**PT341**

# Integrated management of early and late potato blights in Australia

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# PT341

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## Volume 1

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# INDUSTRY SUMMARY

Successful and consistent control of Target spot was achieved by using an integrated management strategy based on crop monitoring which resulted in an overall reduction in the level of spray applications by up to 63%.

This research project examined ways of improving the management of foliar blights on potatoes by testing various strategies, such as varying spray initiation and intervals and fungicides, to determine the most effective control program. Very little Late blight occurred during this time, so the emphasis was on controlling Target spot.

A Potato Crop Management Program (WISDOM), developed by the University of Wisconsin, was tested in South Australia and Tasmania as a tool to control Target spot (Early blight) in potatoes. The program uses weather data to predict initiation and timing of fungicide applications by calculating physiological days (Pdays), based on the maximum and minimum ambient temperatures which determine the growth of the potato plant. The Pdays used to initiate spraying are entered into the WISDOM program, and can range between 200 and 400. Weather stations to monitor temperature, rainfall and leaf wetness were placed at trial sites and in commercial crops and the data used both for running the WISDOM program and to correlate the weather conditions with the level of Target spot.

A spray program initiated after the appearance of the first Target spot lesion was the most consistent method of achieving effective control whilst minimising spray applications. This would require regular and careful monitoring of the crop from tuber initiation. Failure to detect when early leaf infections occur may result in poor disease control and significant reduction in yield, especially when infection occurs early in the growth stage of the crop. The WISDOM program could be a worthwhile tool when used in conjunction with regular crop and weather monitoring, as long as the spray initiation time was correctly entered. However a management strategy based on risk assessment and a protectant spray schedule should also reduce spray applications, especially when the crop is considered "low risk". The spray initiation still needs to be based on lesion appearance, requiring rigorous crop monitoring.

The effectiveness of Score applied only after an infection period was extremely variable. Infection periods were defined as periods of leaf wetness from 8 hours at >15°C to 12 hours at >10°C that were likely to give rise to an infection. Accurate methods of determining infection periods are needed, as if only a few of these occur each season then an eradicant schedule may result in considerable savings in spraying costs. However where heavy dews are frequent or with regular rain events, many infection periods occur and spraying would be more appropriate on a protectant schedule. The manufacturers recommended that Score be sprayed no more than twice consecutively in a season to prevent resistant strains of the fungus developing. Applying protectants on a regular schedule and using Score only after infection periods showed promise, and was an effective program to minimise the use of Score during the season.

The incubation period, the time from infection to the appearance of leaf spots, varied from 7 to 16 days. In most of the crops measured the incubation was 8 days, however in colder weather the growth of the fungus was slowed down and leaf symptoms appeared up to 16 days after infection. Therefore when inspecting crops for disease symptoms, there could be a delay from the expected 7 days from infection to symptom expression, dependant on weather conditions.

In most trials the development of Target spot was difficult to contain, particularly near the end of the growing season. The fungicide sprays controlled the disease to an acceptable level during the early and mid season, but in all crops there was an increase in disease level late in the crop development with no apparent effect on yield. Crop development can be measured by canopy growth stage, where a particular growth stage is expressed as a percentage of the interval between emergence and senescence. For example with a crop of 120 days (eg Russet Burbank in Tasmania), row closure typically occurs 40 days after emergence and is thus at the 35% canopy growth stage. The stage of crop development after which infection does not compromise yield is approximately 60% canopy growth stage, but more work needs to be undertaken to confirm this figure in varying risk conditions.

## TECHNICAL SUMMARY

This research project examined ways of improving the management of foliar blights on potatoes by testing various strategies, including varying the spray initiation and schedules and fungicides, to determine the most effective control program. Very little Late blight occurred during this time, so the emphasis was on controlling Target spot.

Twenty field trials were conducted over 4 years to evaluate the effectiveness of different spray regimes to control Target spot (Early blight) in potatoes. Weather stations to monitor temperature, rainfall and leaf wetness were placed at trial sites and in commercial crops and the data used to run the disease forecasting system, the Potato Crop Management Program (WISDOM), developed by the University of Wisconsin. The spray schedule recommended by the program, based on physiological days (Pdays), was compared using protectant and eradicant spray schedules.

The most effective spray schedule, to control disease whilst minimising fungicide application, was a regular protectant regime which initiated spraying when the first Target spot lesions were observed in the leaves. The PCM program initiated spraying on a Pday value between 200 and 400, manually entered into the program. On the crops evaluated in South Australia, Target spot leaf lesions first appeared at Pdays ranging from 177 to 439, depending on weather conditions and inoculum levels. In Tasmania, the range was much higher, from 325 to 699. For the program to be effective, monitoring of crops from tuber initiation is essential to determine the Pday when leaf lesions are first observed, and this value must be able to be entered into the program as the trigger to initiate spraying.

Infection periods were defined as periods of leaf wetness from 8 hours at >15°C to 12 hours at >10°C that were likely to give rise to an infection. Accurate methods of determining infection periods are needed, as if only a few of these occur each season then an eradicant schedule where Score is only applied after an infection period may result in considerable savings in spraying costs. If infection periods were not able to be accurately determined, the regular protectant schedule provided the best disease control when initiated at sign of first lesion. Where the infection periods were able to be determined, but there were many in the season, substituting the protectant fungicides with Score for 2-3 sprays after an infection period reduced the overall number of sprays without compromising control, as the Score could be applied with a longer interval between applications.

In all crops monitored, and in all trials, the development of Target spot increased near the end of the growing season with no apparent effect on yield. In most of the trials no significant effect on yield could be demonstrated between treatments. The canopy growth stage after which spraying was no longer required was not accurately determined. In Tasmania, the 60% canopy growth stage was shown to be the approximate threshold past which the initiation of spraying for disease control no longer improved yield. However it is likely that when the spray program has been initiated earlier in the season, the threshold where further spraying becomes unnecessary would be later than 60%.

The incubation period which is the time from infection to the appearance of leaf spots, varied from 7 to 16 days. In most crops measured the incubation was 8 days, however in colder weather the growth of the fungus was slowed down and leaf symptoms appeared up to 16 days after infection.

## TECHNICAL REPORT

### AIM

To develop an integrated disease management program for both Target spot/Early blight (*Alternaria solani*) and Irish blight/late blight (*Phytophthora infestans*) in Australia.

Late blight occurred only on one site in Tasmania late in the season of 96/97, so only integrated stategies for Target spot were examined.

### INTRODUCTION

Potatoes are one of the major vegetable crops grown in Australia and as they need large levels of both chemical and cultural inputs to maintain yields, are one of the more expensive crops to produce.

Target spot - also known as Early blight - caused by *Alternaria solani* Sorauer and Irish blight - also known as Late blight - caused by *Phytophthora infestans* (Mont.) de Bary were identified as the two most important potato leaf diseases by growers. A recent survey in South Australia showed that many growers apply up to 8 sprays per season (Dillard et al, 1993) and that fungicides applied to control Target spot make up the major share of pesticides applied to potatoes.

Despite the frequent application of fungicides few growers obtain good control of the disease. The reasons for this are thought to be mistimed spray applications and in particular starting the spray programmes after the disease is well established. In most years this could cost growers between $2,000 to $3,000 per Ha in potential yield loss as well as more than $200 per Ha in spray costs.

*Alternaria solani* attacks leaves and stems and can cause premature defoliation, which may result in yield losses of up to 20-30%. First appearing as tiny brown lesions on the lower to middle third of the plant's leaves, the fungus produces lesions that are roughly circular and consist of concentric rings of dead tissue which result in a "bulls eye" target appearance. As the disease spreads lesions appear on the younger leaves and stems.

The disease persists on infected crop residues and tubers, in the soil, on alternate hosts (i.e. brassicas) and solanaceous species (i.e. nightshade). Spores from these sources are mainly carried by wind or water and deposited onto the leaves of the crop. The spores germinate and infect the plants when wet and humid conditions persist.

*Phytophthora infestans* can over winter as mycelium in living potatoes, including volunteers, waste piles and stored potatoes. The main spread of the fungus is through sporangia which germinate directly or indirectly by zoospores release. During favourable weather (periods combining moderate temperature, extended moist conditions and high humidity) the disease can develop and spread rapidly. Lesions will appear a few days post infection as small flecks and quickly expand to grey/green water soaked areas. This infected tissue dries and dies within a few days, with an outer edge of lighter green tissue often surrounding the expanding lesion. During wet periods or dewy mornings the margins of the lesions on the lower leaf surface show white fungal growth, producing an abundance of sporangia. Sporangia spread the disease rapidly within the crop resulting in defoliation and plant death. Tubers, infected by spores washed from lesions, may show sunken irregular skin lesions.

The present approach to control of these Potato diseases utilises the application of protectant fungicides, with the spray program initiated at an early stage to act as a virtual 'insurance policy' to reduce disease risk. This results in a number of fungicide applications with no measurable effect on disease severity, tuber yield or quality. With the ever present need to reduce the level of pesticide use, both due to increasing costs and the general community's concerns about possible environmental and health risks, there is a need to improve the spray program strategy for the blights.

## STRATEGIES TO REDUCE SPRAYS FOR TARGET SPOT

Disease forecast systems for Target spot which are based on monitoring climatic conditions in the field have been developed overseas (Harrison 1992, Rotem 1994) and need to be evaluated and adopted to Australian conditions. A system developed in the USA is now widely used commercially (Pscheidt and Stevenson *et al*, 1986) and is marketed as an integrated systems approach to potato crop management. In Tasmania, a spray warning system has been developed in the onion industry, but a similar approach has not been adequately tested for potatoes.

This project evaluated a forecast system based on physiological "P" days (WISDOM program) and compared this with systems based on curative or protective programmes. The aim of this was to ultimately recommend a system that allowed more timely applications of fungicides, improved disease control, increased yields as well as reduced pesticide use on potatoes throughout Australia.

The initial project included both Target spot (*Alternaria solani*) and Irish blight (*Phytophthora infestans*), but since the later disease did not develop during the extent of the project, all emphasis was placed on Target spot.

## EPIDEMIOLOGY OF TARGET SPOT

In order to develop a reliable disease forecast system, the epidemiology of Target spot needs to be considered. Several factors are important for determining the severity of disease.

1. **Inoculum levels** : The disease mainly survives as mycelium in potato hulms and tubers, persisting on infected crop residues and tubers, in the soil and on alternate hosts (Rotem, 1994). Spores from these sources are mainly carried by wind or water and deposited onto the leaves of the crop, where they germinate and infect the plants when wet and humid conditions persist (infection period) (Rotem, 1994). Under normal weather conditions with a three year or longer rotation, most if not all inoculum will die out providing host material is not available (Rotem, 1994). Once this happens the only source of inoculum for such a paddock is spores that blow in from neighbouring sources.

   Inoculum levels were not quantified in this study, however it is possible to assess the likely level of inoculum by considering paddock histories. Target spot is generally considered to be ubiquitous, owing to the abundance of hosts during rotations, such as volunteer potatoes and the common weed nightshade, however some paddocks may be more at risk than others.

