Paper 10

RECENT NEW ZEALAND STUDIES ON THE CHEMICAL CONTROL OF LATE BLIGHT OF POTATOES

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INTRODUCTION

Very few diseases have been the subject of as much research as late blight of potatoes (induced by the fugus *Phytophthora infestans* (Mont.) de Bary). Much of this research has been aimed at developing effective control measures, but despite this work the disease continues to cause serious crop losses. Here in New Zealand, the disease may occur infrequently, e.g. in Canterbury, or it may occur for at least part of every season, e.g. at Pukekohe. In areas such as Pukekohe, the problem has been compounded by consumer preference for Ilam Hardy, a cultivar with little or no resistance to late blight, and by farming economics which militate against the elimination of ground-keeping, thus ensuring a perennial source of infection. Growers have therefore come to rely almost entirely on fungicide application to keep the disease under control.

The cost of chemical protection can be high. In the past, costs from all sources (including the direct and indirect costs of wheel damage) have been estimated at 6-10% of crop value — it is probably no less today. Work at Plant Diseases Division has been aimed at reducing the need for frequent spraying and hence at reducing the cost of control.

POSSIBILITIES IN PREDICTING LATE BLIGHT EPIDEMICS

The first step in the research programme was to evaluate the possibility of applying sprays only when the disease is active, by developing a forecasting system to pinpoint the critical periods. Two different forecasting systems are possible:

Infection forecasts

These predict when conditions for infection are about to occur. Infection forecasts have the advantage that they can be used in conjunction with traditional fungicides, since the aim is to apply these fungicides to protect the plant before the fungus has been able to invade. They have, however, the great disadvantage that the weather must be predicted at least 36 hours in advance so that growers can spray all their crop before conditions become critical. Weather forecasting in New Zealand is not yet sufficiently reliable for this option to be used.

Disease forecasts

These indicate that conditions favouring infection have occurred; that disease will become apparent after the normal incubation period. Once what constitutes an infection period has been defined, it is relatively simple to record such periods as they occur and to inform growers immediately — there is then at least 2 days to apply the spray before the disease becomes apparent. In America, sophisticated recorders are obtainable that can be placed in the crop and that automatically record such periods. The overwhelming disadvantage of disease forecasting, until recently, has been that it needs to be used in conjunction with a systemic eradicant fungicide, as the fungus is in the leaf by the time the fungicide is applied. Such fungicides, a group collectively known as the acylalanines, first became available for testing in 1976.

NON-SPRAY APPLICATIONS OF ACYLALANINES

Early tests at Plant Diseases Division showed that some acylalanines were very active, very mobile, and highly suitable for use with forecast applications. In addition, however, because they were so active, it was thought they might also be effective as protectants if applied to the soil or tubers at planting time. If uptake of the fungicide into the developing tops continued for several weeks there would be no need to apply sprays, at least for the early part of the season. This idea worked extremely well, even in seasons when blight was very destructive, and it was found that the protection lasted almost until harvesting (Table 1) and beyond the point where late sprays were economic. Details of this work have been published elsewhere (Hartill, 1980).

Table 1. Comparison of metalaxyl treatments for control of potato late blight in Ilam Hardy planted 24.9.79.

Treatment (rate and method of applying metalaxyl)	Infection (% leaf destroyed) 3.12.79	Yield (g/plant) 7.1.80 total	Yield (g/plant) 7.1.80 saleable	Blighted tubers/ plant
0.8 kg/ha applied to tubers before planting	0.1	1015(b)	833(b)	0.2
7 sprays 0.25 kg/ha/spray in 1100 liters/ha, 700 kPa	0.4	1130(a)	970(a)	0.1
7 sprays 0.25 kg/ha/spray in 400 litres.ha, 350 kPa	1.8	940(b)	815(b)	0.1
Control (no tuber treatment, no sprays)	97.0	660 *	270 *	1.1

*, (a), (b): In each column yield values having different letters differ significantly (P 0.5) Duncan's Multiple Range Test. Control treatment values were not included in the analysis).

