DEVELOPMENT OF DISEASE MANAGEMENT SYSTEMS (DMS) FOR HAWKES BAY PIP AND STONE FRUIT PRODUCTION

D.W.L. MANKTELOW and K.G. TATE

MAF Technology, Hawkes Bay Agricultural Research Centre, P.O. Box 85, Hastings

SUMMARY

Disease management systems (DMS) to optimise spray timing and reduce fungicide use are being evaluated in Hawkes Bay for control of apple black spot and peach brown rot. These systems rely on identification of infection periods in time to enable growers to make effective disease control responses. Infection periods are identified on the basis of crop susceptibility, forecast and/or monitored weather, inoculum presence and control expected from previous management actions. Where quantitative data is lacking heuristic (rule of thumb) information is used to assess potential for infection. This work represents the first attempt to formally integrate management techniques for control of black spot or brown rot in Hawkes Bay.

Keywords: disease management systems, apples, peaches, black spot, brown rot

INTRODUCTION

Horticultural producers are under increasing pressure to reduce pesticide use while maintaining high quality standards. These pressures arise from market residue restrictions, disease resistance problems and production costs. Most New Zealand pip and stone fruit producers rely on intensive fungicide use to prevent disease losses. However, large variations in pesticide use have been observed between growers, probably reflecting different grower perceptions of pest and disease risk rather than real risk differences (Manktelow 1990). An ability to assess disease risks accurately would enable growers to use pesticides only in response to biological needs.

There are many examples of integrated pest management (IPM) systems around the world. However, few have been implemented in horticultural crops (Wearing 1989) and pesticide use, based on calendar intervals and/or crop growth stages, still dominates pest and disease control practice in New Zealand pip and stone fruit. Integrated mite control (IMC) (Collyer and Van Geldersman 1975) is probably the most used IPM system applied in New Zealand pipfruit crops. There are virtually no IPM systems, or related decision-aids, used for disease control in New Zealand pip or stone fruit crops. The most notable exception is the Mill's Period system for monitoring black spot (*Venturia inaequalis* Cke. Wint.) infection periods (Mills and Laplante 1954). For example, several Hawkes Bay growers have equipment for monitoring infection periods and Mills period information is broadcast on a local radio station. However, there are no systems operating by which growers can integrate this information with other aspects of black spot control.

The authors have initiated the development and field-testing of two disease management systems (DMS) in Hawkes Bay for control of black spot in apples and brown rot (caused by *Monilinia fructicola* Wint. Honey) in peaches. System extension and user implementation are the subject of separate projects (e.g. Manktelow and Laurenson 1990) and are not reported in this paper.

DMS DEVELOPMENT

DMS objectives are to provide cost effective disease control without unacceptable risks of control failure, reduce pesticide requirements and fruit residues (relative to

Proc. 44th N.Z. Weed and Pest Control Conf. 1991: 216-219

current standard levels), encourage use of pesticide resistance management strategies and integrate control methods for individual diseases with overall pest, disease and crop management. The philosophy underlying DMS development was to combine available abstract (soft) and quantified (hard) information into a problem solving system. Use of soft and hard systems approaches in pest management has been reviewed by Teng (1987).

In DMS development major factors that influence disease are identified for each crop/disease combination. Factors associated with occurrence of individual infection events and disease epidemics are treated separately. Data required to monitor and interpret these crop/disease interactions are identified, with information drawn from published research and personal experience. Types of data required and their accuracy, period and frequency for measurement are defined for each crop/disease combination (Table 1).

For infection to occur disease inoculum must be available, the crop must be susceptible, environmental conditions must be suitable and no inhibitory management applied. Infection events are said to have occurred if all the above conditions are met, and any resulting disease would be expected to make a significant contribution to the disease epidemic (and hence risk of crop loss). Many of these requirements have been documented, so can be interpreted quantitatively (hard systems approach). However, interpretation of even well defined factors usually involves unquantified (soft systems) data which can still provide information useful to DMS. Generally there is little hard data available to describe and predict epidemic progress and crop loss interactions. The ability to make reasonable predictions of infection in time to take remedial action is an essential component of a successful DMS. A soft systems approach using heuristics (rules of thumb, used as a basis of computer expert systems (Denning 1986)) may be the only practical method available at present to assess disease risk.