   Factors that contribute to high inoculum levels include:
   - paddock with history of poor control
   - a large number of volunteer potatoes or alternate hosts
   - adjacent to a likely inoculum source such as the previous year's potato paddock or cull piles
   - downwind of a likely inoculum source
   - less than three years since last potato crop

   Factors that would favour low inoculum levels include:
   - paddock with history of well controlled volunteer potatoes and alternate hosts or only low numbers of each
   - not adjacent to a likely inoculum source such as the previous year's potato paddock or cull piles
   - not downwind of a likely inoculum source
   - more than three years since last potato crop

2. **Presence of suitable infection site** : Ageing, injured or stressed leaves are more susceptible and some cultivars have a level of field resistance.

3. **Number of infection periods** : Once a spore lands on a susceptible leaf it requires moist humid conditions to actually infect the leaf. The number of infection periods can be recorded using electronic weather monitoring stations. An infection period requires leaf wetness periods that persist for eight hours or more above 15°C or 12 hours or more above 10°C. Since irrigation can increase the number of infection periods, particularly overnight where drying is less, sensors from the monitoring equipment need to be placed within the crop canopy.

4. **Time of disease occurrence in relation to canopy growth stage** : The time of the appearance of the first disease lesion was recorded in most trials, and Target spot was rarely seen on the young rapidly expanding leaves. Older leaves are more susceptible, however it is uncertain what, if any, is their contribution to tuber bulking. They may be only "passenger" leaves, possibly even having a negative contribution to tuber bulking. The still green older leaves in the middle third of the plant are more likely to contribute to tuber bulking, but are most at risk from new infections.

The severity of an epidemic will be determined by a combination of all these factors. For instance, if there is little inoculum then the epidemic is unlikely to be severe unless there are a large number of infection periods to facilitate spread, but unless these occur early in the canopy development, the disease is still unlikely to impact on yield. It is well documented that if Target spot does not begin until late in the canopy development, then there will be no effect on yield. Thus, the timing of initial infection in relation to canopy growth stage can be of value in determining whether or not to spray.

## SIGNIFICANCE OF DISEASE DEVELOPMENT.

In most of the trials the appearance of the first lesion was recorded and can be related either to emergence or to the canopy growth stage, and hence to senescence. Table 1 provides data from trials in this study which show how the timing of the first infection in relation to canopy growth stage effects yield.

In this study, canopy growth stage refers to the interval between emergence and senescence, and the particular growth stage is expressed as a percentage of this interval from emergence. For example, row closure, which typically occurs 40 days after emergence, is about the 35% canopy growth stage if the interval between emergence and senescence is 119 days, a common interval in Tasmania for Russet Burbank.

The standard protectant program effectively prevented yield reduction in three out of the five trials undertaken in Tasmania. It is interesting to note that on the occasions it was effective, Target spot first appeared relatively early in the canopy growth stage (53%, 43% & 45%). The two trials where it had no significant yield effect, the disease first appeared later in the canopy growth stage (61% & 61%). The same observation can be made from the other trials not involving the standard Dithane program where again significant differences in yield were only measured when the disease occurred relatively early in the canopy growth stage (53%) compared to the trials with no yield effect where the disease first appeared later in the canopy growth stage (62% & 73%).

While significant differences in yield will also depend on whether or not the fungicides applied actually worked, in these trials the pattern is very consistent and highlights the importance of considering canopy growth stage when the disease first appears in an integrated management strategy. If the disease first appears late in the canopy development it is likely that it will have less impact on canopy growth and consequently yield.

For developing an integrated management strategy for Target spot, the timing of appearance of the first symptom in relation to canopy growth can be measured and could be considered in making a decision as to the control measures to be implemented.

In Tasmania the majority of potatoes are the one cultivar, Russet Burbank, grown for processing. Most planting occurs in October and November and cropping times are generally very uniform. Farmers plan harvest dates based on planting dates and emergence dates. This relative uniformity of production timing makes the prediction of canopy growth stage very reliable and practical. Thus the timing of infection in relation to canopy growth stage could be used as part of an integrated management strategy.

Tuber bulking can occur throughout the canopy growth stage, however 65% to 95% of bulking occurs prior to the 60% canopy growth stage (Chung, pers comm.), depending on irrigation scheduling. The disease will first attack ageing leaves, which are declining in the amount of contribution to tuber bulking and it will take several disease cycles before any significant impact is made on the total area available for photosynthesis. Thus the commencement of an epidemic after the 60% canopy growth stage is unlikely to impact on yield unless there are a large number of infection periods occurring soon after the epidemic is initiated. Infection periods towards the end of the canopy growth will almost certainly have no impact on yield as most of the tuber bulking will be completed and there will be insufficient time for enough active leaves to be damaged.

In Tasmania, the data suggested that the 60% canopy growth stage was the threshold past which disease development did not compromise yield (Table 1). In South Australia the disease developed much earlier, however the yield data was too variable to draw the same conclusions. More research needs to be undertaken on this aspect of the disease and large field trials would be required as yields are too variable with the small plot trials used in this work. Measuring yield is imperative, as using total leaf damage, while an excellent indication of disease initiation and development, can be misleading. Even though the middle third of the plant was used for the leaf disease measurements, the results can not always be directly correlated to yield, because it would depend on how much these leaves are contributing to carbohydrate assimilation.

Table 1. Marketable yield (t/ha) from all the Tasmanian trials, and timing of first target spot lesion.

| TRIAL | Yield t/ha Control | Yield t/ha (Fungicide treatment)** | Lsd P<0.05 | Canopy stage first lesion appeared* |
|---|---|---|---|---|
| **Barrington 1 94/95** | 32.9 | 44.5 **(Dithane Program - 7 to 10 day interval from row closure)** | 3.77 | 53% |
| **Barrington 2 94/95** | 32.5 | 43.6 **(Score at 10-14 day interval from first forecast infection period)** | 3.20 | 53% |
| **Sisters Creek 95/96** | 35.9 | 45.7 **(Dithane Program - 7 to 10 day interval from row closure)** | 4.61 | 43% |
| **FVRS 2 96/97** | 29.8 | 39.3 **(Dithane Program - 7 to 10 day interval from row closure)** | 5.52 | 45% |
| | | | | |
| **Table Cape 1 94/95** | 50.4 | 50.5 **(Rovral at 10-14 day interval from first lesion to senescence)** | ns | 62% |
| **Table Cape 2 94/95** | 48.3 | 51.0 **(Rover at 7-10 day interval from row closure with 2 x Rovral at first lesion 10-14 days apart)** | ns | 73% |
| **Scottsdale 94/95** | 52.8 | 61.1 **(Score at 10-14 day interval from P200 days to senescence)** | ns | not recorded |
| **Cressy, 95/96** | Trial destroyed by flood waters 3 weeks after row closure | | | |
| **FVRS 95/96** | 55.3 | 50.3 **(Dithane Program - 7 to 10 day interval from row closure)** | ns | 61% |
| **FVRS 1 96/97** | 47.0 | 50.6 **(Dithane Program - 7 to 10 day interval from row closure)** | ns | 61% |

*Growth stage from emergence to senescence.

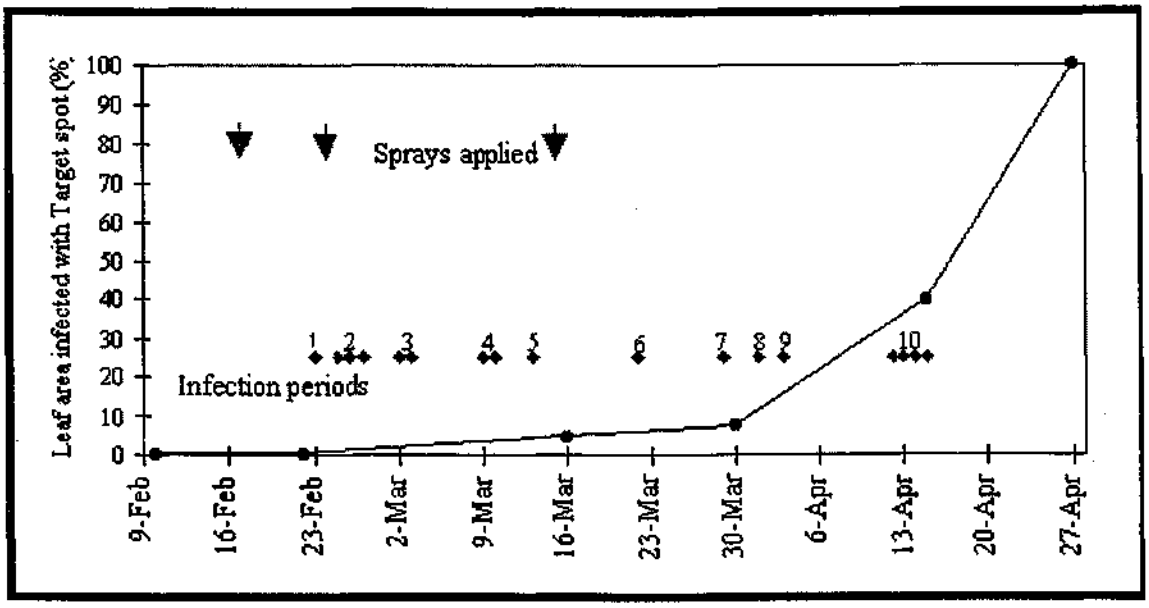
**Yield from standard spray program for Tasmania (Dithane program - 7 to 10 day interval from row closure) given for all trials that included this treatment, otherwise highest yielding fungicide treatment is presented.

A major limiting factor in determining the effect of disease on yield is being able predict the severity of the epidemic, as this will vary from paddock to paddock and season to season. The severity will depend not only upon when the epidemic begins but also how much inoculum is present and how many infection periods occur, and when they occur. The number of infection periods can be recorded as the season progresses and this data may be needed to plan spray programs in situations where the epidemic commences late in the canopy growth stage.

Potato plantings on commercial properties near two trial sites in South Australia were regularly monitored to assess the level of disease. The amount of Target spot was assessed using the disease keys in appendix 3 on a full leaf from the middle third of each of 10 plants from 10 areas chosen at random within the planting. A disease progression curve was correlated against rainfall and temperature data collected from nearby weather monitoring equipment.