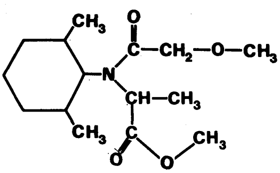
RESISTANCE TO ACYLALANINES

The first acylalanine fungicide to be released, metalaxyl ('Ridomil'), was used from 1978 onwards to control late blight in the poroporo crop then being developed at Waitara. In some areas, particularly in the seedbeds, sprays were applied frequently as a routine treatment. In 1980, there was a report that, in one poroporo seedbed, sprays were not controlling the disease. Shortly afterwards there were similar reports from potato crops in Europe and elsewhere (Davidse *et al.*, 1981), and at the end of the year from a potato grower at Onewhero, South Auckland. In early 1981, a further case was reported from Cambridge. In all these cases it was found that strains of the fungus had appeared that were resistant to metalaxyl. The resistant isolates were also resistant to a number of other fungicides (Fig. 1) *in vitro* (Hartill, 1983) and this has subsequently been confirmed with leaf disc bioassays.

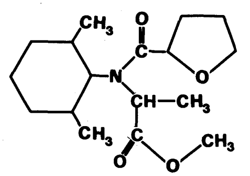
Metalaxyl was withdrawn from the market, but has since been re-issued in combination with mancozeb. It was anticipated that the combination of the two fungicides would be very effective in controlling the disease and that the addition of the protectant would reduce the probability of resistant strains proliferating. Since then no further cases of acquired resistance to metalaxyl have been discovered in field crops.

In many countries, the use of metalaxyl, either alone or in mixtures, for the control of potato late blight has been abandoned. However, the apparent failure of the resistant strains to spread to further locations in New Zealand since their first discovery, suggests that it may be possible to use acylalanine fungicides effectively for a number of years, providing they are used prudently.

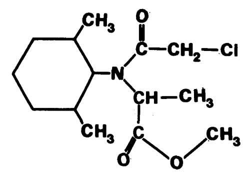
A strategy for the use of metalaxyl mixtures that should minimise the chance of populations of the late blight fungus acquiring resistance has been outlined by Hartill



metalaxyl 'Ridomil'



furalaxyl 'Fongarid'



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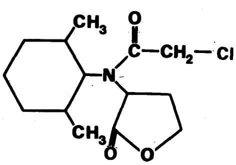

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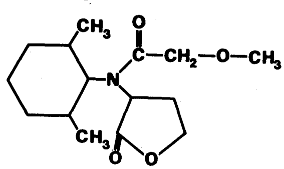

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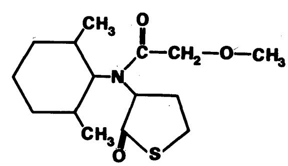

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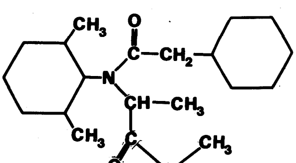
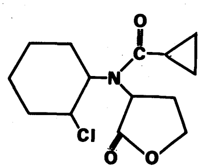


benalaxyl 'Galben'



cyprofuram 'Vinicur'

Figure 1. Comparative structures of acylalanine fungicides.

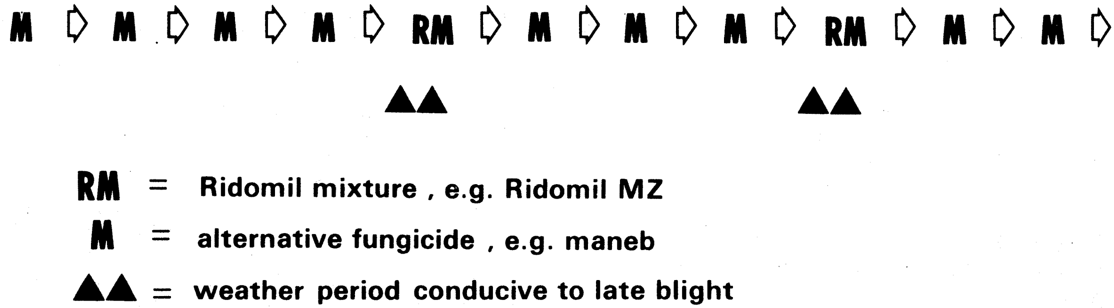


Figure 2. Suggested strategy for the use of metalaxyl (or other acylalanines). Note that applications should be timed according to weather.

