SYSTEMIC INSECTICIDAL CONTROL OF THE ASTER LEAFHOPPER (*MACROSTELES FASCIFRONS*, STÅL) AND ASTER YELLOWS IN CARROTS AND CELERY IN MANITOBA

A Thesis

Submitted to the Faculty

of

Graduate Studies

The University of Manitoba

by

George Brian Ure

In Partial Fulfillment of the

Requirements for the Degree

of

Doctor of Philosophy

Department of Plant Science

October 1981

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ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to Dr. L. J. LaCroix, Department of Plant Science for his continued support and guidance; to Dr. C. C. Bernier, Department of Plant Science for his advice; to Dr. P. H. Westdal, Agriculture Canada, Research Station, Winnipeg, for his counsel and permission to use greenhouse facilities; to Dr. J. F. Moore, former Director of Research, Campbell Soup Company Ltd., for his constructive criticisms regarding the field studies and to Mrs. M. Henderson and Mrs. S. Armstrong for their conscientious typing of this manuscript.

The financial assistance of the National Science and Engineering Research Council and the Campbell Soup Research Fellowship is gratefully acknowledged.

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ABSTRACT

Ure, G. Brian. Ph.D., The University of Manitoba, February, 1982. Systemic Insecticidal Control of the Aster Leafhopper (Macrosteles fascifrons, Stål) and Aster Yellows in Carrots and Celery in Manitoba. Major Professor; L.J. LaCroix.

In Manitoba, aster yellows (AY) disease, as transmitted by the aster leafhopper, Macrosteles fascifrons, Stål, often results in reduced yield and quality of celery and carrots. The incidence and severity of the disease, which may reach epidemic proportions, are directly related to spring influxes of migrant leafhoppers which represent the major source of disease inoculum. A critical situation thus exists, when large numbers of an efficient vector, a certain percentage of which are persistently infectious, invade an area when many susceptible crops are in the seedling stage.

Due to the lack of adequate control programs, replicated field trials were conducted over a period of 3 years at Portage la Prairie. The efficacy of contact spray materials, as compared to several foliar and granular systemic insecticide treatments, for control of the aster leafhopper and aster yellows disease in celery and carrots

was assessed. Foliar sprays of carbaryl (1.7 kg/ha ai), methoxychlor (1.7 kg/ha ai) and oxydemeton-methyl (0.6 kg/ha ai) were applied weekly, while granular treatments (3.4 kg/ha ai) were applied in-furrow at planting. The aster leafhopper population was monitored by weekly sweep net counts, just prior to application of foliar treatments.

In individual trials, and over the 3 year period, foliar contact sprays, systemic foliar applications and systemic granular in-furrow treatments were found to have increasing orders of efficacy. Applications of carbaryl resulted in minimal crop protection. Leafhopper control averaged 30% and disease incidence was only slightly reduced in carrots. Methoxychlor treatments were equally ineffective. Oxydemeton-methyl applications were more effective when the leafhopper population was stable, than during periods of migrant influxes. The maximum carrot yellows reduction achieved with oxydemeton-methyl was 60%.

Of the granular materials evaluated, disulfoton was ineffective for leafhopper or disease control in either crop. Phorate, carbofuran and aldicarb treatments had increasing orders of efficacy. The duration of activity of phorate was 7-8 weeks. Carbofuran treatments effectively controlled the early-season leafhopper population and reduced AY disease incidence. The maximum celery yellows reduction was 75%. Aldicarb was the most effective and consistent treatment tested. Early-season leafhopper control was 60-70%.

Maximum carrot and celery yellows reductions were 72 and 66%, respectively. The duration of insecticidal activity of aldicarb was 9-12 weeks but a longer period of efficacy was often noted.

Linear correlation analysis, of the trial variables, revealed the importance of early seedling protection. Early season leafhopper populations were better correlated with AY incidence at harvest and decreased yield than other variables.

The persistence and fate of aldicarb in carrots was investigated. Residues of toxic aldicarb equivalents in carrot roots, determined by gas chromatography, ranged from 0.06 to 0.21 ppm, 70 days after in-furrow applications at rates of 1.7 to 6.7 kg/ha ai. Residues did not accumulate in the root, were found to be rate related and declined to 0.04 to 0.10 ppm at harvest, 130 days after application. Residue levels in the leaves, 51 days following aldicarb applications, ranged from 1.4 to 6.9 ppm. Leaf residues declined rapidly at first, then more slowly, and at day 99 ranged from 0.16 to 0.62 ppm. Leaf residues were also rate related. Furthermore, the proportion of toxic aldicarb metabolites in the leaf relative to the root was also rate related.