Current disease management practices are based on recommendations that are conservative, relatively simple, and easily interpreted (e.g. calendar schedules). Typically such recommendations are most appropriate for disease control under high risk conditions. Growers and advisors frequently modify such recommendations by using empirical heuristics and the limited decision aids currently available to them (e.g. weather forecasts, black spot infection period data). In our experience so called 'good' growers have usually developed rules for making disease management decisions. A part of DMS development is to identify and incorporate such rules. It is anticipated that some will not have a sound epidemiological basis, or prove robust enough to be applied to conditions beyond those in which they were developed. However, some should prove generally applicable, and are expected to be useful decision aids.

Initially the DMS under development are relatively crude, use conservative loss-risk thresholds and do not meet all the objectives stated previously. However, the systems should be improved as they are modified with testing and the incorporation of further research. The need to use conservative thresholds is directly related to high potential costs, both financial and for system credibility, of incorrect management decisions.

The main problems anticipated during DMS development are prediction of infection periods, prediction of epidemic progress and *quantification* of risks of making incorrect management decisions. One method to reduce the first problem may be to focus on periods when disease risks are low. For example, "negative forecasting" to predict fine weather (R.M. Beresford pers. comm.), or predicting when fungicide residues will be adequate to prevent disease. Problems in predicting epidemic progress and crop losses may be reduced if "fuzzy logic" (set membership theory; Self 1990) can be applied to factors such as monitored rates of disease increase in relation to damage thresholds and time left to harvest. Regular crop, disease and environmental monitoring are an essential part of DMS. Monitoring is necessary to detect results of incorrect management actions in time to take remedial action, and the data collected provides a useful database.

Mechanistic models of disease epidemics provide the fastest method to test DMS rules. No models were available for the DMS being developed, so we relied on field testing to validate the systems. Field testing is slow and expensive. It is hoped that experimentation using models will become possible in the future, although field testing and validation of the systems will always be necessary.

FIELD TESTING AND RESULTS TO DATE

In the 1990-91 season preliminary DMS for apple black spot and peach brown rot control were evaluated in two commercial orchards. Evaluations were based on comparison of fungicide spray programmes based on DMS rules with "standard" grower spray programmes. Most spraying decisions in the peach/brown rot DMS relied on forecasts of infection, while the apple/black spot system used both forecast and monitored data. The types of data used to predict/monitor infection are indicated in Table 1. Weather was monitored at each site using CR10 data loggers (Campbells Scientific Instruments Inc.). Weather was forecast using a combination of five day forecasts from the NZ Meteorological Service (received daily), and interpretation (based on heuristic rules) of daily newspaper weather maps. Crop susceptibility (based on growth stage), disease inoculum and epidemic progress were monitored at regular intervals according to protocols established for each disease. Likewise, spraying decisions were made according to protocols established for each DMS. A summary of results from the field experiments is given below.

TABLE 1: Data required to predict/monitor individual infection events.