(1982). The strategy suggested is to restrict the use of mixtures of metalaxyl, or its analogues, to the few days following severe infection periods before the sporulating lesions appear. In this interval maximum use can be made of the eradicant properties of the fungicide, while keeping the selection pressure towards resistance in the fungal population to a minimum. At other times, applications of traditional fungicides, e.g. maneb or mancozeb, should give sufficient protection (Fig 2). The number of metalaxyl mixture applications should be restricted; three is probably the maximum that should be applied to any one crop. Metalaxyl should never be applied to severely diseased crops.

With this system it should be possible to widen the interval between sprays, however, there is still a problem in defining the periods when the metalaxyl mixture should be used. Research is now concentrated on producing a workable forecasting system.

POTATO LATE BLIGHT FORECASTING RULES

Late blight forecasting was pioneered by Van Everdingen in the Netherlands in 1926. However, it was not until about 1950 that further studies led to other forecasting rules being formulated. These rules basically predict that blight outbreaks will follow the occurrence of certain weather conditions usually specified in terms of air temperature, relative humidity and/or rainfall. Details of many of these early forecasting rules have been described by Bourke (1955).

In a preliminary study on the relationship between weather and late blight outbreaks in Ilam Hardy potato at Pukekohe (Young, unpublished), three forecasting rules were tested.

Beaumont Rule — a blight period is 48 consecutive hours during which relative humidity (RH) is at least 75% and temperature is at least 10°C (Beaumont, 1947).

Irish Rule — a blight period is 16 consecutive hours during which RH is at least 90% and temperature is at least 10°C (Bourke 1955).

90% Rule — a blight period is 2 consecutive days (each day from 1300-1200 h) during which temperature is at least 10°C and there are 11 or more hours per day when RH is at least 90% (Croxhall and Smith, 1976).

All these rules were found to be unreliable under Pukekohe conditions. In general, they seriously underestimated the number of blight outbreaks and thus were unsuitable for disease forecasting purposes. A revised project was initiated in May 1981 to examine more critically the influence of weather on late blight outbreaks. Essentially this required that late blight infectious days be accurately identified and that the concurrent weather conditions be simply but specifically defined.

IDENTIFYING BLIGHT DAYS AT PUKEKOHE

The earlier study had clearly shown that blight periods could not be reliably identified by periodic observations of the progress of the disease in field plots. The procedure described below was therefore adopted.

- Plots of Ilam Hardy potato were planted at regular intervals adjacent to an automatic weather station. These plots were exposed to natural infection and it was ensured that growing plants were always present.
- Ilam Hardy potato plants ("trap plants") were raised in planter bags in a blight-free environment at DSIR, Auckland and transported to a dry glasshouse at Pukekohe at weekly intervals.
- Everyday at 1000 h, 2 plants were taken from the glasshouse and exposed for 48 hours in the field plots where blight was most active.
- Exposed plants were removed from the field plot and held in a dry, cool environment for assessment of disease. If late blight infection had occurred, symptoms usually appeared in the trap plants after 4-7 days, depending on air temperature.
- Disease level was assessed as the % of leaflets infected by blight on the 3rd day after the initial appearance of symptoms (to minimize the chance of

assessing disease caused by post-field infection). diseased plants were then destroyed. Plants which were not infected were destroyed 10 days after field exposure.

The use of trap plants in this over-lapping manner enabled blight days to be readily identified. Except when the disease level in the field was very low (less than 1 lesion per 10 plants), the procedure has been very effective.

THE CLIMATOLOGICAL MODEL DEVELOPED FOR POTATO LATE BLIGHT

Field and crop weather conditions were recorded every hour by the automatic weather station. Extensive analyses of the data indicated that air temperatuer and duration of leaf wetness were the prime parameters which influenced late blight infections. Air temperature which was measured at 1.4 m over an open site would be similar to that measured within a standard Stevenson screen. Duration of leaf wetness was estimated from readings from a leaf wetness probe (Young *et al.*, 1979).

