INTRODUCTION

The primary pests of onions in the Bradford region are the onion maggot (*Delia antiqua*), onion leaf blight (*Botrytis squamosa*), and onion smut (*Urocystis magica*). Pests which occasionally cause significant damage are cutworms (Noctuidae), thrips (*Thrips tabaci*), and downy mildew (*Peronospora destructor*). The severity of damage caused primarily by the onion maggot and leaf blight has led to intensive insecticide and fungicide use by growers. Often treatments are applied after damage is present or are used on an insurance basis. The onion pest management program is designed to determine if insecticide or fungicide treatments are required, and to time the treatments to maximize their effect. Cultural control techniques are also used for both insect and disease control.

INSECTS

The onion maggot overwinters as a pupa in the top 15 cm of the soil and has three generations per year. They are present in all onion fields in the area and would result in a 50 to 70 % crop loss if control methods are not used. The cultural control methods recommended to control this pest include crop rotation, removal of cull piles and all cull onions from fields after harvest. The chemical methods used are the application of granular insecticides in the seed furrow to control larvae, and foliar treatments for control of the adult flies. If the granular insecticides used at seeding are applied properly, they will provide control of the onion maggot until the onions are placed in windrows.

Treatments against the adults are recommended if the granular insecticide does not provide adequate control or if flies are in the fields after the onions have been windrowed. These adult treatments are timed on the basis of day-degree accumulations and peaks in fly activity in each field. A detailed description of the life cycle of the onion maggot is included in Appendix I.

Other potential insect problems include thrips and cutworms. Thrips only become a significant pest under very hot, dry conditions. Cutworms can cause significant damage especially when onions are grown after carrots. The dense foliage of the carrot crop provides an excellent oviposition site for those cutworm species that overwinter in the egg stage (eg. red-backed cutworm).

DISEASES

The primary disease that causes economic losses in onions in this area is leaf blight (Botrytis squamosa). This disease usually develops after mid-June when temperatures and leaf-wetness periods are sufficient to allow infection to occur. The pathogen which causes this disease overwinters as sclerotia in the soil and occurs in every onion field in the area. Downy mildew (Peronospora destructor) is usually not a major problem if dithiocarbamate fungicides are used on a preventative basis. Downy mildew overwinters in onions that are infected in the previous year and left in the field as culls or seconds. Therefore, it is more likely to develop in fields with a former history of the disease. Smut overwinters in the soil and is present in all fields in the area and attacks germinating onions. The only practical means of control is the use of seed treatments or fungicides in the seed furrow.

It is not possible to include this disease in the pest management program due to the means of control that are presently available. Cultural control techniques recommended for the reduction of downy mildew and smut include crop rotation and removal of cull onions from all fields after harvest. A detailed discussion of disease pests of onions is included in Appendix II and III. A discussion of seed treatments for the control of smut is included in Appendix IV.

MATERIALS AND METHODS

ONION MAGGOT

Residue Information

Soil samples are taken from each onion field soon after planting to determine if the granular insecticide applied at seeding is present in sufficient quantity to control the onion maggot. Fifty samples are taken from each field of 8 ha or less with a 10 cm diameter soil corer. Each sample is taken in the seed furrow to a depth of 10 cm. The 50 samples are mixed in a pail and a composite sample of approximately 1 kg placed into a labelled plastic bag. Fields larger than 8 ha are sampled on the basis of one composite sample (i.e. 50 cores) per 8 ha. The samples are transported to the Provincial Pesticide Testing Laboratory at the University for analysis. Samples are taken as early as possible, usually during the first two weeks of May.

Crop Damage

Crop damage is assessed in each field using plots containing 100 onions. Each plot consists of either four double or single rows with 25 plants per row. Wooden stakes (25 cm X 5 cm) are placed in each row to denote the 100 onions in the plot. A red flag attached to a 1-m flexible rod is placed at each plot so that they can be found after the crop has grown. Ten plots are placed randomly in the field. All damage plots are examined after the first and second generations to determine the number of plants damaged by onion maggots. After the second generation the damage plots are removed. Damage to the crop at harvest, i.e. late second-and early third-generation damage, is assessed when the onions are in windrows immediately prior to harvest. Ten samples of 100 onions each are examined for damage. The samples are taken near where the damage plots are located.

Day-Degree Model

The day-degree model used to predict emergence of the three generations is based on Liu et al. 1982. Air and soil temperatures and day-degree accumulations are monitored at the K1 site (Fig. IV) in the Keswick Marsh and at the Muck Crops Research Station (Fig. I) in the Holland Marsh. Laboratory experiments have determined that 4°C can be used as the development threshold for all stages of the onion maggot. Based on this threshold, the development of the overwintered pupa to the adult requires 210 day-degrees, while the full life cycle requires 746 day-degrees. First-generation adults are expected to emerge at approximately 210 day-degrees, second-generation adults at 1025 day-degrees and third-generation adults at 1772 day-degrees. This model provides one means by which growers can be warned several days in advance of expected peaks in the populations of adult flies.

