SOME VECTOR, VIRUS, HOST-PLANT RELATIONSHIPS OF THE SIX-SPOTTED LEAFHOPPER, *Macrosteles fascifrons* (Stål) AND ASTER YELLOWS VIRUS IN MANITOBA.

A Thesis

Presented to

The Department of Entomology

Faculty of Agriculture and Home Economics

The University of Manitoba

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

by

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January 1966

ABSTRACT

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SOME VECTOR, VIRUS, HOST-PLANT RELATIONSHIPS OF THE SIX-SPOTTED LEAFHOPPER, Macrosteles fascifrons (Stål), AND ASTER YELLOWS VIRUS IN MANITOBA.

Contact and systemic insecticides formulated as emulsive concentrates (EC), wettable powders (WP), and granules (G) were compared at various times, rates and intervals of application to control the six-spotted leafhopper, Macrosteles fascifrons (Stål), and prevent the spread of aster yellows virus (AYV) to head lettuce and carrots. The insecticides malathion EC, Baygon EC and G and phorate G, at the rate of one pound per acre controlled the six-spotted leafhopper and prevented the spread of AYV to the head lettuce in the spring and summer crops of 1960, 1961 and 1962. The same insecticides gave only partial protection to the spring crop and failed to protect the summer crop of 1963 because of a combination of a large population of M. fascifrons with a high percentage (ten per cent) of infective leafhoppers. Other insecticides tested against M. fascifrons on head lettuce were less effective.

The start of applications of insecticides to the spring crops may be delayed for two or three weeks after the plants emerge. On summer crops, spray applications must begin at crop emergence.

DDT EC and Carbaryl WP, one pound per acre, one application per week gave a significant reduction in carrots affected by AYV when the spray applications were started within two to three weeks of crop emergence.

Less than 0.5 p.p.m. of malathion was found on lettuce heads which were analyzed nine days after the last of 15 applications.

Three strains of AYV, "A", "B", and "C", were isolated from lettuce, zinnia and celery, respectively, in Manitoba. The three strains were separated by symptoms on aster, Nicotiana rustica var. humilis and celery. The criteria: 1) plant height from first leaf node to tip; 2) plant height from first to last exposed leaf node; 3) number of exposed leaf nodes and 4) axillary growth on aster were also successfully used to separate the strains.

The transmission of the three strains of AYV by single infective M. fascifrons showed that the six-spotted leafhopper, male or female, is a consistent and reliable transmitter after a two-day inoculation feed; that aster is a poor indicator of the proportion of infective leafhoppers; that stinkweed and head lettuce are superior indicator plants; and that different species of host plants vary in their susceptibility to different strains.

The acquisition of the three strains of AYV by M. fascifrons from 14 different host plants showed that it depended on the strain of AYV and the host plant.

ACKNOWLEDGMENTS

I wish to thank Dr. A. E. Hannah, Director, Research Station, Canada Department of Agriculture, Winnipeg, Manitoba for permission to use the project as a thesis, and Dr. A. G. Robinson, Department of Entomology, University of Manitoba, for accepting the project as a thesis.

Thanks are due also to Mr. P. H. Westdal for doing the final statistical analysis of data presented in Chapters IV, V, VI, and VII; to Dr. L. B. Smith and Dr. W. Ives for advice on statistical methods; to Mr. R. Cheale for photographing the plants in Fig. 8, 10, and 19; to Dr. P. Barker, Dr. W. C. McDonald and others for reviewing the manuscript and Mr. J. Ilchyna, Mr. N. Brandt, Mr. D. Tiltman and Mr. G. Cox for assistance in carrying out the field experiments.

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CHAPTER I

INTRODUCTION

The recognition of plant virus infections as a distinct class of disorders and of insects as vectors of the plant viruses dates back to the end of the nineteenth century (Cook, 1947). Since then, it has been shown that most plant species of economic importance are infected by one or more virus diseases, many of which are transmitted by insects (Chapman, 1959). In Manitoba, wheat is known to be infected by three insect-transmitted viruses: barley yellow dwarf, aster yellows, and wheat striate mosaic; oats by two: barley yellow dwarf and oat blue dwarf; barley by four: barley yellow dwarf, oat blue dwarf, aster yellows, and wheat striate mosaic; flax by two: oat blue dwarf and aster yellows, and most other crops, vegetables and herbaceous ornamentals by at least one: aster yellows. Barley yellow dwarf, a virus disease of world distribution, was discovered in 1951 by Oswald and Houston (Bruehl, 1961), and the oat blue dwarf as recently as 1961 (Banttari and Moore, 1961).

The protection of the crops from the insect-transmitted viruses may be based on the development of crop varieties resistant to the insect or the disease, or, on the use of chemicals. Each method has its particular advantages or disadvantages, but common to each is the necessity for a thorough understanding of the vector, virus and host-plant relationships. The complexity of the relationship is illustrated by the aster yellows virus (AYV). It is a complex of virus

strains (Granados, 1965) some with different host ranges, different host effects and different vectors in different parts of its range. Macrosteles fascifrons (Stål), the six-spotted leafhopper, is the major vector, though only one of at least 25 different species of leafhoppers which are capable of transmitting AYV. In Manitoba the migrant populations of M. fascifrons are the major source, through the eggs they deposit, of the local population that develops in Manitoba. The migrants are also the major source of AYV which they carry with them and inject into the local crop and weed plants. The diseased crop and weed plants form the major source of infection for the generations of M. fascifrons which develop in Manitoba.