The climatological model developed from further analyses of temperature and leaf wetness data is shown schematically in Figure 3. It is a fairly simple concept requiring only that leaves be wet for a sufficiently long period to accumulate 80 growing degree hours (80GDH) using a base of 7.2°C. The GDH method quantifies the termal climate which must have some influence on the rate of the infection wetness fall below the respective thresholds) of up to 2 hours each to allow for short term fluctuations within a critical period. In practice these breaks seldom occur during blight weather.

The close correlation between trap plant infection and 80GDH periods is evident from Figure 4a which covered a period when late blight was active, the host was growing vigorously, and there was continuous climatological and trap plant information. Occurrences of critical periods according to the Beaumont, Irish and 90% rules are also included in this diagram. Points to note from Figure 4a are:—

- during late blight epidemics, infection on trap plants occurred more frequently than would be suggested from the occurrences of Beaumont, Irish or 90% rule periods.
- the 80GDH periods were closely related to late blight infection. In this context it is the date of infection and not the amount of infection which should be compared with the occurence of 80GDH periods. The level of infection reflects mainly the number of blight spores present on any particular day.

To facilitate the interpretation of 80GDH periods in terms of a forecasting system, the 80GDH information

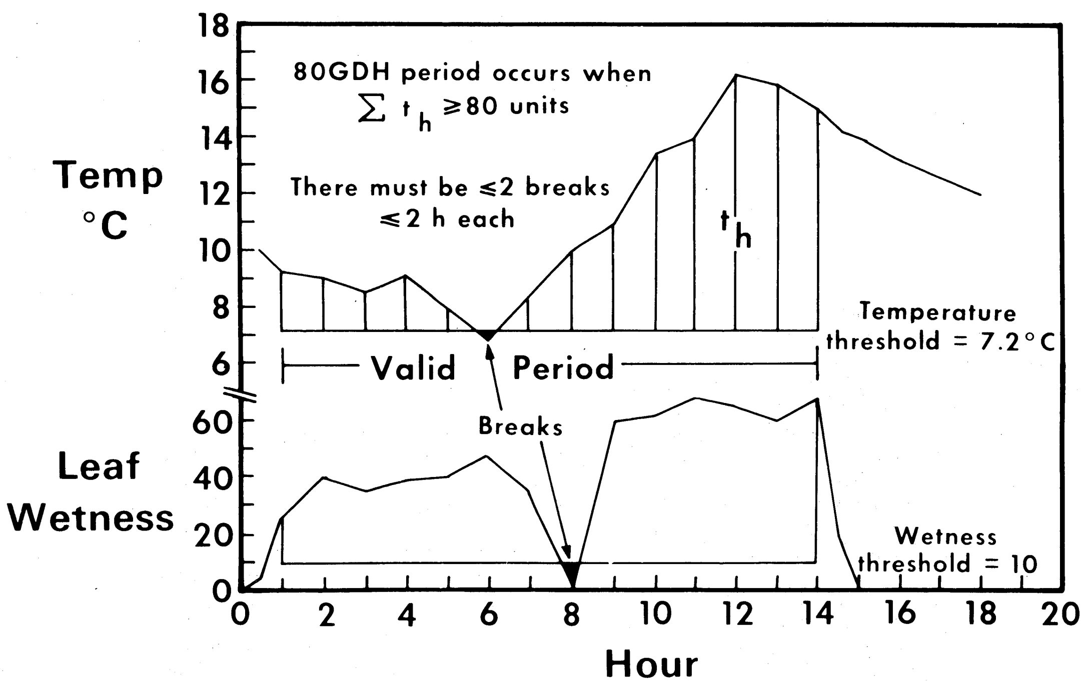


Figure 3. The climatological model for forecasting potato late blight.