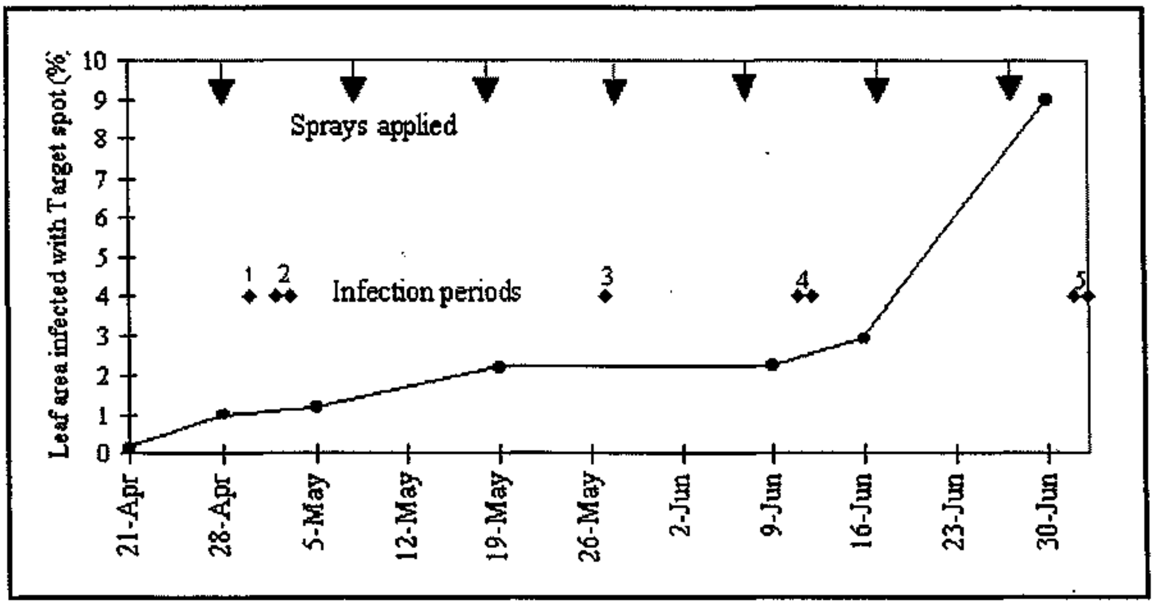
In the potato crop adjacent to the Lenswood trial, 1993/94, there were 10 infection periods from the start of flowering to harvest (Fig 1). The first lesion was observed during flowering, and the disease steadily increased until approximately 70% canopy growth stage, where most likely due to lack of fungicides applied, the progression rapidly increased resulting in total canopy destruction. Where infection periods occur regularly as in this example, it would have been more appropriate to use a protectant fungicide regime. The use of an eradicant schedule of Score at every infection period would have resulted in more applications than recommended by the manufacturer.

Figure 1. Disease progression curve and infection periods, Lenswood 1994



In contrast, the planting at Virginia adjacent to the 1995 trial, where 5 infection periods occurred after flowering (Fig 2), would have been suitable for an eradicant program. At this site the infection periods were sufficiently apart in time to be considered as 3 groups which would have required only 3 well timed sprays over the season. The level of Target spot remained quite low, only affecting 10% of the leaf area by harvest.

Fig 2. Disease progression curve and infection periods, Virginia 1995.



## ACCURACY OF TARGET SPOT FORECAST.

It is well established that Target spot mostly infects ageing or stressed leaves, and under normal growing conditions senescence does not begin in the very first leaves until after row closure or flowering. This is consistent with observations in the field where the first lesions usually appear on old leaves close to the soil.

The forecast parameters used were periods of leaf wetness greater than 8 hours above 15°C or 12 hours above 10°C (Rotam, 1994). Weather stations were placed in each crop with sensors positioned in the canopy.

Table 2 summarises Tasmanian data showing the first warning period the disease forecast gave after row closure. Apart from the two trials at Table Cape, the forecast gave at least 4 days warning before the first lesion appeared. This accuracy of forecast is dependant on the frequency and diligence of crop inspection. This warning interval is an indication of the time taken from infection to symptom expression. As the crop was inspected on a weekly basis and symptoms may have been present up to 6 days before sighted, this interval is consistent with the South Australia work (Table 3). This level of accuracy of prediction of infection periods would be a very useful and practical tool for a commercial situation. The major limitation is the need for sensors in each crop. This would be needed to account for the influence of irrigation on infection periods, as well as to be able to take into account micro climate variation.

The trial site at Table Cape had a rather unique location, as the paddock was adjacent to the beach with a north westerly aspect. If inoculum was not already present in the paddock, then it could only come in on southerly winds. The prevailing winds at that time of year were north westerly, and records of wind direction indicate that southerly winds did not occur until well after the first forecast infection period. Thus the apparent failure to predict disease onset at this site may have been due to the absence of inoculum in the early part of the trial. No other trial sites were located adjacent to the beach. This finding suggests a need to inspect crops for the presence of disease in addition to forecasting infection periods. In the past it has been assumed that all paddocks had inoculum, but it would appear that this need not be the case.

Table 2. Accuracy of Target spot forecast in Tasmania.

| Trial | Row closure (days from emergence) | First forecast infection period after row closure | Appearance of first lesion | Warning period |
|---|---|---|---|---|
| **Barrington 1, 94/95** | 12/1/95 | 6/2/95 | 2/2/95 | 4 days warning |
| **Barrington 2, 94/95** | 13/1/95 | 6/2/95 | 2/2/95 | 4 days warning |
| **Table Cape 1, 94/95** | 22/1/95 | 5/2/95 | 2/3/95 | 25 days warning |
| **Table Cape 2, 94/95** | 1/2/95 | 5/2/95 | 15/3/95 | 38 days warning |
| **Scottsdale, 94/95** | 24/12/94 | not recorded | 1/2/95 | not recorded |
| **Sisters Creek, 95/96** | 18/1/96 | 20/1/96 | 25/1/95 | 5 days warning |
| **FVRS, 95/96** | 22/12/95 | 31/12/95 | 6/1/96 | 6 days warning |
| **Cressy, 95/96** | Trial destroyed by flood waters 3 weeks after row closure | | | |
| **FVRS 1, 96/97** | 31/12/96 | 23/1/97 | 30/1/97 | 7 days warning |
| **FVRS 2, 96/97** | 18/1/97 | 23/1/97 | 30/1/97 | 7 days warning |

**THE ROLE OF P-DAYS IN FORECASTING TARGET SPOT.**

Physiological "P" days are used to determine spray initiation (Pscheidt and Stevenson, 1986). P days are calculated from daily ambient temperatures after emergence and are based on the minimum (7°C) and maximum (30°C) growth temperatures of the potato plant and have been used to predict bulking rate and yield of potatoes. Pscheidt and Stevenson (1986) found that spore concentrations of *A. solani* generally increase after 300 P days and that spray applications are most effective when they are initiated after this level of P days is reached.

To assist in determining which Pday was best to initiate a spray program, commercial plantings and trial sites were monitored regularly from emergence and the P days calculated when the first symptoms were observed. These varied considerably, from 177 to 439 in South Australia (Table 3) and 325 to 699 in Tasmania (Table 4). The weather data was then used to determine the most likely date of the infection period causing the lesions, defining the infection period as 12 hours at 10°C to 8 hours at 15°C. The incubation time was then calculated, and was usually around 8 days, however in the colder weather this extended up to 16 days (Table 3). On some occasions there were more than one possible infection period, and in these cases all possibilities have been listed.

Uninfected leaves immediately above an infected leaf on several plants within the unsprayed areas in trial sites were also monitored to determine the incubation period of the new lesions. The incubation period was between 8 and 10 days to infect from leaf to leaf.

From this data, it is apparent that P-days alone are not always reliable when determining the initial spray timing. The WISDOM forecast program initiates spraying at a preset Pday, usually 300, but reducing to 200 when the perceived risk of infection is high and increasing to 400 with low risk. While this is acceptable for some of the crops, there was extreme variability in crops within each risk category. For "normal" risk crops, the prescribed 300 Pdays was too early for most crops in Tasmania, thus wasting sprays. However for some of the South Australian trials, 300 would have been far too late to effectively control the disease, possibly compromising yield with severe early infection. As this program relies solely on Pdays to initiate spraying, parameters to determine the risk category need to be closely examined and better defined for the program to be useful in all instances.

Table 3. Pdays and incubation periods of first lesions in various potato crops, South Australia.

| Location | Variety | Emergence date | Date of first lesion | Pdays | Incubation period (days) |
|---|---|---|---|---|---|
| Lenswood | Winlock | 26.12.93 | 10.2.94 | 326 | 9 |
| Currency Creek | Atlantic | 22.1.94 | 11.2.94 | 177 | 8 |
| Angle Vale | Atlantic | 10.2.94 | 10.3.94 | 241 | - |
| Angle Vale | Whiti | 19.5.94 | 13.7.94 | 337 | 16 |
| Angle Vale | Brodic | 29.6.94 | 18.8.94 | 215 | 16, 19 |
| Angle Vale | Whiti | 19.7.94 | 29.9.94 | 343 | 14, 16 |
| Angle Vale | Atlantic | 19.9.94 | 10.11.94 | 349 | 8 |
| Angle Vale | Atlantic | 2.10.94 | 28.11.94 | 389 | 8 |
| Angle Vale | Atlantic | 12.11.94 | 6.1.95 | 376 | 9 |
| Currency Creek | Atlantic | 12.2.95 | 14.3.95 | 261 | 8, 12 |
| Virginia | Sequoia | 2.4.95 | 28.4.95 | 196 | 9, 12 |
| Purnong | Coliban | 12.8.95 | 23.10.95 | 439 | 8 |
| Lenswood | Coliban | 27.12.95 | 29.1.96 | 204 | 7, 10 |
| Currency Creek | Atlantic | 27.1.96 | 22.3.96 | 425 | 7, 10, 13 |

Table 4. P-Day data for Target spot forecasts in Tasmania .

| **Trial** | **P days at:** | | | **Warning period** |
|---|---|---|---|---|
| | **Row closure (days from emergence)** | **First forecast infection period after row closure** | **Appearance of first lesion** | |
| **Barrington 1, 94/95** | 367 (42) | 502 | 544 | 4 days warning |
| **Barrington 2, 94/95** | 367 (43) | 502 | 544 | 4 days warning |
| **Table Cape 1, 94/95** | 446 (40) | 478 | 699 | 25 days warning |
| **Table Cape 2, 94/95** | 446 (50) | 478 | 564 | 38 days warning |
| **Scottsdale, 94/95** | 275 (49) | not recorded | 570 | not recorded |
| **Sisters Creek, 95/96** | 358 (41) | 377 | 424 | 5 days warning |
| **FVRS, 95/96** | 228 (45) | 225 | 325 | 6 days warning |
| **Cressy, 95/96** | Trial destroyed by flood waters 3 weeks after row closure | | | |
| **FVRS 1, 96/97** | 250 (43) | 448 | 512 | 7 days warning |
| **FVRS 2, 96/97** | 295 (38) | 341 | 404 | 7 days warning |

## SPRAY PROGRAMS FOR TARGET SPOT

Spray programs were designed to compare the efficacy of different regimes, varying factors such as fungicide, spray intervals and timings of the initial application.

Treatments in these experiments included:

1. the application of fungicides following the development of a predetermined physiological "P" days between 200 and 600 (Pscheidt and Stevenson, 1986)

2. the conventional protectant schedule where fungicide applications were commenced around flowering or row closure

3. when the first Target spot lesions were observed

4. where a certain threshold level of disease had developed in a crop. The threshold level of around 5 *A. solani* lesions every 10 m of row was based on the work of Schtienberg(1992), who used a level of 0.01 lesion per plant to recommend the application of fungicides to control *Alternaria* leaf spot in cotton.