Population Monitoring

The day-degree model predicts when population peaks can be expected; however, in order to determine when peaks occur in individual onion fields, populations of adult flies are monitored using sticky traps. These traps are placed in the onion fields as early as possible after seeding, i.e. early May, and checked throughout the summer until the crop is windrowed. Each trap consists of three wooden stakes (2.5X5.0X121 cm) placed in a row with 0.3 m between stakes. One-litre milk cartons are painted yellow, coated with Tangletrap and placed into a notch on each stake. The cartons are kept just above the onion canopy to maintain trapping efficiency. The cartons are replaced at 10-to 15-day intervals or more frequently if they become covered with dust or large numbers of insects. The longevity of the traps can be extended if extraneous material is removed with a knife or small stick.

The number of traps per field is dependent on field size. Fields of up to 4 ha have 4 traps, 1 on each edge of the field. Fields of 4 to 8 ha have 6 traps, 1 on each of the short sides and 2 on each of the longer sides. Fields larger than 8 ha have 8 traps, 2 per side. Each trap is randomly positioned along the side of the field. Sticky traps are examined 2 or 3 times each week throughout the growing season. Traps are checked at approximately the same time each day to prevent errors in fly counts caused by periodicity of flight activity. When the traps are checked the flies are counted and removed with a scraper.

Treatment Decisions-Onion Maggot

A schematic diagram of the treatment decision process for the control of the onion maggot is shown in Fig. VI. All growers apply a granular insecticide at seeding. If the granular insecticide is applied properly, first-generation damage is negligible. In addition, damage from the first generation, occurring as killed seedlings, is compensated for by more rapid growth of adjacent onions. In addition, seedlings killed at this time disintegrate and thus do not cause spoilage in storage. Due to the above factors, treatments against the adults of the first generation are rarely recommended. However, if insecticide residues are less than 5 ppm, treatments are recommended as significant damage may occur. The timing of these treatments is based on the day-degree model and the number of flies caught on sticky traps in each grower's field.

The treatment decisions for control of the second generation are based on the insecticide residue data, and damage caused by the first generation. If insecticide residues are less than 15 ppm, applications against the second generation are usually recommended. Also if crop damage from the first generation exceeds 2 %, foliar treatments are recommended against the second generation. This amount of damage indicates that the granular insecticide is not providing adequate protection. If significant damage is present in the field which is not evident in the damage plots, treatments are also recommended. These treatments are timed by the day-degree model and the sticky-trap catches. Damage resulting from the second generation seldom kills the plants and damaged onions will be harvested and placed in storage where they may cause additional spoilage.

Treatments against the third generation are based upon initial insecticide residues and damage caused by the previous generations. Treatments are recommended if total damage during the second generation exceeds 1 % or if residues are less than 15 ppm. During the start of emergence of the third generation the onions are windrowed so that they will dry. This results in the loss of protection afforded by the granular insecticide and adulticides must be recommended even if only small numbers of flies are present in the fields. Before the onions are windrowed, treatments are recommended according to the day-degree model and sticky trap catches, thereafter an adulticide treatment is recommended immediately after windrowing. If the onions are left in the fields for more than a week to dry then a second treatment is recommended. Treatments are not recommended in the windrow if the onions are being sold directly off the field and not being stored. This procedure respects the 10-15 day pre-harvest interval required for the insecticides.

THRIPS AND CUTWORMS

Damage due to cutworms is assessed while walking through the field to the sticky traps and damage plots. Thrip damage is similarly assessed and the relative number of thrips caught on the sticky traps noted in qualitative observations. Treatment for either of these pests is recommended on a qualitative basis as economic thresholds have not been established.

LEAF BLIGHT AND DOWNY MILDEW

In order to determine when leaf wetness periods and temperatures are sufficient to allow infection by leaf blight, these parameters are monitored at the Muck Crop Research Station. This provides information to determine when infection has occurred so that monitoring for this disease can be intensified. The onion leaves in each field are examined whenever sticky traps are checked, i.e. 2 or 3 times per week and more often after infection periods. Leaf blight is characterized by white spots (most of which are surrounded by a white halo) on the onion leaves. These lesions have a diameter of <1 to 5 mm.

Downy mildew develops in very localized areas. It is characterized by a violet or greyish downy growth over the infected leaves. The infected tissues die quickly resulting in a mass of straw-colored leaves. Due to its initiation in very small areas of the field, normal scouting does not usually discover the infection until a massive outbreak occurrs. To avoid such outbreaks, a preventative control program using dithiocarbamate fungicides must be used.