Data type	Factor, accuracy + recording interval, (for disease/crop type)
Actual Weather	<ol style="list-style-type: none"> 1. surface wetness of leaves & fruit, duration and time of occurrence to nearest half hour (black spot) or hour (brown rot). 2. average temperature, over wet period to nearest ° Celsius. 3. rainfall, total hourly (black spot), total daily (brown rot). 4. time of sunrise and sunset to nearest half hour (black spot). 5. humidity, duration and time of occurrence >90 %RH (black spot).
Forecast Weather	<ol style="list-style-type: none"> 1. NZ Met. service forecasts, daily for 5 days in advance. listing <ol style="list-style-type: none"> a) rainfall, quantity expected, time of fall and duration. b) temperature, average. c) wind, speed and direction. 2. Newspaper and televised weather maps, showing positions and movement of weather systems, examined daily.
Crop growth stage ¹	<p>(apples) bud break, green tip, 1 cm green, tight cluster, open cluster, king bloom, full bloom, petal fall, days to harvest, end of extension growth.</p> <p>(peaches) % bloom, % petal fall, stone hardening, days to harvest. Recorded weekly to end of petal fall, estimates thereafter.</p>
Disease	<ol style="list-style-type: none"> 1. sources of inoculum (Black spot) wood cankers, infected pygmy or late-set fruit, assessed only once (assume that ascospores will be present). (Brown rot) viable and/or sporulating apothecia, fruit mummies, pedicels or twig cankers — monitoring for incidence required weekly over bloom, then after each infection period. 2. quantity of inoculum, quantities of leaf litter spore yield monitored every two to three weeks from bud break until ascospores are no longer detected (black spot). Numbers of apothecia, fruit mummies, blighted blossoms or twigs (brown rot). 3. Disease incidence, on leaves (separate surfaces) and fruit (black spot), blossoms, twigs and fruit (brown rot).
Management	<ol style="list-style-type: none"> 1. pesticide use, pesticides applied with application rate and volume, date, time (to nearest 6 hours for black spot), mix, sprayer calibration, equipment used and method. 2. inoculum source removal, what, when, how, to what extent. 3. Manager plans for other pesticide or nutrient spray applications, what and when required.

¹Separate data required for different cultivars.

In the peach brown rot control trial: 1) a low (0.3%) level of brown rot blossom blight occurred in first blooms (<1%) from both treatments (prior to first spray and before any disease risk was acknowledged), 2) no sources of primary inoculum were located, 3) two less blossom fungicide applications were used in the DMS programme than the standard, 4) less than 1% of fruit in either treatment had developed brown rot by harvest, 5) loss of fruit from latent infections in storage was low and differences in final disease losses (<3%) were not significant.

In the apple black spot control trial: 1) black spot incidence on fruit at harvest was not significantly different between treatments and was less than 1.4%, 2) no differences in incidence of fruit russet or other diseases were detected between treatments, 3) the DMS treatment received ten black spot and one mildew spray applications compared with 14 and three respectively for the grower treatment, 4) both spray programmes used equal numbers of eradicant fungicides (three DMI, three dodine), 5) fungicide costs were approximately 20% lower in the DMS treatment than in the grower treatment.

CONCLUSIONS

While systems for management of peach brown rot and apple black spot are still at an early stage of development, initial testing has been encouraging, both in terms of potential benefits in disease control and from responses of growers associated with the projects. There appears to be a definite role for the formal DMS approach in disease management. Risk assurance remains a major barrier to the success of such systems and decision rules will need to be applied successfully to many different disease epidemics before the systems can be extended to growers. The evolutionary development approach, by which conservative decision thresholds are refined with experience, should assist system development and ultimate implementation.

ACKNOWLEDGEMENTS

P. Elmer for valuable advice on the brown rot DMS. L. Morgan and I. Sorenson for technical assistance.

REFERENCES

- Collyer, E. and Van Geldersman, M., 1975. Integrated control of apple pests in New Zealand 1. Outline of experiment and general results. *N.Z. J. Zool.* 2: 101-134.
- Denning, P.J., 1986. Towards a science of expert systems. *American Scientist* 74: 18-20.
- Manktelow, D.W., 1990. A systems approach to apple black spot management in Canterbury. M.Hort.Sc. Thesis, Lincoln University. pp 79-89.
- Manktelow, D.W. and Laurenson, M., 1990. Development of a decision aid for pest and disease management in fruit crops. *Proc. 43rd N.Z. Weed and Pest Control Conf.*: 114-116.
- Mills, W.D. and Laplante, A.A., 1954. Diseases and insects in the orchard. *Cornell Extension Bulletin No. 711*: 20-28.
- Self, K., 1990. Designing with fuzzy logic. *Institute of Electrical and Electronics Engineers Spectrum* 11: 42-44 + 105.
- Teng, P.S., 1987. A systems approach to pest management. *In*: P.S. Teng (Ed) Crop Loss Assessment and Pest Management. American Phytopathological Society, USA. 270pp.
- Wearing, C.H., 1988. Evaluating the IPM implementation process. *Ann. Rev. Entomol.* 13: 17-38.