5. an eradicant program which evaluated the curative activity of the fungicide Score (Dahman and Staub, 1992) by applying the fungicide only after conditions suitable for infection were recorded. This was based on leaf wetness periods of at least 8 hr or 12 hrs at 15°C or 10°C respectively and did not take into consideration the level of inoculum (Rotem, 1994) (Appendix 4).

The fungicides used are outlined in Table 5.

Table 5. Application rates of fungicides used to control Target spot.

| Fungicide | Active Ingredient | Rate Used | Volume/Ha (SA) | Volume/Ha (Tasmania) |
|---|---|---|---|---|
| Score | 250 g/l difenoconazole | 300ml/ha | 400-800L/ha | 300L/ha |
| | | 500ml/ha | 400-800L/ha | 300L/ha |
| Rovral | 250 g/l iprodione | 1.5 l/ha | 400-800L/ha | 300L/ha |
| Bravo | 500 g/l chlorothalonil | 2.6 l/ha | 400-800L/ha | not used |
| Rover | 500 g/l chlorothalonil | 2.0 l/ha | not used | 300L/ha |
| Dithane M-45 | 800 g/l mancozeb | 175g/100L | not used | 300L/ha |

This research was aimed at better managing the currently used fungicides while reducing spray applications, so few trials were initiated that actually compared the protectant chemicals in the same schedule. One Tasmanian trial compared Rovral and Rover, however there were no significant differences found in either disease incidence or yield.

Score applied on a regular schedule but initiated only after first symptoms or first infection period was very effective in controlling Target spot. However this resulted in the application of up to 10 sprays. The manufacturers recommended that Score be sprayed no more than twice consecutively and no more than six in one season to prevent resistant strains of the fungus developing. Due to Score being considerably more expensive that the protectant fungicides, it is unlikely that growers would apply 6 sprays of Score, especially when a full protectant program was quite effective in controlling the disease.

The effectiveness of Score applied only after an infection period was extremely variable. Infection periods were defined as periods of 8 hours of leaf wetness at >15°C to 12 hours leaf wetness at >10°C that were likely to give rise to an infection. Score was applied within 24 hours of the infection period only if no sprays had been applied in the last 10 days. Where weather monitoring equipment could be accessed daily via modem, the infection periods could be identified and the spray applied within the required 24 hours. However where daily access was not available, this interval was often extended to several days, reducing the effectiveness of the program. An eradicant schedule may result in considerable savings in spraying costs when limited infection periods occur. However where heavy dews are frequent or with regular rain events, many infection periods occur and spraying would be more appropriate on a protectant schedule.

Integrating Score into a protectant schedule either after infection periods or after the first lesion appearance, achieved equivalent control to the standard protectant schedule while reducing the number of sprays. However the value of savings in spray application costs would not always cover the higher cost of Score. More work needs to be undertaken to determine the most effective integration of Score into a protectant schedule, both to maximise the yield benefit and minimise costs while reducing spray applications.

# CONCLUSION

From the data obtained in this study, and considering work done elsewhere, two integrated management strategies based on expected disease levels, are proposed for Target spot control:

Integrated control of Target spot will not suit all farmers and farm enterprises, but at least it provides a tool for individuals or companies that are interested in a way to minimise chemical input into the crop.

Farmers that currently spray by air would have difficulty implementing these strategies due to difficulties of being able to book aerial sprays to suit observations in the paddock. Thus, the strategies are really only appropriate for farmers using ground rigs.

Another possible barrier to adoption is the requirement for crop monitoring. However many farmers would be willing to take on this duty and as there are also a number of private consultants operating a similar service, with some training this obstacle could be overcome.

It should be noted that the current protectant program with the addition of Score sprays as necessary is very effective for controlling Target spot, and is a very easy program to implement with a regular spray regime clearly defined. There is no doubt that adopting the new integrated management strategy to reduce sprays will require additional effort, and in some years that effort may not be rewarded, but the findings from this work indicate that in many instances it is likely that large savings can be made in the number and cost of sprays, and occasionally no sprays at all will be needed. However in Tasmania, the risk of Irish Blight needs to be considered against any potential savings, and this risk is likely to vary from region to region. At this point in time, Irish blight occurs so infrequently in South Australia that it is not usually considered a factor in choosing the spray program.

Irish blight currently can be managed by monitoring crops and applying Ridomil at first sign of the disease and then applying Dithane thereafter which will protect the crop against Irish Blight. Score does not control any of the strains of Irish Blight. New strains of Irish Blight overseas are resistant to Ridomil and cannot be controlled in this manner. A project to identify management options for Irish Blight and assess the risk of these new strains either entering Australia or even developing in Australia has been proposed to HRDC, and findings from this project will need to be integrated with the Target spot control program before widespread of the integrated control strategy can be adopted. Most Tasmanian potato growing areas do not currently have severe Irish Blight problems, but any high risk area would probably be well advised to continue using the Dithane protectant program as this will currently protect the crop against both diseases.

The use of a forecasting program such as WISDOM has the potential to reduce both number of sprays and amount of chemical applied. As WISDOM uses a set P day to initiate spraying, the program would need to be altered to allow the spray initiation to be determined by when the first lesions occurred in the crop. This could possibly be done by asking the question "have lesions been observed?" and an answer of "Yes" will initiate the spraying schedule. This would require both a rigorous crop monitoring program to detect the early signs of Target spot infection and reliable weather data. The adoption of strategies based on this program would be limited in many areas due to the lack of reliable weather data, and cannot afford to purchase and maintain their own equipment. Also many growers do not currently use or have access to computers. The program also determines spray intervals based on a protectant regime, so may not be suitable for use with eradicants such as Score.

Overall, the new integrated management strategies for Target spot are a positive step towards minimising the use of chemicals in the potato crops and will help ensure Australia's future as a producer of clean and green produce.

# PROPOSED INTEGRATED SPRAY SCHEDULE FOR TARGET SPOT

**LOW DISEASE RISK PADDOCK**

**(paddock with history of well controlled volunteer potatoes and alternate hosts or only low numbers of each, not adjacent to a likely inoculum source such as the previous year's potato paddock or cull piles, not downwind of a likely inoculum source, more than three years since last potato crop)**

The following integrated management strategy is proposed as an alternative to the standard protectant program in order to attempt to reduce spray inputs. (The level of reduction will vary from paddock to paddock and year to year.)

1. At row closure, note date, and begin regular crop inspections for first sign of disease (Thorough crop inspection involves walking through the crop inspecting lower leaves for lesions at least once per week.)

2. Do not irrigate between mid afternoon and dawn as this will increase the chance of creating infection periods.

3. If using infection period forecasts, do not spray once an infection period has been recorded in your paddock. Instead closely inspect the crop one week later for signs of the disease.

4. Note date of appearance of first lesion and mark area with a pole in the paddock

5. Continue to inspect crop regularly, especially area marked with pole.

6. Increase diligence of inspection as more infection periods are forecast if using the infection period forecast system in your crop.

7. Once disease increases, and before reaching the threshold level 5 lesions per 10m row, commence spray program. Apply Score and repeat 10-14 days as per manufacturers recommendations, and then commence protectant program 10-14 days after the last Score application. **If threshold level of disease is not reached before 4 weeks from senescence spraying should not be necessary.**

8. If disease is confined to a small patch, consider spot spraying.

**HIGH DISEASE RISK PADDOCK**
**(paddock with history of poor control, or large number, of volunteer potatoes or alternate hosts, adjacent to a likely inoculum source such as the previous year's potato paddock or cull piles, downwind of a likely inoculum source, less than three years since last potato crop)**

Planting this paddock is less than ideal if it is in an area prone to Target spot infection, however if the crop is planted, the following standard integrated management strategy should be followed for such a worse case scenario. (This is the best available strategy to maximise control under high disease pressure and is not intended as a strategy to reduce spray inputs.)

1. From 2 weeks after emergence, begin regular crop inspections for first sign of disease (Thorough crop inspection involves walking through the crop inspecting lower leaves for lesions at least once per week.)

2. At first sign of lesions, spray Score twice at 10-14 days and implement protectant program.

3. If using infection forecasts, implement the two Score sprays at the first infection period recorded after row closure, or at first sign of lesions, whichever occurs first, then implement protectant program.

4. Do not irrigate between mid afternoon and dawn as this will increase the chance of creating infection periods. If possible, timing of irrigation should be aligned with the spray program. If irrigation creates an infection period, Score is best applied after irrigation. However the protectants would be best applied with a good "sticker" prior to irrigation allowing enough time for the fungicide to adhere properly.

5. Continue to inspect crop regularly. If disease level increases, or further infection periods are forecast, consider replacing 2 protectant sprays with Score at 10-14 day intervals. **Do not apply more that 2 consecutive sprays of Score.**

# RECOMMENDATIONS

## Extension/Adoption

This work has shown that weather data and disease monitoring coupled with appropriate computer software are useful tools to predict the initiation and timing of fungicide applications for the control of Target spot.

Although automated electronic weather stations were used in these studies, including some connected to remote telemetry, our experiments demonstrated that those stations still required regular maintenance. The development of simple and user friendly weather stations would be more appropriate for rapid adoption of this technology.

Demonstrating the integrated control strategy will be necessary to encourage industry adoption, particularly as crop inspections are not currently routine for some farmers.

The results of this work have been presented at several grower meetings in South Australia, Tasmania and Victoria.

## Direction for future research

Score is one of the more effective fungicides for the control of Target spot. The use of this material on a curative (post infection) schedule can reduce the number of fungicide applications by 4 or 5 per season. However the manufacturers do not recommend Score to be used in this manner due to the possible development of resistant strains. Resistance to these type of fungicides has been found overseas and in order to monitor changes in sensitivity, Australian isolates of *A. solani* should be tested to develop base line levels of sensitivity. This will enable any suspect resistant strains of *A. solani* to be tested and compared with known sensitive isolates.

If the post infection activity of Score is to be utilised, the conditions suitable for infection need to be accurately measured. Cheap and robust electronic weather stations that measure temperature and leaf wetness are being developed and these need to be critically evaluated in Australian conditions.

Although Late blight (*Phytophthora infestans)* did not develop in these experiments, further work evaluating spray warning and predictive systems for this disease need to be developed in conjunction with Target spot. In light of the present situation in the USA and Europe where an $A_2$ strain of *P. infestans* which is more aggressive than other strains and is also resistant to Ridomil has caused widespread destruction of potato crops. In Australia work needs to be done to identify the mating types of the local strains of *P. infestans*, and to continue evaluation of disease warning systems for this pathogen. If there are significant climatic changes due to the glasshouse effect then many potato growing areas may become warmer and wetter and in these situations Late blight may become a significant problem.

Further work needs to be done in developing and evaluating new fungicides for use on potatoes. Apart from Score, few of the registered fungicides are outstanding in the control of Target spot. Fungicides with new chemistry need to be evaluated on potatoes and their effect on other diseases of potatoes determined. Other aspects that need investigation are new spray application techniques that improve spray coverage as well as applying spray volumes lower than those presently used in the industry.