Treatment Decisions-Leaf Blight and Downy Mildew

The recommendation for the initiation of fungicide treatments is based on the economic threshold level of 1 leaf-blight-lesion per leaf. If fungicide applications are initiated at this time the epidemic will not normally attain economically significant levels. If the first treatments applied are dithiocarbamate fungicides and these are mixed or alternated with other fungicide groups, both leaf blight and downy mildew will be controlled. After initiation, fields are usually treated on a 10-14 day schedule, however as the epidemic progresses this interval is shortened. If the epidemic is not severe, applications are recommended only prior to rain if the field has not been treated in 7 to 10 days.

DOCUMENTATION

The records used in the onion pest management program are: 1. Crop history; 2. Onion maggot fly abundance; 3. Spray record; 4. Recommendations and comments; 5. Onion maggot damage. These are included in Appendix VIII.

INTEGRATED PEST MANAGEMENT IN CARROTS

INTRODUCTION

The primary pests of carrots in the Bradford area are the carrot rust fly (Psila rosae), carrot weevil (Listronotus oregonensis) and blight caused by either Cercospora carotae or Alternaria dauci. The aster leafhopper (Macrosteles fascifrons) has occasionally caused damage in carrots due to its ability to transmit the pathogen of aster yellows. Due to the significant damage caused by these pests, carrot growers apply large amounts of pesticide for their control. As mentioned in the onion program these treatments are often not necessary or poorly timed. The techniques described here are designed to maximize the efficiency of pesticide use.

INSECTS

The carrot rust fly overwinters as a pupa in the soil and usually has two generations per year. About once every ten years sufficient heat-units are accumulated so that a third generation emerges in late September and October. This third generation occurs too late in the season to have any serious affect on the carrot crop. Therefore, control efforts are focussed upon the first and second generations. A granular insecticide is applied at seeding in fields with a previous history of carrot rust fly damage. This should provide adequate control of the first generation. However, foliar treatments for control of the adults are recommended against both the first and second generations as the granular insecticide does not provide consistent control. Cultural control techniques which are recommended include crop rotation, late seeding to avoid the first generation and avoidance of growing carrots in sheltered areas.

The carrot weevil overwinters as an adult and has one generation per year. Oviposition by the adult occurs from May through early July. Chemical control methods focus on treatments against the adults prior to the commencement of oviposition. Cultural control methods include crop rotation and weed control around the edges of the fields. A full description of the life cycles of these insects is included in Appendix V.

DISEASES

Alternaria dauci causes irregular brown spots (often surrounded by yellowish halo-like zones) on the carrot leaves. *Cercospora carotae* causes circular gray or brown lesions on leaves and petioles. These diseases overwinter in the crop residue of infected carrots and their spores are distributed by wind. Disease control is based on the use of fungicides after the diseases have reached an economic threshold level. Cultural control methods recommended include crop rotation and the seeding of resistant varieties. A full description of these pathogens is included in Appendix VI and VII.

MATERIALS AND METHODS

INSECTS

Day-Degree Model

The day-degree model used to predict the emergence of the carrot rust fly is that developed by Stevenson (1981). Air and soil temperatures and day-degree accumulations above the threshold of 3 °C are monitored at the Muck Crop Research Station in the Holland Marsh. The predictions from the day-degree model are used to warn the growers when treatments might be necessary.

Poulation Monitoring

Adult carrot rust flies are monitored using sticky traps to determine when emergence and adult activity occurs in individual carrot fields. The traps are made of stiff cardboard (Bristol board), painted yellow and coated with Tangletrap. They are attached with Bulldog clips to the top of 1-m metal rods which are pushed into the soil. Five traps are placed parallel to and 2 m from the edge of the field with 2 m between adjacent traps. The bottom of the traps are kept at the top of the carrot canopy to maintain trapping efficiency. The traps are examined three times each week and the carrot rust flies caught are counted and removed. The traps are replaced at approximately 10-14 day intervals or more often if they became dusty or covered with insects. The traps are located in the most sheltered section of the field as the rust flies are very poor fliers and are most likely to be found in these areas.

The presence of carrot weevils in fields is detected by placing pieces of carrot root (2 cm diameter X 2 cm length) along the edge of carrot fields. The carrot pieces are placed in the fields after seeding but before the carrots have emerged. Thus the carrot pieces are the only oviposition sites available for the weevils. The pieces of carrot are checked for oviposition activity at two-day intervals and replaced when necessary with fresh carrots. Each field is checked for approximately two weeks after seeding for the presence of oviposition activity. This procedure is necessary in all carrot fields, even those with no previous history of damage. The carrot weevil, despite its inability to fly, is very mobile.

Treatment Decisions-Insects

The application of granular insecticides for the control of carrot rust flies is recommended in areas where previous damage has been significant. Treatments for control of the adults are recommended if populations reach a level of 1 fly/trap/day. This threshold is used for both growers who had applied a granular insecticide and those who had not. This is due to the inconsistent control provided by the granular insecticides.