The metabolism of S-methyl-^{14}C-aldicarb in carrot following 12 hours of root uptake from nutrient solution containing 11.25 ppm aldicarb was studied. Uptake was rapid (30% in 12 hrs) resulting in an initial concentration of aldicarb equivalents in the plant of 38.5 ppm. Plants were

sampled over time (0.5 to 45 days) and analysed for total aldicarb metabolites in the root, and toxic and non-toxic metabolites in the leaves. Elimination of activity from the root, leaves and plant was approximated by first order kinetics.

Translocation of aldicarb metabolites to the leaves was rapid. Radio activity was evenly distributed in leaves and stems but concentrated in the leaf tips. The half-lives of aldicarb metabolites in the root, leaves and whole plant were 6.5, 17.8 and 13.9 days, respectively. Toxic aldicarb metabolites were rapidly degraded/eliminated from the leaves (half-life, 8.7 days). The level of toxic metabolites in the leaf, as a percentage of total plant ^{14}C, declined slowly over the duration of the experiment.

In bioassay experiments, infectious leafhoppers were fed on plants containing a range in concentration of toxic aldicarb equivalents (0.7 - 15.4 ppm). Subsequent mortalities ranged from 5-89% in 24 hr and 26-100% in 48 hr. The LC_{50} values for 24 and 48 hr were found to be 3.44 and 1.24 ppm, respectively, and correspond to toxic aldicarb concentrations in field leaf samples, 7 weeks following in-furrow aldicarb applications. The LC_{95} value (48 hr) was 16.7 ppm while the LC_{95} (24 hr) was extremely high. Low leaf residuals and rapid degradation in the plant do not explain the long duration of leafhopper control in the field. These results, as well as an apparent avoidance from feeding in bioassay

tests, are suggestive of a repellent action for aldicarb in the plant.

The major benefits of effective granular in-furrow treatments are: elimination of a critically timed spray program, early seedling protection, persistent activity and ease of application. The maximum yellows reduction expected as a result of in-furrow treatments is 60-75%.

INTRODUCTION

This thesis contains the results of a study of the insecticidal control of aster yellows disease and its primary vector the aster leafhopper, Macrosteles fascifrons (Stål) in vegetable crops in Manitoba.

Insect pests of plants may be controlled with a wide range of insecticides. With respect to non-vectors or non-infectious vectors, crop protection requires only that the insect population be reduced below a certain critical level. That is, damage is usually proportional to the number of insects and the length of the feeding period (Carter, 1973). If the insect is also a vector of a plant virus, however, the problem is compounded and factors arise which are not directly related to the effectiveness of the insecticide (Mathews, 1970). Although disease incidence may be reduced, application of insecticide does not guarantee prevention of disease spread. In fact, a specific vector may be controlled but the spread or incidence of disease may not be reduced (Broadbent, 1957). Since a vector carrying a stylet-borne virus rapidly loses infectivity, insecticidal applications are not expected to reduce primary infection or spread of the disease to the same extent as is possible with a persistently borne virus (Burt, 1960). The requirement for a latent period in the vector before transmission can occur

imposes a time limitation on the acquisition and spread of a persistent virus. However, once the vector becomes infectious it is doubly dangerous.

A critical situation thus occurs when a vector population carrying a persistent disease agent invades a crop. This is the case with the aster leafhopper and the transmission of aster yellows disease to susceptible crops in Manitoba. Migrant leafhoppers from the southern United States generally arrive in mid-May with 1% to 5% of the population typically being infectious (Chiykowski and Chapman 1965, Westdal 1969a). The importance and biology of the insect and disease in Manitoba have been reported in a number of studies (Lee and Robinson 1958; Sackston 1957; Westdal 1969a; Westdal et. al. 1961). Preferred host plants include cereals, flax, lettuce, celery and carrots. Disease incidence varies from year to year and may reach epidemic proportions depending on population influxes, percentage of infectious leafhoppers and environmental conditions (Westdal and Richardson 1963). Such conditions may be the limiting factor(s) to the production of lettuce and celery and can result in significant yield loss in carrots (Chapman and Libby 1971).