The problem

The problem is the protection of the crops from infection by AYV. The first method studied was the direct destruction of the six-spotted leafhopper by chemicals. For this purpose a series of insecticides were evaluated to determine the most effective time of application, rates and interval of application.

The second method was a study to determine the relationship of the vector and virus with a number of common host plants. The purpose was to elucidate the facts that may prove effective in reducing AYV infections, possibly through the reduction of certain host plants or in the production of resistant crop plants.

Importance of the problem

The host range of M. fascifrons and AYV includes most of

the cereal crops, oil seed crops, vegetables and many of the herbaceous ornamentals grown in Manitoba. Although the losses due to AYV infection seldom exceed ten per cent of most crops, these losses have practically eliminated commercial production of head lettuce in Manitoba, and constitute serious problems on carrots and celery; in some years some growers have lost their entire celery crops. The loss in most of the other crops caused by the virus disease although low, represents another addition to the cost of production and to the cost of the final food product.

Organization of the thesis

The chemicals used in the tests are referred to by their trade names or company designations throughout the thesis. The chemical names are given in the section on Materials and Methods Chapter III. The results of the field tests are presented in Chapters IV to VII.

The laboratory tests conducted at the Canada Department of Agriculture, Research Station, Winnipeg, to differentiate three strains of aster yellows virus, and on the ability of M. fascifrons to transmit three strains of AYV to and from fourteen different host plants are given in Chapters VIII, IX and X respectively.

Two publications based on the results presented in Chapters IV, V, VI and VII are given in Appendix A. Summary tables of data that form the basis for the final Tables presented in the text are given in Appendix B.

CHAPTER II

REVIEW OF LITERATURE

Control of insect vectors of plant viruses

The control of vectors of plant viruses to prevent the spread of diseases has been attempted with insecticides, trap crops, and various types of barriers. A survey of the literature on insecticidal control of the spread of plant viruses was presented by Broadbent (1957). In this review he listed the earlier successes and failures by a number of workers attempting to reduce the spread of spotted tomato wilt on tomatoes by thrips, potato viruses by aphids, aster yellows virus on lettuce, carrots, and endive by M. fascifrons and curly top of sugar beets by the leafhopper Circulifer tenellus Baker. Broadbent (1957) concluded from the early attempts to control the spread of viruses by using such insecticides as nicotine, derris and pyrethrum, that it is not sufficient to kill the insects on the crop, that insufficient insecticide remained active on the foliage, and very frequent applications were necessary to prevent virus spread. These were expensive and often failed because incoming insects introduced virus or spread it from plant to plant in the intervals between applications. An increased incidence of potato virus Y in potato fields sprayed with insecticides has been reported by various workers (Chapman, 1951; McEwen, 1953; Roland, 1953). McEwen (1953) showed that insecticides kept the foliage green late in the season thus making the plants susceptible to late-season infection. Chapman (1951) hypothesized that parathion increased aphid activity and

Roland (1953) suggested that it attracted aphids. According to Shanks and Chapman (1965), aphids, after initial probes made longer feeding probes on parathion-treated tobacco than on untreated leaves and vice-versa on DDT-treated leaves. Neither material affected aphid acquisition of potato virus Y but parathion tended to decrease and DDT to increase the number of transmissions to treated plants. The authors found that the insecticides required 51-180 min. to kill 90 per cent of the aphids two hours after application and much longer three days after treatment, while aphids can transmit non-persistent viruses in less than a minute. They also found that the winged aphids remain longer on parathion-treated plants than on DDT-treated plants, and, that infected aphids transmitted potato virus Y slightly more often to parathion-treated than to untreated tobacco plants.

It was shown by Becker and Rich (1956) and by Morgan (1965) that the control of aphids, Pentatrichopus spp., on strawberry beds prevented the spread of virus diseases and, as a result, increased runner and fruit production. Morgan (1965) showed that one application of Meta-Systox or dimethoate during the spring to prune trees gave a season-long control of aphids and suggested that limitation of the spread of viruses in the field through control of insect vectors, whether or not the identity and behavior characteristics of such vectors are known, is feasible.

Harrison et al (1963) and Murant et al (1965) showed that the nematocide D-D effectively controlled two species of nematodes Xiphinema diversicaudatum (Micol) and Longiforus elongatus (de Mon) and thus

prevented the spread of virus diseases in strawberry beds. According to Murant et al (1965) the effects lasted throughout the four year experiment.

Strong and Rawlins (1958) tested four insecticides: DDT, demeton, malathion and parathion at various dosages for the control of M. fascifrons on lettuce. The materials were sprayed on plants growing outdoors and which were taken into the laboratory for tests after different lengths of time. Their conclusion was that none of the insecticides applied as sprays was very effective for as long as three days. Further tests were carried out by Strong and Rawlins (1958) in the field using the same four insecticides and using populations of infective insects. The authors were able to differentiate between incidence of disease on sprayed and unsprayed lettuce, and in the residual effectiveness of the insecticides tested. The differences between the insecticides were not evident and the degree of protection was not satisfactory for commercial conditions. Chiykowski (1958), found malathion effective for the control of M. fascifrons on head lettuce and prevention of infection by AYV. Miller (1960) recommended DDT and malathion for the control of M. fascifrons on carrots and lettuce in Ontario.

Thompson and Rawlins (1961) tested the systemic insecticides phorate, dimethoate and Di-Syston to control M. fascifrons and reduce the incidence of lettuce yellows. The insecticides, applied at the rate of one pound per acre at time of seeding as granules or as drenches, were more effective than seed treatments and equally or more effective than malathion applied twice weekly as a spray. Phorate was more