STATUS OF ENTOMOLOGICAL RESEARCH ON INSECT TRANSMITTED PLANT DISEASES IN CANADA

A report prepared by a Special Committee of
the Entomological Society of Canada

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In 1988, the Science Policy Committee of the Entomological Society of Canada identified insect transmission of plant diseases as one of the neglected areas of entomological research. A preliminary inquiry lead to the discovery that only two or three entomologists were presently or then concentrating most of their research efforts in the field. In late 1989, an ad hoc committee was formed and given the mandate to prepare a brief on the issue. The committee was asked to evaluate the status of entomological research in relation to the major problems faced by Canadian farmers and foresters, the impact on crop production, and the potential major research requirements.

Committee members were chosen to represent the various sections of the various geographical areas of Canada. Early discussions confirmed the lack of factual information with respect to insect vector research. It was then decided to survey the status of the research efforts in agricultural and forestry laboratories using a standard questionnaire. The questionnaire utilized can be found in Appendix 1. Each committee member was asked to contact 10 scientists in his area who were known to conduct or to have conducted insect transmission studies. Each contact was interviewed by phone and asked to provide factual information and opinions. Reports from each committee member were then produced and collated to produce this final report. A total of 39 scientists including committee members, participated in the survey. Almost one third of those were pathologists working in pathology laboratories or entomologists with professional training in pathology. The survey was addressed primarily to entomologists, but it would have been impossible to obtain a complete picture of research requirements in many regions without including some pathologists.

Major Problems

One of the most important problems in Canada and world wide is likely to be the barley yellow dwarf virus of cereals and grasses transmitted by aphids. On cereals and forage crops, there are also problems with the streak mosaic viruses transmitted by mites, the aster yellows, the verticillium wilt transmitted by aphids, and other forage insects and a new rhabdovirus of winter wheat likely transmitted by leafhoppers. A variety of virus diseases of legumes and fruits were also reported as problems. These diseases are carried by aphids, leafhoppers, plant bugs, and thrips. On cucurbits, aphids transmit the cucumber mosaic virus and the potato virus Y. On legumes, a mycoplasma is transmitted by leafhoppers. On onions, thrips transmit diseases such as OYDV. Thrips are especially important vectors of diseases in greenhouse crops. For example, they transmit the spotted wilt of tomatoes. On carrots, aphids can transmit a variety of luteoviruses and leafhoppers will transmit yellows. On potato, known and unknown species of aphids transmit non-persistent viruses such as potato virus Y^O and Y^N and the persistent potato

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leafroll virus. On strawberries and raspberries, there are many virus diseases transmitted by unknown species of aphids or related insects. Fusarium species can be a problem in corn and the vectors are unknown. In forestry, the dutch elm disease is the best known and the most important. Beetles transmit a variety of fungal and bacterial diseases. Two of these diseases are the lodgepole pine blight and the oak wilt. Hemiptera can transmit elm yellows, a disease caused by a mycoplasma.

Impact of Problems

There are generally no precise data available but a lot of indications that losses are major for most problems cited as important. The barley yellow dwarf virus is the most important plant disease worldwide but its estimated losses vary widely within Canada from two percent on the average in oats, barley, and wheat but with greater losses during the years of widespread epidemic. On carrots, losses are around 1 percent for the early crop and up to 10 percent for the late crop. On cucumbers, losses average 5 percent. Potato virus Y in potato can cause up to 30 percent loss in the table commodity, but its impact on the seed potato industry can be much more significant. The recent introduction of the PVY^N in eastern Canada, has for example, endangered the future of the seed potato exports towards the United States. In forestry, dutch elm disease reaches 65 to 80% incidence in Quebec alone.

Losses caused by insect vectored diseases are difficult to document because of their sporadic nature. However, measures taken by governments, growers and industries to reduce the losses (sprays, monitoring, inspection, testing and freeing stocks of virus) represented a large cost in dollars and PY's. In potatoes, grapes, fruit trees, strawberry and raspberry virus related costs are very high.

Current Status of Research

Research establishments do not presently place a high priority on transmission of plant diseases by vectors. In the monitoring programs, the presence of vectors or suspected vectors initiates control on crops that begin the season virus free.

Today, we identify most agents of diseases without much entomological input and control the pathogen without additional knowledge about transmission mechanics. In the 1950's and 1960's, entomologists and pathologists required vectors to identify many plant pathogens.

As a result, research on the biology and ecology of vectors or pathogens has become very limited. Entomology has not succeeded in taking advantage of the biotechnological developments whereas pathology has embraced biotechnological developments and become involved almost entirely in the development of detection techniques.

The mechanisms that result in observed vector-pathogen-plant specificity remain poorly researched. Important advances could be made using the molecular methods now available in conjunction with transmission studies. If more were known about the molecular basis of the specificity, production of transgenic resistance to specific viruses and to entire virus groups might be more effectively done.

With rare exception, we know little about what may be called the population dynamics or life cycle of plant viruses in nature. The effect of temperature in the field on symptom expression, pathogen latency, and availability to vectors is poorly known. However, those are important attributes of the rate of damage development and spread of pathogens.

The key to understanding and controlling plant diseases transmitted by insects is to go one step beyond simply monitoring vectors. It is essential to consider insect transmitted plant diseases as the union of the population dynamics of the vector, the replication, and the cycle in physiology of the plant and the weather regime. This type of study, by its nature, can only be done by a team of researchers from various disciplines. The team members need not all be at the same location.

One member of the committee referred to this integrated approach as epiphytology of insect transmitted plant diseases. In fact, the introduction of new terminology, epiphytology, or other terms, might be quite helpful in bringing back to life this area of research involving many disciplines.