The use of Dithane before irrigation to protect the crop against possible infection caused by leaf wetness from the irrigation needs work. The longevity of the fungicide on leaves, and the ability to "stick".

The crop growth stage past which spraying is not economically viable needs to be more clearly defined as many growers may be applying sprays unnecessarily at the end of the season. This work determined the timing of the initial spray was critical for disease control and reduction of sprays, however the latter may also be achieved by determining the final spray timing required to maximise benefits and minimise cost.

The cost-effectiveness of spray programs require further study in light of the various scenarios identified in the management strategy. This study could be combined with demonstrations of the technique.

As cultivars have shown variable susceptibility in America, it would be advisable to test Australian cultivars and any new ascension lines used in breeding work. Thus if there is a choice of variety, a less susceptible one could be chosen if planting in areas of higher perceived risk.

In summary, future research should involve the following:-

- Further evaluation of fungicide spray strategies:
  - ⇒ Evaluation of new fungicides.
  - ⇒ Determination of base line levels of sensitivity to new fungicides.
  - ⇒ Evaluation of new spray application technology.
  - ⇒ Determination of spray deposits - distribution and tenacity.
  - ⇒ Determination of crop growth stage past which spraying is not economically viable.
  - ⇒ Cost effectiveness of spray programs.
- Evaluation of field resistance in different cultivars.
- Evaluation of weather stations
- Integration of Irish blight strategies in Tasmania

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# APPENDIX 1. - EXPERIMENTAL DETAILS - TASMANIA

## Barrington 1 (94/95)

| | |
|---|---|
| Location: | Barrington, Tasmania |
| Potato cultivar: | Russet Burbank |
| Date of planting: | 6 November 1994 |
| Date of emergence: | 1 December 1994 |
| Date of scenes: | 30 March 1995 |
| Replicates: | Five |
| Experiment design: | Complete randomised block |

### Treatments

1. Control (no fungicide spray).
2. Spray Score as an eradicant within 24 h leaf wetness of 8 h @ 15°C or 12 h @ 10°C, if after 10 days from the last spray.
3. Spray Score at 10-14 day intervals.
4. Spray Score after sign of first lesion and later at 10-14 day intervals.
5. Spray Score after 50% flowering and later at 10-14 day intervals.
6. Spray Score after P 300 days and later at 10-14 day intervals.
7. Spray Score after threshold level of 5 lesions/10 m row and later at 10-14 day intervals.

### Spray Schedule

Barrington Ex. 1

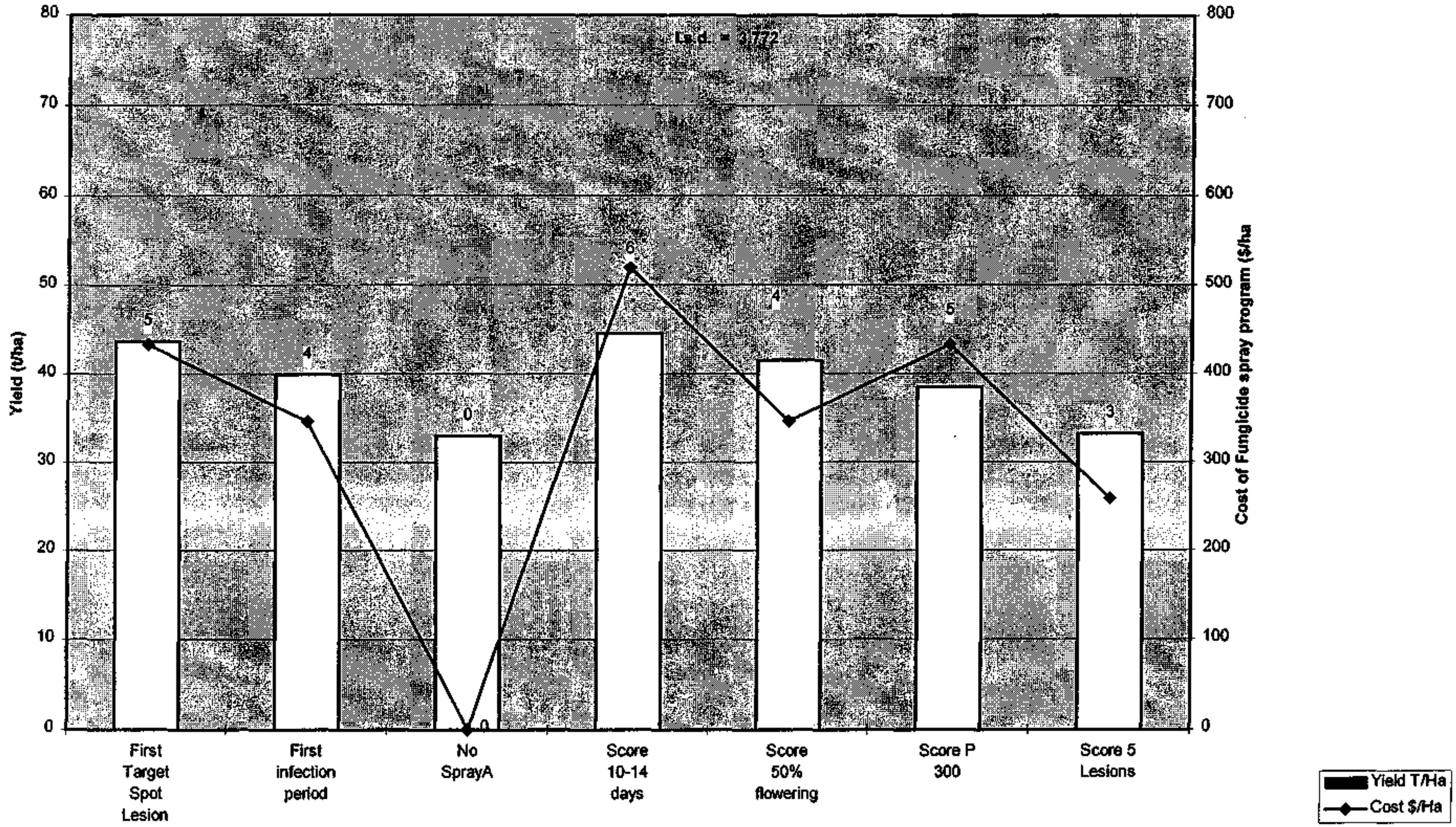
Spray Dates

| | T1 | T2 | T3 | T4 | T5 | T6 | T7 |
|---|---|---|---|---|---|---|---|
| 12/01/95 | | | Score | | | | |
| 24/01/95 | | | Score | | | | |
| 2/02/95 | | | Score | Score | | Score | |
| 6/02/95 | | Score | | | | | |
| 14/02/95 | | | Score | Score | Score | Score | |
| 20/02/95 | | | Score | | | | |
| 28/02/95 | | Score | | Score | Score | Score | Score |
| 10/03/95 | | Score | Score | Score | Score | Score | Score |
| 23/03/95 | | Score | | Score | Score | Score | Score |

| Treatment | Emergence - 1st Spray Days | 1st Spray - Scenes |
|---|---|---|
| 1 | No spraying | |
| 2 | 68 | 51 |
| 3 | 42 | 77 |
| 4 | 64 | 55 |
| 5 | 69 | 50 |
| 6 | 64 | 55 |
| 7 | 58 | 61 |

## Barrington Experiment 1 94/95

(number above column = number of spray applications)



Barrington Ex.1

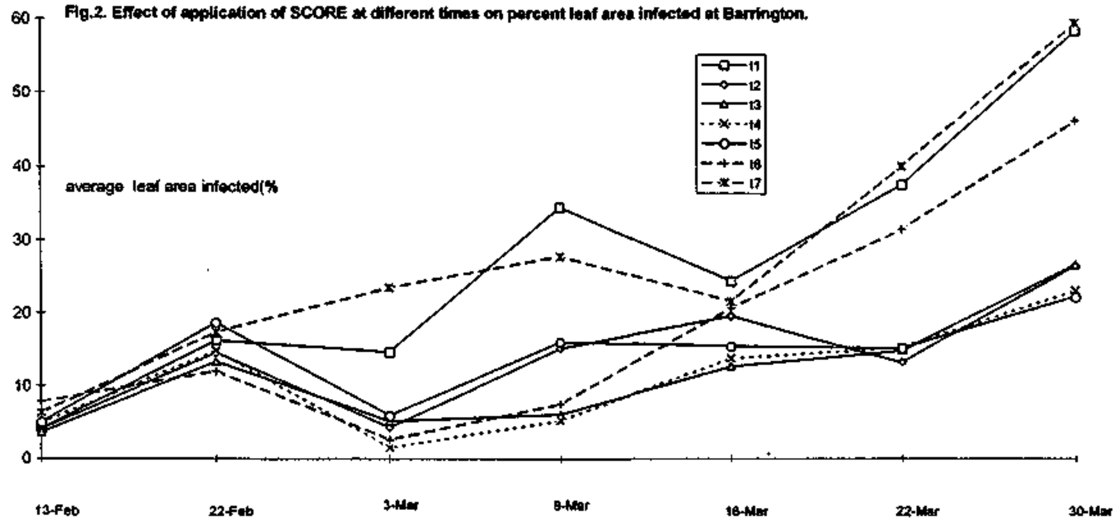



Fig.2. Effect of application of SCORE at different times on percent leaf area infected at Barrington.

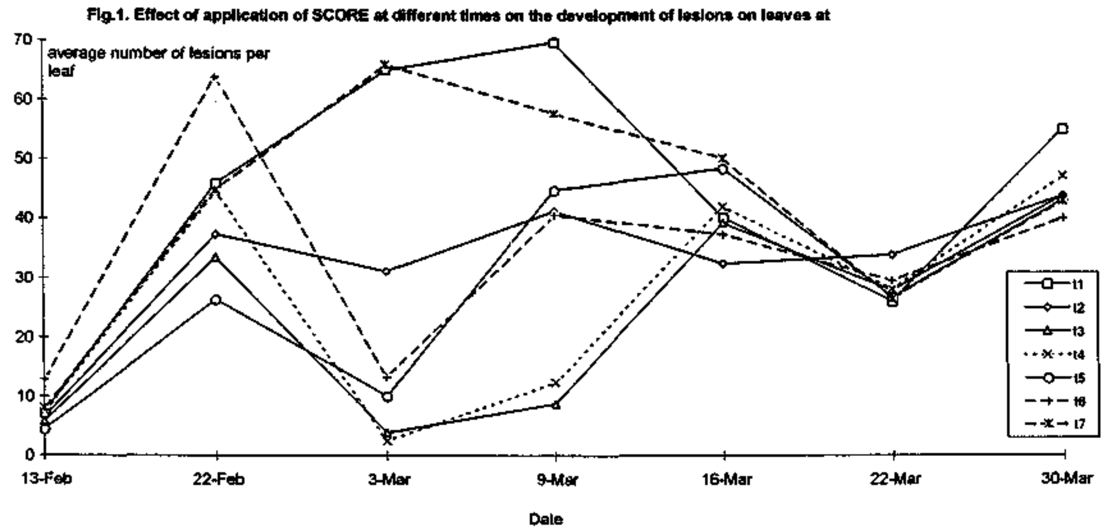



Fig.1. Effect of application of SCORE at different times on the development of lesions on leaves at