Treatments against carrot weevils are recommended if oviposition activity is found in more than one carrot piece.

DISEASES

The diseases in carrots are monitored when carrot rust fly traps are checked, i.e. three times per week. Treatments are recommended when the incidence of disease attains a 2 % infection level. This is determined by sampling 50 leaves from the middle of the canopy while walking a transect across the field. If more than 25 % of these leaves show lesions, treatments are recommended. The use of this threshold is described in Appendix VII. Initiation of fungicide treatments at this infection level will usually keep the epidemic below economically significant levels. Once initiated treatments are recommended on a 7-to 10-day schedule. If the epidemic becomes severe this interval is decreased. Treatments are recommended if rain is predicted and the fields have not been treated within 10 days.

DOCUMENTATION

The records used for the carrot pest management program are: 1. Crop history; 2. Carrot rust fly abundance; 3. Spray record; 4. Recommendations and comments. These are included in Appendix VIII.

REFERENCES

Liu, H. J., F. L. McEwen and G. Ritcey. 1982. Forecasting events in the life cycle of the onion maggot, Hylemya antiqua (Diptera:Anthomyiidae): application to control schemes. Environ. Entomol. 11:751-755.

Stevenson, A. B. 1981. Development of the carrot rust fly, Psila rosae (Diptera:Psilidae), relative to temperature in the laboratory. Can. Entomol. 113:569-574.

TABLE 1. Schedule for integrated pest management program in onions and carrots in the Bradford region.

Month	Week(s)	Supervisor/Scout Activity	Crop/Grower Activity
March	1	Install day-degree integrators and thermal probes. Take inventory, develop budget, order supplies.	Planning crops, ordering supplies, maintenance of machinery etc.
April	1&2	Hire scouts. Copy all required forms. Rent vehicles.	Land preparation for onions and some carrots and lettuce (plough, disc, fertilize and level).
	3&4	Paint milk cartons and bristol board. Supplies delivered to MRS and trailer. Prepare trailer and living accommodation.	Seeding of onions and some carrots and lettuce (Nibex, Planet Jr., and Stan Hay seeders). Granular insecticides applied at seeding for onion maggot and some carrot rust fly control. Fungicide applied for smut control.
May	1	Scouts start work. Scout orientation. Scouts introduced to growers.	Carrots and lettuce continue to be seeded through May and early June. Germination of onions and carrots. Onions pass crook and flag stages by end of month. Carrots pass rabbit ear stage.
	2-4	Residue soil samples taken. Onion maggot and carrot rust fly traps set out. Carrot weevil monitoring starts after carrots planted, before crop emergence. Monitoring program for insects in full operation during week 4. Onion maggot flies and carrot rust flies expected in week 4.	

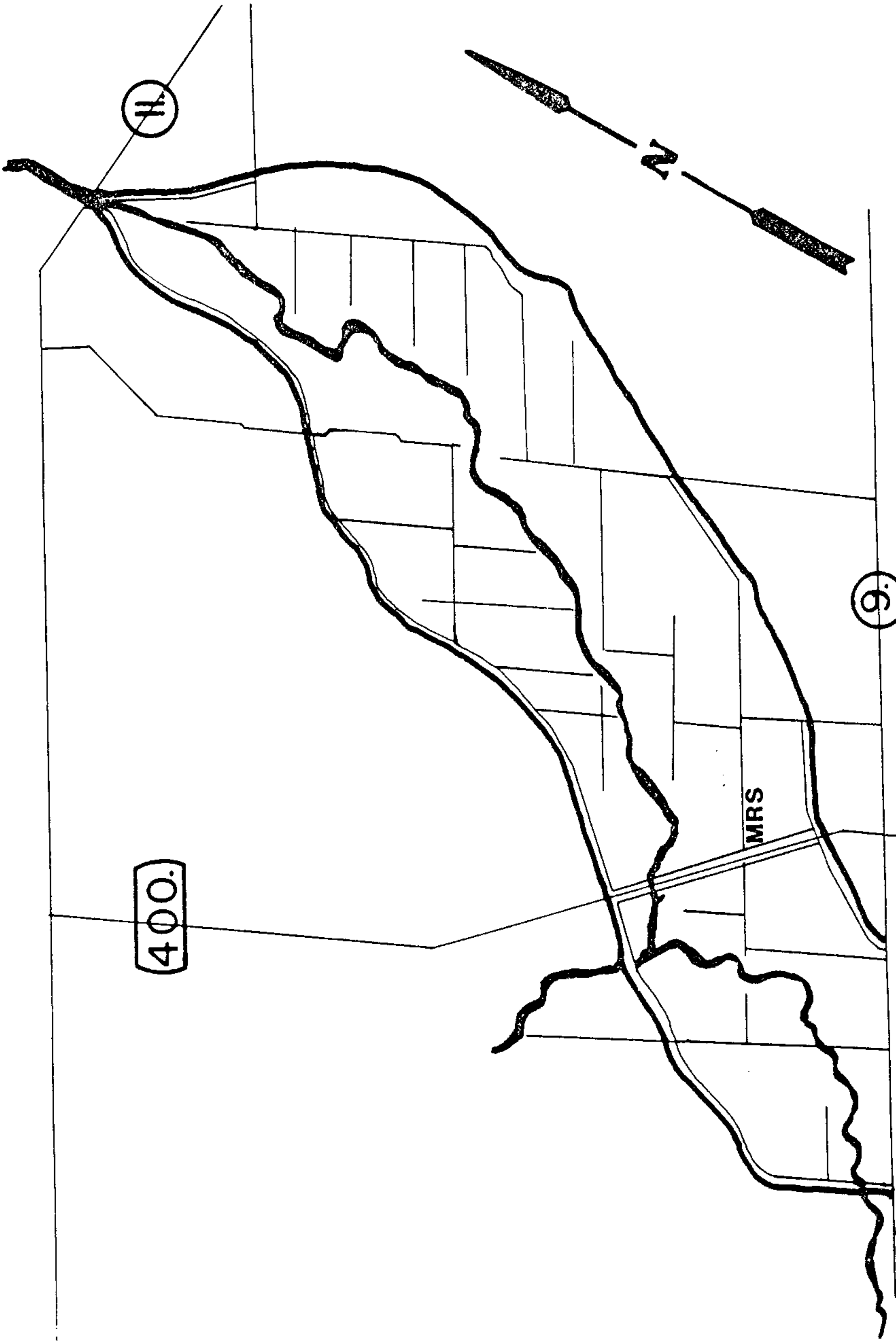
TABLE 1. (cont'd)