The movement of insects is one of the least well understood aspects of insect ecology. Our lack of understanding is partly the result of the practical difficulties of performing experiments over suitable areas. Many insect transmitted plant diseases become epidemic in Canada as a result of northerly movement of large numbers of vectors from USA. This is the case with diseases such as barley yellow dwarf virus and potato leafroll virus. Similarly, there is a great deal of knowledge missing on the role of local vector population dynamics, micro- and macro-scale weather etc. These are only known well enough to explain the situation after the fact but not to forecast epidemics.

Pest control programs presently assume that all most individuals of all vector species are carrying the pathogen. The molecular methods have now been developed to detect the presence of virus in single vectors. Together, the use of these methods eliminates the need to assume that all vector species are carriers.

There is a need for research on insect transmission of diseases. This can be best done through the cooperation of entomologists and plant pathologists working as a team to solve a problem or answer a question. Unfortunately, collaboration between individuals trained in different disciplines such as entomology and plant science is likely to remain exceptional. Most researchers are trained and hired for their individual abilities. The conditions of promotion and recognition for contributions to science favour individual efforts, not group effort. We have a structural problem both at training and research levels. The tendency now in government institutions is to contract research outside the establishment which results in fractionates efforts, negates sustained programs, and exacerbates the problem. Textbooks tell us that integrated pest management is the way of the future. Monitoring advisory networks are encouraged. Is it possible for the institutions to follow these recommendations?

The number of entomologists/ecologists in government, at least, is decreasing as molecular biochemists are hired to replace them. Putting all disease-orientated eggs into the molecular basket is the greatest threat to field oriented, ecologically based plant disease studies. Most remaining government entomologists work on insects as direct pests only. Almost all diseases are now investigated from a molecular perspective. The ability to do epiphytology is approaching extinction.

Training

Entomologists make naive pathologists and pathologists make naive entomologists. Could the problem be resolved by improving the training in the respective disciplines? There was unanimous agreement among the surveyed scientists that there is no need for new training programs in insect transmitted plant diseases in the entomology or the pathology curricula. The subject is covered adequately in general plant pathology or protection courses in both agricultural and forestry levels. Many

of those surveyed commented that there would be no point in training individuals because there are no positions available.

When considering research on vector transmitted virus plant diseases, it is important to realize that the symptoms of disease are the most apparent part of the problem from the agricultural or forestry standpoint. As a result, the issue has been one primarily for plant pathologists. The insect side of the problem is not as well recognized nor is it perceived adequately.

Enrichment of plant pathology courses and economic entomology courses would seem to be of short- and long-term benefits for the two types of professionals and to their clients. Pathologists surveyed have commented that most entomologists seem entirely unaware of the basic fundamentals of pathogens and are interested only by the insect biology. On the other hand, entomologists have stated that pathologists seem to neglect the important contribution of insect behaviour and dispersal to the epidemiology of plant diseases. This is somewhat supported by the statement of one plant pathologist that the life cycle and biology of most insect vectors are known and that, therefore, there is no need for further entomological contribution. Evidently, there is need for bridging. As far as could be established, there is only one graduate course in vector entomology offered in Canada, at the University of British Columbia. The course is offered every other year and includes lectures on the full range of vectors and diseases. The content includes pathology, population dynamics, evolution, and transmission characteristics. Perhaps this course could be used as a model by other universities in other areas of the country.

Publications

The Canadian Entomologist has published results of studies on the biology of vectors of insect transmitted diseases to agricultural and forest crops. The number has been limited. Most of our respondents considered the coverage of the Canadian Entomologist too large, too general, and poorly adapted. They would prefer to publish in a journal of horticultural research or plant pathology.

Conclusion

Insect transmitted plant diseases cause major problems to the Canadian agricultural and forestry industries. The economic importance of most of the diseases has not been scientifically established. Plant pathologists have developed detection techniques that allow crop managers to control most of those diseases effectively with a minimum of information on the identity and/or number of vectors.

The field of insect transmitted plant diseases offers challenging studies for entomologists. The mechanisms by which insects acquire and transmit pathogens are almost entirely unknown. The ecology of insect dispersal is also understudied. With the increasing interest of agriculture and forestry for sustainable development, it will become essential that mechanisms underlying pathogen transmission by insects be understood. The dominance of plant pathologists over entomologists in this field resulted partly from the absence of adequate training in biotechnology for entomologists.

The committee recommends that the entomology curricula be enriched by paying more attention to plant science and plant pathology and encourages participation of entomologists in biotechnology courses. It also recommends the promotion of entomology in plant pathology departments to create an awareness of the complexity of vector-pathogen life systems. The agencies providing research funding need also to be made aware that plant disease epidemiology cannot be understood fully if it is only studied from the plant pathology angle.

APPENDIX 1

QUESTIONS FOR THE PHONE QUESTIONNAIRE

1. What proportion of your job is devoted to research? To extension?

2. What proportion of your research effort is devoted to:
   a. Ecology of insect vectors of plant pathogens?
   b. Epidemiological studies of insect vectored diseases?
   c. Studies of disease transmission?
   d. Control of diseases vectored by insects?

3. Is there anyone else at your establishment working on vectors of plant pathogens?

4. What are the major problems in your province or area regarding plant disease organisms vectored by insects (agriculture and/or forestry)?

5. What is the impact of insect transmitted diseases in your province or area? Yield loss? Cosmetic effects?

6. Where have you published research related to insect transmission of disease organisms? Same trend for your colleagues?

7. What programs of control or extension education are provided in your area?

8. Where did you receive your training in the area of insect vectored plant pathogens?
   By formal education? Location?
   Through research establishments or workshops?
   On your own?

9. Is there training available in your area? Should there be?

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