## Barrington 2 (94/95)

| | |
|---|---|
| Location: | Barrington, Tasmania |
| Potato cultivar: | Russet Burbank |
| Date of planting: | 6 November 1994 |
| Date of emergence: | 1 December 1994 |
| Date of scenes: | 30 March 1995 |
| Replicates: | Five |
| Experiment design: | Complete randomised block |

### Treatments

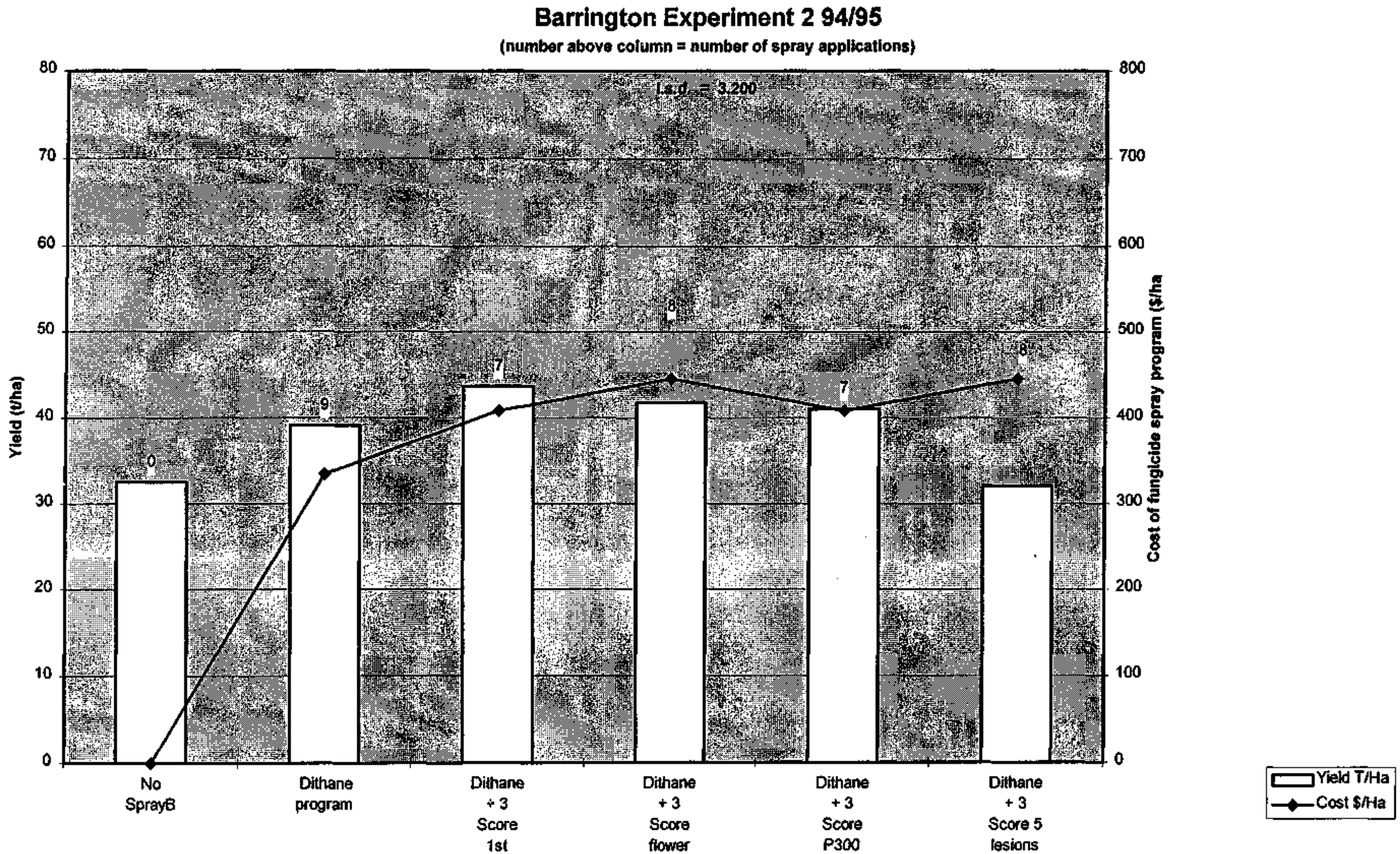
1. Control (no fungicide spray).
2. Spray mancozeb at 7-10 day intervals.
3. Spray mancozeb followed by two consecutive rounds with Score at 10-14 day intervals, after sign of first lesion and return to mancozeb at 7-10 day intervals.
4. Spray mancozeb followed by two consecutive rounds with Score at 10-14 day intervals, after flowering and return to mancozeb at 7-10 day intervals.
5. Spray mancozeb followed by two consecutive rounds with Score at 10-14 day intervals, after P300 days and return to mancozeb at 7-10 day intervals.
6. Spray mancozeb followed by two consecutive rounds with Score at 10-14 day intervals after threshold level of five lesions/10 m row and return to mancozeb at 7-10 intervals.

### Spray Schedule

Barrington Ex. 2
Spray Dates

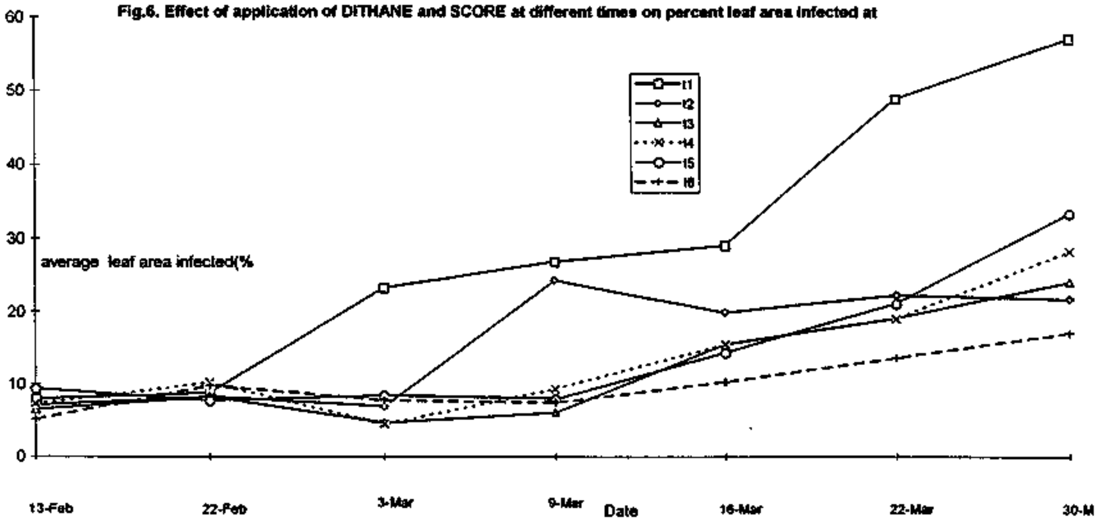
| T1 | T2 | T3 | T4 | T5 | T6 |
|---|---|---|---|---|---|
| 13/01/95 | Dithane | Dithane | Dithane | Dithane | Dithane |
| 24/01/95 | Dithane | Dithane | Dithane | Dithane | Dithane |
| 2/02/95 | Dithane | Score | Dithane | Score | Dithane |
| 14/02/95 | Dithane | Score | Score | Score | Dithane |
| 20/02/95 | Dithane | | | | Dithane |
| 28/02/95 | Dithane | | Score | | Score |
| 10/03/95 | Dithane | Score | Score | Score | Score |
| 16/03/95 | Dithane | Dithane | Dithane | Dithane | |
| 23/03/95 | Dithane | Dithane | Dithane | Dithane | Score |

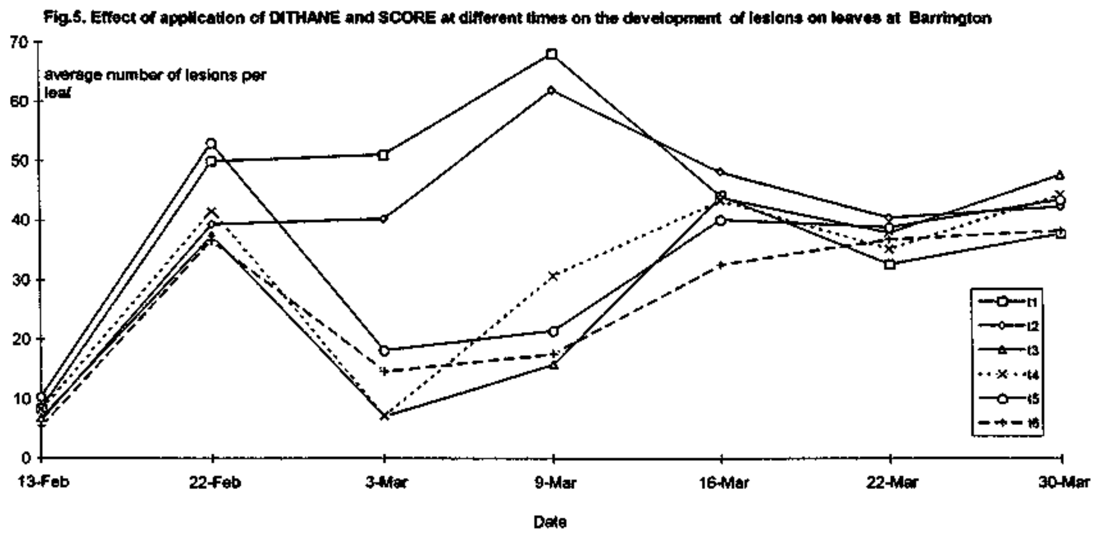
| Treatment | Emergence - 1st Spray Days | 1st Spray - Scenes | Emergence - 1st Score Days | 1st Score - Scenes |
|---|---|---|---|---|
| 1 | No spraying | | No spraying | |
| 2 | 44 | 75 | | |
| 3 | 44 | 75 | 63 | 56 |
| 4 | 44 | 75 | 75 | 44 |
| 5 | 44 | 75 | 63 | 56 |
| 6 | 44 | 75 | 89 | 30 |



Barrington Experiment 2 94/95
(number above column = number of spray applications)
l.s.d. = 3.200
Yield (t/ha)
Cost of fungicide spray program ($/ha
0
9
7
8
7
8
No SprayB
Dithane program
Dithane + 3 Score 1st
Dithane + 3 Score flower
Dithane + 3 Score P300
Dithane + 3 Score 5 lesions
Yield T/Ha
Cost $/Ha

Barrington Ex.2



## Table Cape 1 (94/95)

**Effect of application of Rovral at different times on the incidence and severity of target leaf spot and yield of potatoes.**

| | |
|---|---|
| Location: | Table Cape, Tasmania |
| Potato cultivar: | Russet Burbank |
| Date of planting: | 24 November 1994 |
| Date of emergence: | 13 December 1994 |
| Date of scenes: | 18 April 1995 |
| Replicates: | Five |
| Experimental design; | Complete Randomise block |

### Treatments

1. Control (no fungicide spray).
2. Spray Rovral as an eradicant within 24 h leaf wetness of 8 h @ 15°C or 12 h@ 10°C, if after 10 days from the last spray.
3. Spray Rovral at 10-14 day intervals.
4. Spray Rovral after sign of first lesion and later at 10-14 day intervals.
5. Spray Rovral after 50% flowering and later at 10-14 day intervals.
6. Spray Rovral after P300 days and later at 10-14 day intervals.
7. Spray Rovral after threshold level of five lesions/10 m of row and later at 10-14 day intervals.