Month	Week(s)	Supervisor/Scout Activity	Crop/Grower Activity
June	1	Damage plots set in onions. Start some disease monitoring and leaf wetness meters.	Application of herbicides, insecticides and foliar fertilizers.
	1-3	Control recommendations for 1st-generation onion maggot and carrot rust fly. First-generation onion maggot damage evident.	
	4	Most carrot weevil treatments should be applied by now. Start intensive disease scouting, depending on leaf-wetness periods and recommendations for fungicide treatments in onions.	Some manual weed control.
July	1	Populations of onion maggots and rust flies low. Evaluate 1st-generation damage.	As in June.
	2	Second generation of onion maggot expected this week.	
	3&4	Start disease monitoring in carrots. Second generation of carrot rust fly expected in 4th week.	Start of carrot harvest.
Aug.	1	Intensive disease monitoring in carrots.	As in July.
	2	Onions start to lodge, especially early varieties Pronto, Rocket). Some fungicide treatments in onions stopped.	
	3&4	MH applied when crop is 50-70% lodged. Onions windrowed if tops are dry.	

TABLE 1. (cont'd)

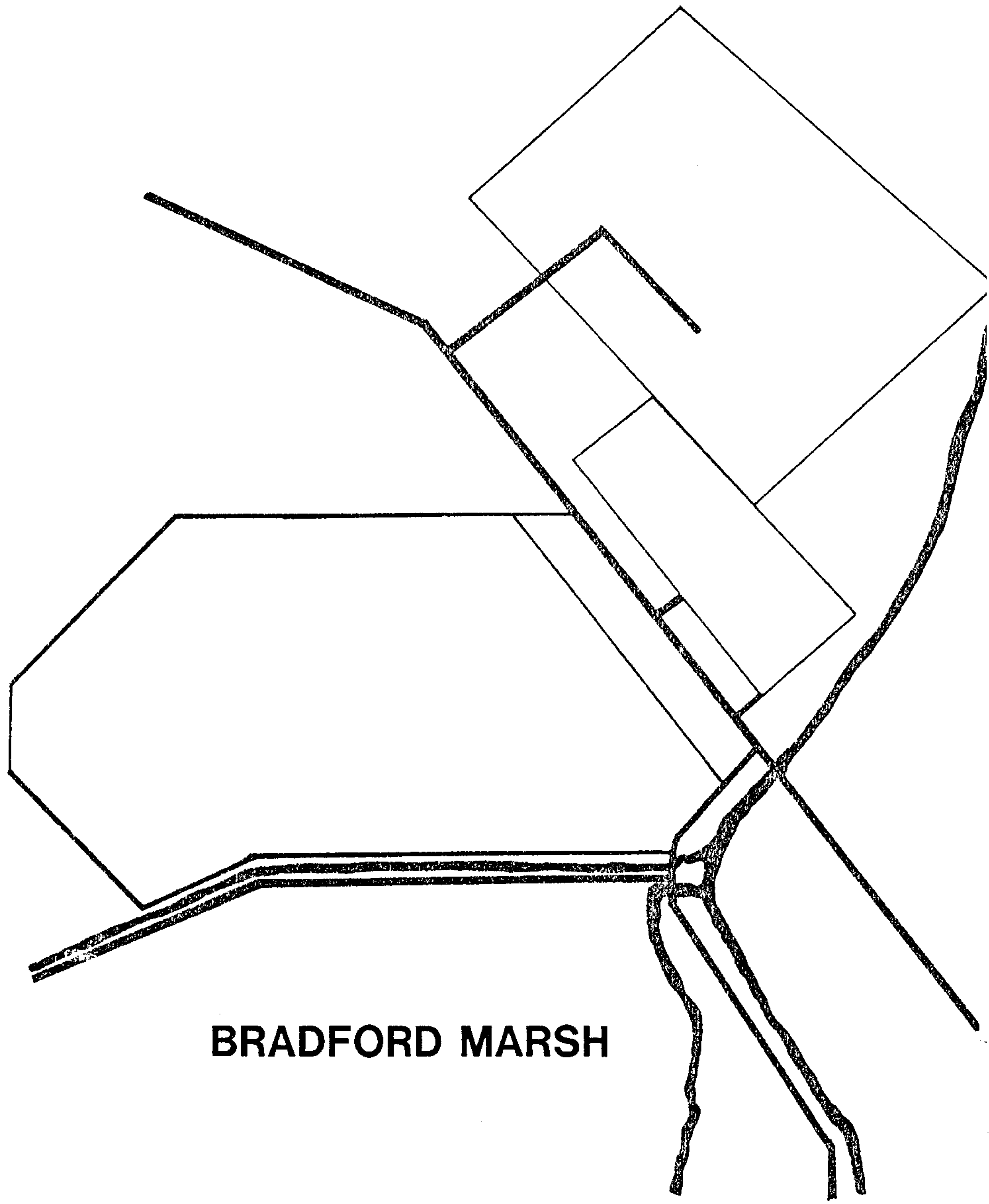
Month	Week(s)	Supervisor/Scout Activity	Crop/Grower Activity
Aug.	3&4	All traps removed and all monitoring ceases in 4th week. Recommendation of treatment in windrows. Some early harvesting of windrowed onions.	
Sept.	1&2	Treatments in windrow against 3rd-generation control. Onions harvested.	