Although the causal organism had not been isolated, aster yellows disease was, until 1967, considered to be the result of a virus infection. At that time electron microscopy studies of the phloem elements of yellows infected plants by Doi et. al (1967) combined with the therapeutic effect of

tetracycline antibiotics (Ishie et. al. 1967) culminated with the implication of a mycoplasma or chlamydia-like organism as causal agent of the disease. Subsequent reports confirming the similarity between the presumed yellows agent found in diseased plants and infectious vectors, and members of the order Mycoplasmatales were first reviewed by Maramorosch et. al. (1970), Whitcomb and Davis (1970), and Davis and Whitcomb (1971).

Although antibiotic treatments can suppress or delay symptom development in the plant and result in reduced efficiency of vector transmission (Sinha and Peterson, 1972), practical disease control in annual crops remains a problem of vector control. When this study was initiated only the contact insecticides, carbaryl and malathion were recommended for aster leafhopper control in vegetable crops in Manitoba. Even with a diligent spray program involving frequent applications, a high disease incidence could occur (Henne 1970). Persistent insecticides, especially those which move systemically through the plant offer more hope for disease control. As well, systemics offer savings in time, material and labour; protect the crop in the critical early stages of growth; and, reduce the hazards of environmental contamination. A number of studies have reported systemic insecticidal control of the aster leafhopper on carrots(Chiykowski 1958; Thompson 1965) and lettuce (Chiykowski 1958; Thompson and Rawlins 1961; Thompson 1964, 1965, 1967; Richardson and Westdal 1964;

Rawlins and Gonzalez 1966). A limited amount of information is available regarding the control of aster yellows in carrots (Henne 1970) and celery in Manitoba.

The objectives of this study were:

(1) To determine the efficacy of a number of granular and foliar systemic insecticides for aster leafhopper and aster yellows control in carrots and celery;

(2) To compare the relative efficiency of granular systemics applied at planting, with standard contact spray programs;

(3) To monitor levels of the granular systemic insecticide aldicarb in carrot roots and foliage during the season and at harvest;

(4) To monitor uptake, translocation, degradation and elimination of ^{14}C-aldicarb from carrot roots and leaves; and,

(5) To develop a bioassay with respect to leafhopper mortality from, and disease transmission to, aldicarb treated carrots.

LITERATURE REVIEW

Introduction

A basic knowledge of the factors affecting the epidemiology of a plant disease is a prerequisite to the design of an effective control program. The purpose of this review is to summarize those factors affecting the incidence and spread of aster yellows disease. The interactive contributions of the vector, causal organism, host and environment are discussed with respect to possibilities for insecticidal control of the vector and reduction of disease incidence.

The arthropod-borne plant viruses are among the most economically important and most widely distributed disease agents in the world (Maramorosch 1963). Typically,but not exclusively, the vectors of any one virus disease are limited to one of the major taxa (Black 1959). Of the many vectors of plant viruses, the Homopterous insects, including the aphids and leafhoppers are of primary importance.

The Aphidae is the largest group of insect vectors from the standpoint both of numbers of viruses, as well as species of aphids involved (Carter 1973). Second in importance are the leafhopper transmitted plant viruses. In fact,the first plant virus shown to be insect transmitted was one transmitted by a leafhopper. This disease,called rice dwarf,was first noted in

Japan in 1883 (Fukushi 1969). Since that time,numerous other virus diseases have been found to be leafhopper vectored until today when more than 120 species of leafhoppers are implicated in plant virus transmission (Nielsen 1968, 1979).

In addition to group specificity in the transmission of a virus disease,two other broad generalizations occur with respect to aphid and leafhopper vectors. Whereas mosaic type diseases are associated with the former, the general categorization of "yellows" diseases has been attributed to leafhopper vectors (Bennett 1967). Yellows diseases typically result in a disturbance to the vascular system, primarily the phloem and result in yellowing, dwarfing, streaking, curling, rosette formation or a proliferation of axillary growth, but rarely induce mottling. Secondly,leafhopper transmitted viruses are, with one exception, characterized by persistence in the insect and in many cases are propagative. The tungro disease of rice transmitted by Nephotettix impicticeps Ish. is non-persistent (Ling 1966). In addition,leafhopper transmitted viruses are not readily juice transmissable nor are they seed transmitted (Frazier and Posnette 1957).

Many widely distributed diseases of economic importance to a number of food, forage and horticultural crops are included in the "yellows" group (Maramorsch et. al. 1970, Whitcomb and Davis 1970). Characteristic symptoms,in addition to the above, include: abnormalities to flower parts including virescence and phyllody, vein clearing, chlorosis, reduction in leaf lamina and