### Spray Schedule

Table Cape Ex. 3
Spray Dates

| | T1 | T2 | T3 | T4 | T5 | T6 | T7 |
|---|---|---|---|---|---|---|---|
| 22/01/95 | | | Rovral | | | | |
| 7/02/95 | | Rovral | Rovral | | | Rovral | |
| 16/02/95 | | Rovral | Rovral | | | Rovral | |
| 2/03/95 | | Rovral | Rovral | Rovral | Rovral | Rovral | |
| 15/03/95 | | Rovral | Rovral | Rovral | Rovral | Rovral | Rovral |
| 28/03/95 | | Rovral | Rovral | Rovral | Rovral | Rovral | Rovral |
| 11/04/95 | | Rovral | | Rovral | Rovral | Rovral | Rovral |

| | Date of Spraying | | | | | | |
|---|---|---|---|---|---|---|---|
| Treatment | 1 | 2 | 3 | 4 | 5 | 6 | Total no. of sprays |
| 1 | No spraying | | | | | | |
| 2 | 7/02/95 | 16/02/95 | 2/03/95 | 15/03/95 | 28/03/95 | 11/04/95 | 6 |
| 3 | 22/01/95 | 7/02/95 | 16/02/95 | 2/03/95 | 15/03/95 | 28/03/95 | 6 |
| 4 | 2/03/95 | 15/03/95 | 28/03/95 | 11/04/95 | | | 4 |
| 5 | 2/03/95 | 15/03/95 | 28/03/95 | 11/04/95 | | | 4 |
| 6 | 7/02/95 | 16/02/95 | 2/03/95 | 15/03/95 | 28/03/95 | 11/04/95 | 6 |
| 7 | 15/03/95 | 28/03/95 | 11/04/95 | | | | 3 |

| Treatment | Emergence – 1st Spray Days | 1st Spray – Scenes |
|---|---|---|
| 1 | No spraying | |
| 2 | 56 | 70 |
| 3 | 40 | 86 |
| 4 | 79 | 47 |
| 5 | 79 | 47 |
| 6 | 56 | 70 |
| 7 | 92 | 34 |

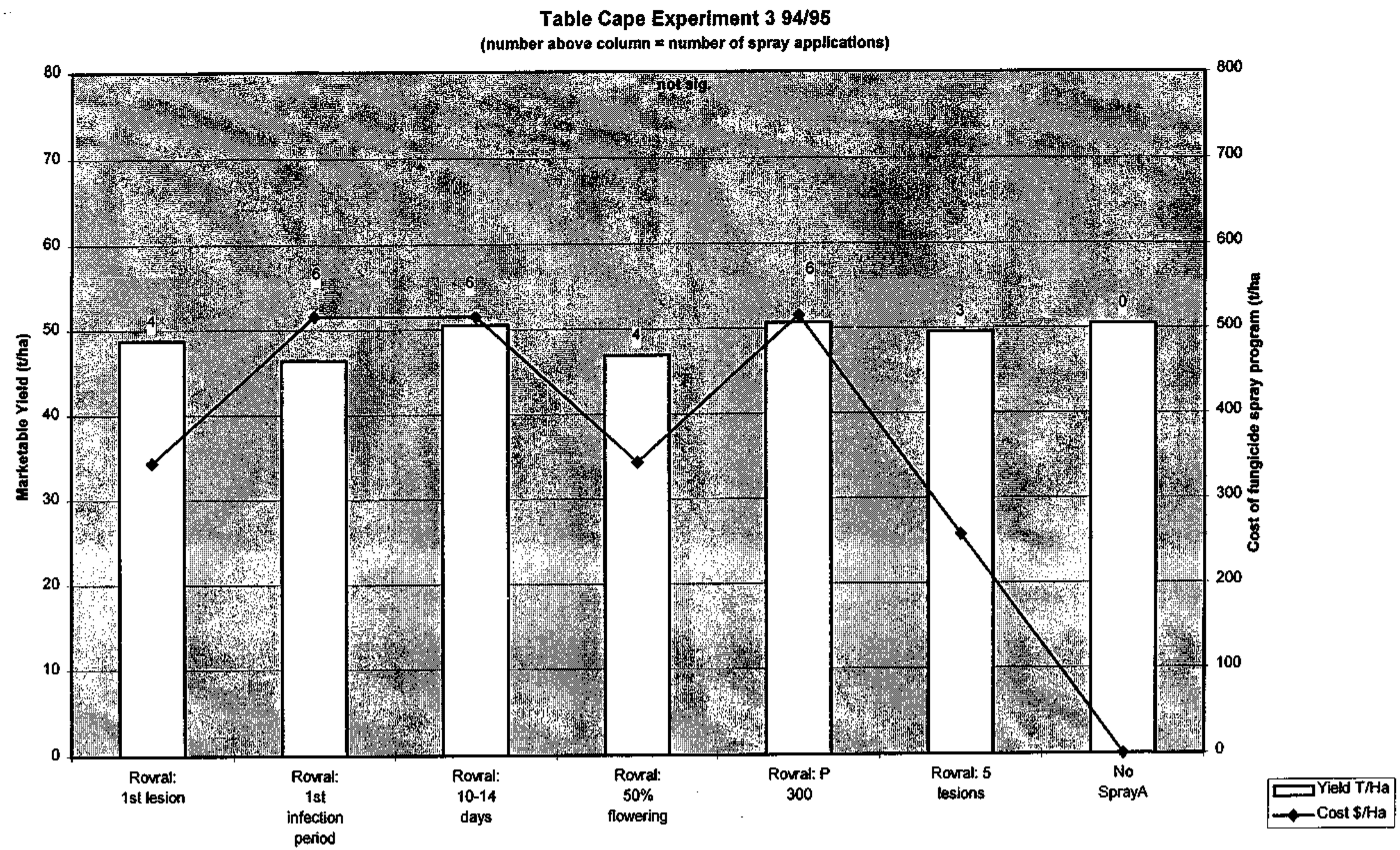
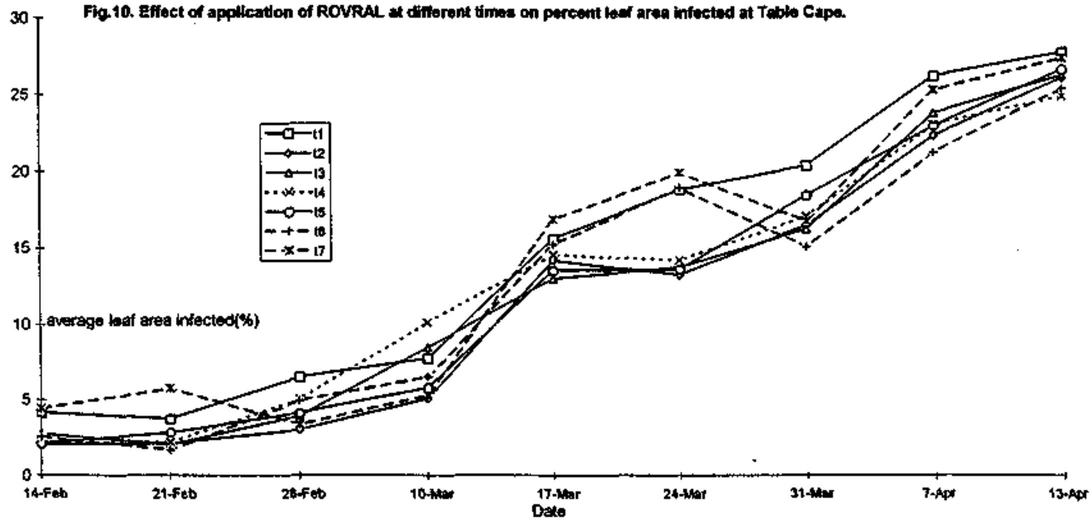
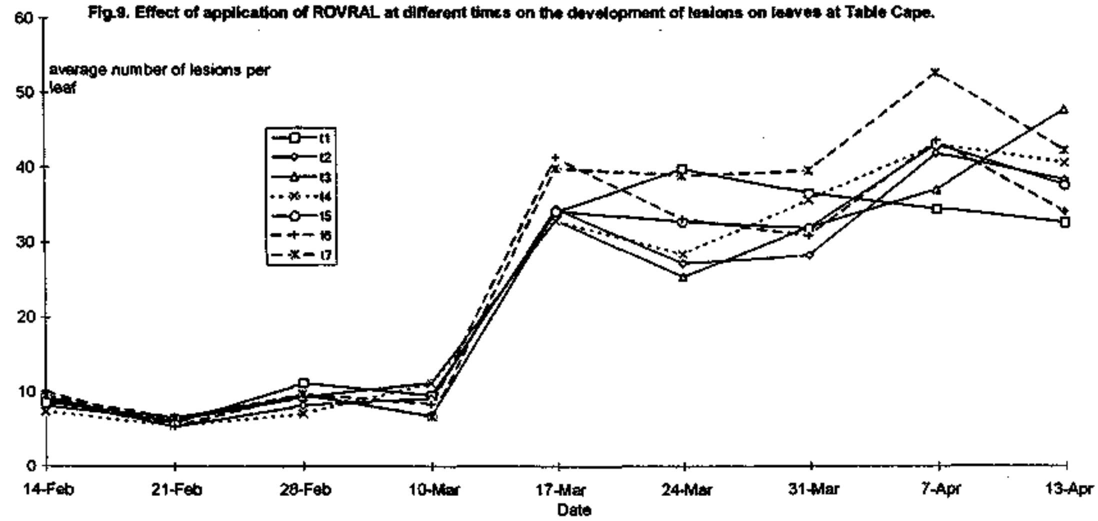


Table Cape Experiment 3 94/95
(number above column = number of spray applications)
not sig.
Marketable Yield (t/ha)
Cost of fungicide spray program (t/ha
0
10
20
30
40
50
60
70
80
100
200
300
400
500
600
700
800
4
6
6
4
6
3
0
Rovral: 1st lesion
Rovral: 1st infection period
Rovral: 10-14 days
Rovral: 50% flowering
Rovral: P 300
Rovral: 5 lesions
No SprayA
Yield T/Ha
Cost $/Ha

Table Cape Ex.3



## Table Cape 2 (94/95)

**Effect of Rover and Rovral on the incidence and severity of target leaf spot and yield of potatoes.**

| | |
|---|---|
| Location: | Table Cape, Tasmania |
| Potato cultivar: | Russet Burbank |
| Date of planting: | 29 November 1994 |
| Date of emergence: | 13 December 1994 |
| Date of scenes: | 18 April 1995 |
| Replicates: | Five |
| Experimental design: | Complete Randomise Block |

### Treatments

1. Control (no fungicide spray).
2. Spray Rover at 7-10 day intervals.
3. Spray Rover followed by two consecutive rounds with Rovral at 10-14 day intervals after sign of first lesion and return to Rover.
4. Spray Rover followed by two consecutive rounds with Rovral at 10-14 day intervals after 50% flowering and return to Rover at 7-10 day intervals.
5. Spray Rover followed by two consecutive rounds with Rovral at 10-14 day intervals after P300 days and return to Rover at 7-10 day intervals.
6. Spray Rover followed by two consecutive rounds with Rovral at 10-14 day intervals after threshold level of 5 lesions/10 m row and return to Rover at 7- 10 day intervals.