FIGURE I



HOLLAND MARSH

FIGURE II



BRADFORD MARSH

FIGURE III

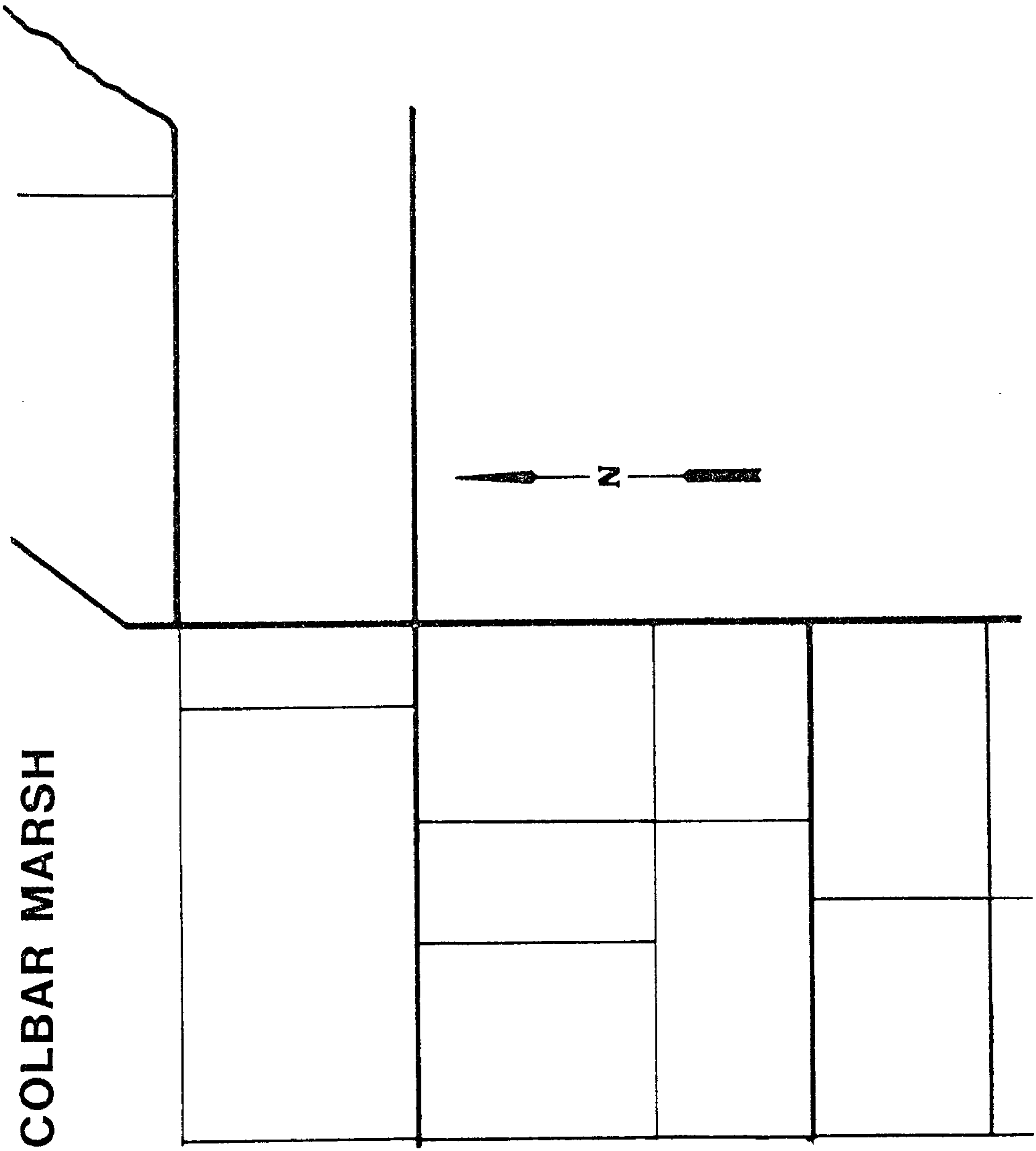