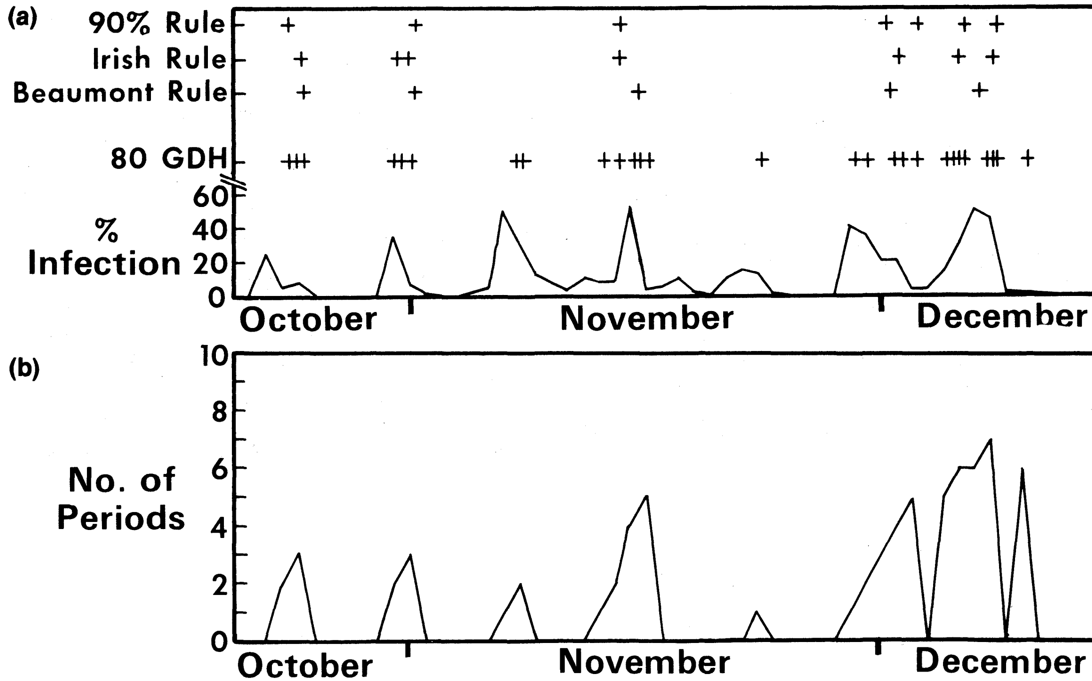


Figure 4. a) Trap plant infection and occurence (+) of some blight periods — 20/10/81 to 15/12/81.
b) Number of 80GDH periods over 5 days when the last day of the interval had at least 1 period.

presented in Figure 4a was transformed into the curve presented in Figure 4b. The characteristic peaks in Figure 4b were developed by summing the number of 80GDH periods over 5 day intervals when the last day of the interval had at least one period. Examination of this information, collected over the past 2 years, suggests that the 5-day technique could be used as a guide in optimising a spray programme designed to prevent the buildup of late blight epidemics. For example, it would appear that spraying is not required when the height of the peak does not exceed a single period. Based on the previous history of the crop, a spray may have to be applied when the peak is greater or equal to 2 periods. When the peak is at 3 or more periods, spraying would be mandatory.

PROSPECTS

The 80GDH method appears to be a satisfactory basis for predicting periods when late blight is active. However, its precision is diminished following long dry or cold periods when the disease virtually disappears. During blight-active periods, live spores may be present at the time that foliage becomes wet and the 80GDH period may only be taking account of the time required for infection to become established. Following long intervals between blight outbreaks, a longer period (e.g. 100GDH) may be necessary to allow for the time taken for spores to be produced. Further research is needed before a workable forecasting system can be formulated and tested. Recently formulated late blight forecasting systems, such as BLITECAST (Krause *et al.*, 1975), also need to be evaluated.

In the final analysis, a forecasting system based entirely on climatological information is unlikely to be completely successful. Perhaps such a system can only work when biological information on the disease is integrated with the forecasting system — in practice the grower may need to interpret the forecast in relation to his particular situation, rather than to be totally reliant on it. The implementation of the system may appear to be complex, but with modern technology, electronic recorders should be able to automatically provide forecasts.

Note added in proof

Since this paper was presented, resistant strains of *P. infestans* have become common in the South Auckland potato-cropping area and have reduced the efficacy of acylalanine fungicides. Further field developments of this forecasting system will be deferred until the introduction of new fungicides effective against all local strains of the pathogen.

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