FIGURE IV

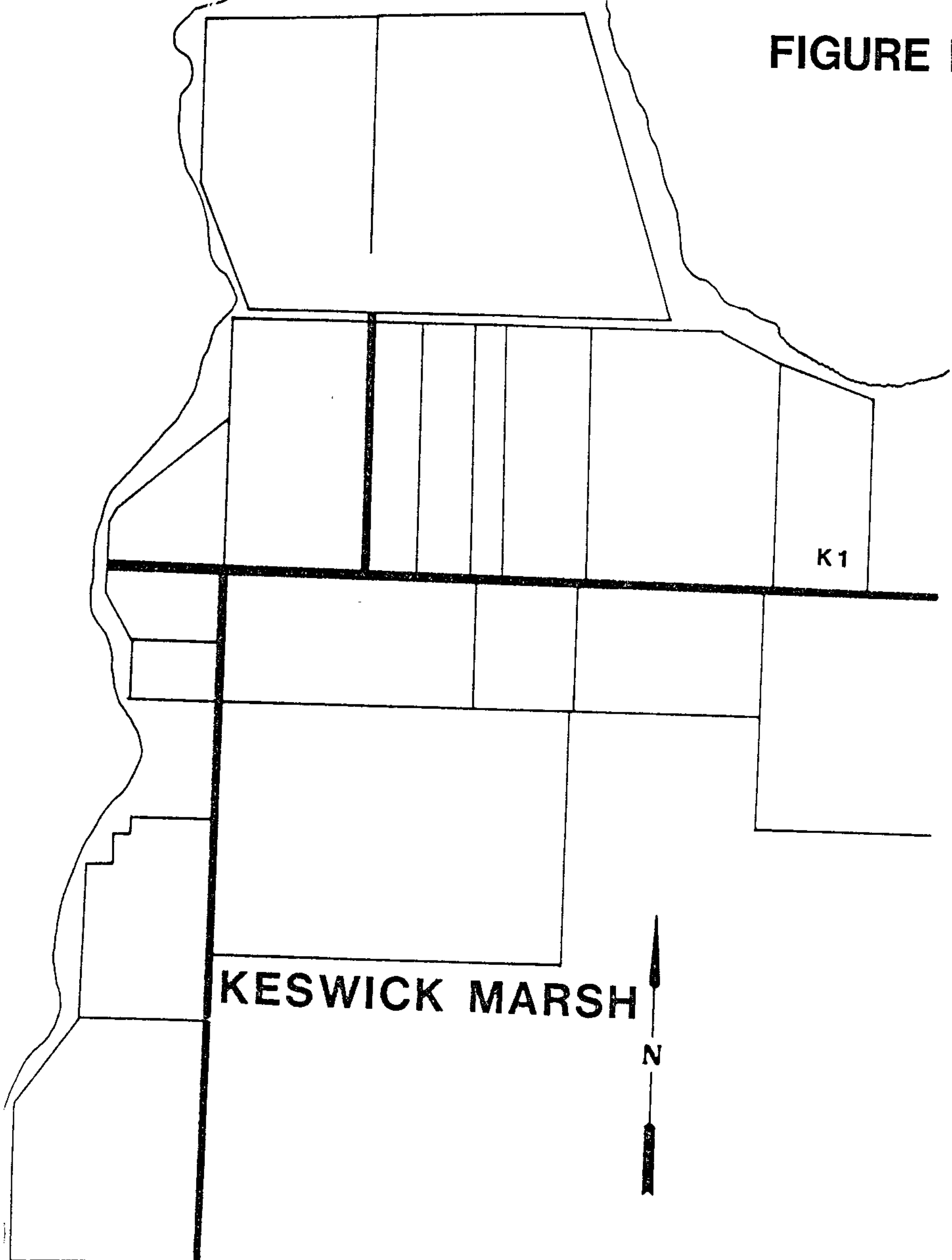


FIGURE V

COOKSTOWN MARSH

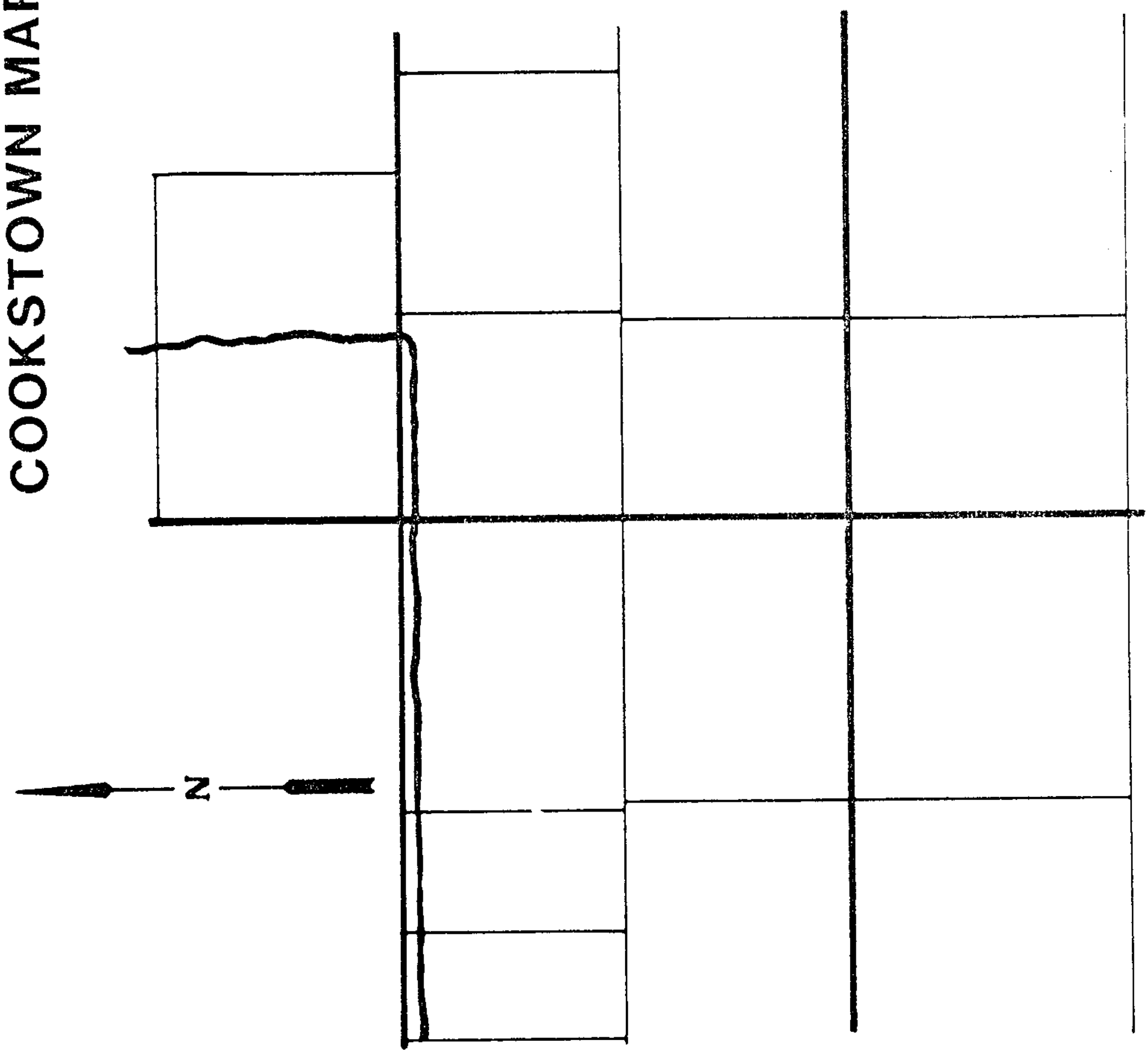


FIGURE VI. Integrated pest management program for Delia antiqua in the Bradford region.