### Spray Schedule

Table Cape Ex. 4
Spray Dates

| | T1 | T2 | T3 | T4 | T5 | T6 |
|---|---|---|---|---|---|---|
| 1/02/95 | | Rover | Rover | Rover | Rover | Rover |
| 8/02/95 | | Rover | Rover | Rover | Rovral | Rover |
| 16/02/95 | | Rover | Rover | Rover | | Rover |
| 23/02/95 | | Rover | Rover | | | Rover |
| 24/02/95 | | | | Rovral | Rovral | |
| 2/03/95 | | Rover | | | | Rover |
| 9/03/95 | | Rover | | | | Rover |
| 15/03/95 | | Rover | Rovral | Rovral | Rovral | Rovral |
| 22/03/95 | | Rover | | | | |
| 28/03/95 | | Rover | Rovral | Rovral | | Rovral |
| 4/04/95 | | Rover | | | | |
| 11/04/95 | | Rover | Rovral | | | Rovral |

| Treatment | Emergence – 1st Spray Days | 1st Spray – Scenes | Emergence – 1st Roval Days | 1st – Roval Scenes |
|---|---|---|---|---|
| 1 | No spraying | | No spraying | |
| 2 | 50 | 76 | | |
| 3 | 50 | 76 | 92 | 34 |
| 4 | 50 | 76 | 73 | 53 |
| 5 | 50 | 76 | 57 | 69 |
| 6 | 50 | 76 | 92 | 34 |

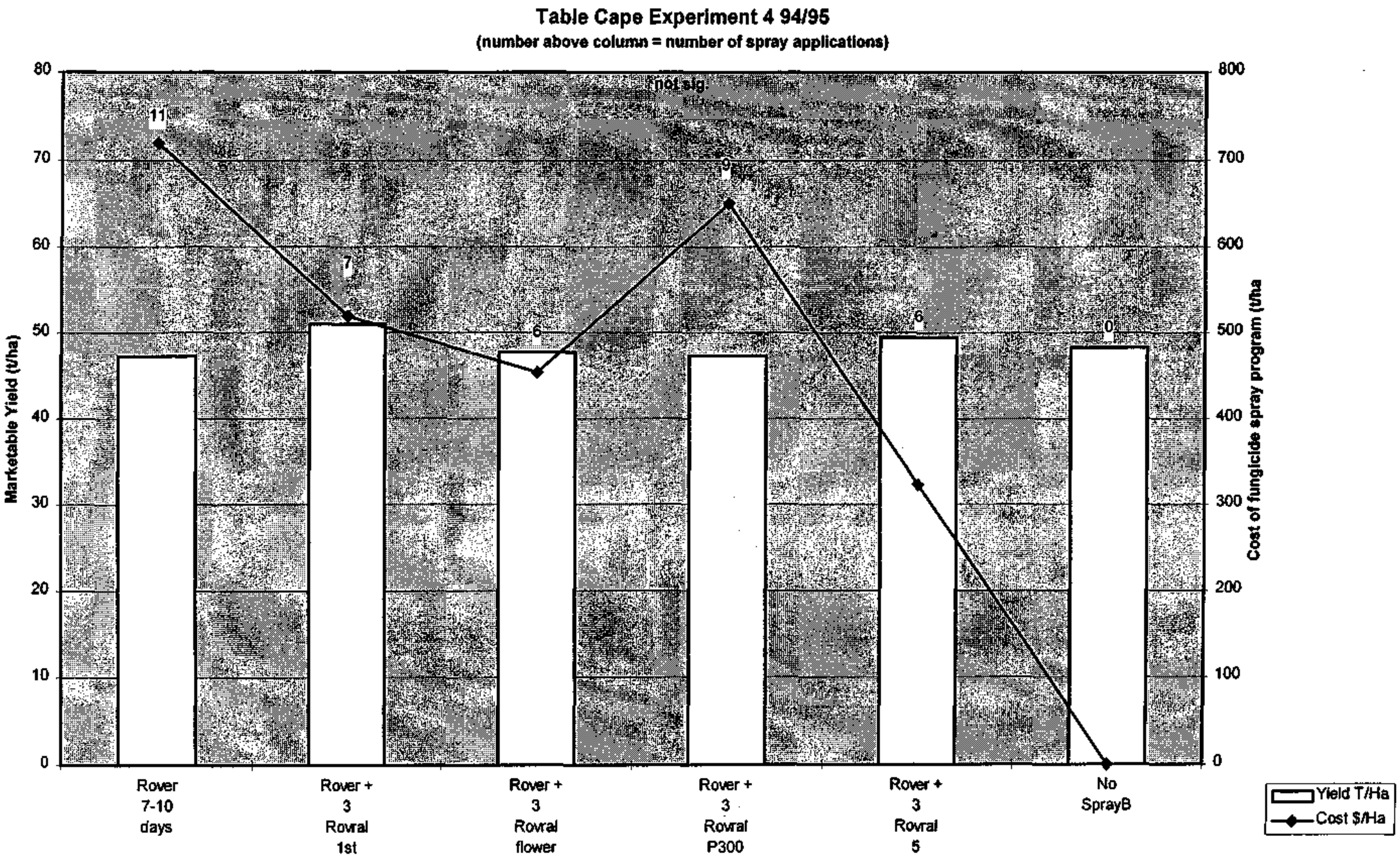
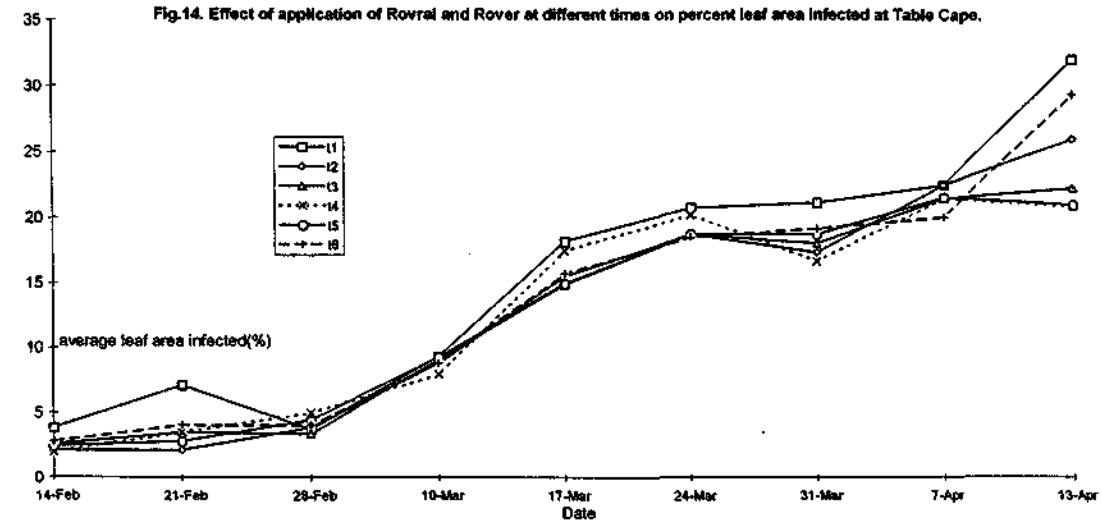
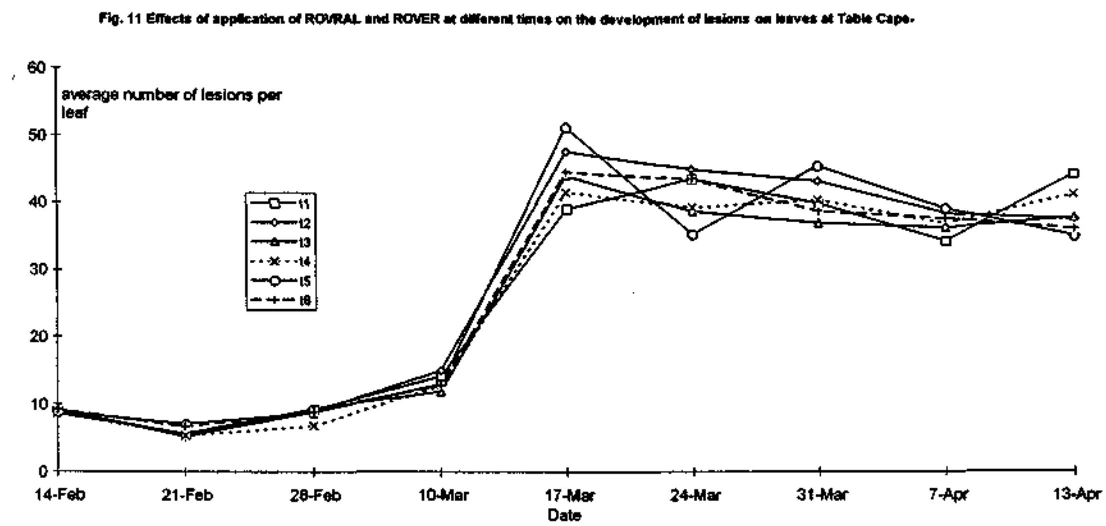


Table Cape Experiment 4 94/95
(number above column = number of spray applications)
not sig.
11
7
6
9
6
0
Marketable Yield (t/ha)
Cost of fungicide spray program (t/ha)
0
10
20
30
40
50
60
70
80
100
200
300
400
500
600
700
800
Rover 7-10 days
Rover + 3 Rovral 1st
Rover + 3 Rovral flower
Rover + 3 Rovral P300
Rover + 3 Rovral 5
No SprayB
Yield T/Ha
Cost $/Ha

Table Cape Ex.4



## Scottsdale (94/95)

**Effect of application of Score at different P-Days on the incidence of target spot and yield of potatoes.**

| | |
|---|---|
| Location: | Scottsdale, Tasmania |
| Potato cultivar: | Russet Burbank |
| Date of planting: | 15 October 1994 |
| Date of emergence: | 5 November 1994 |
| Date of scenes: | 3 March 1995 |
| Replicates: | Five |
| Experiment design: | Complete randomised block |

### Treatments

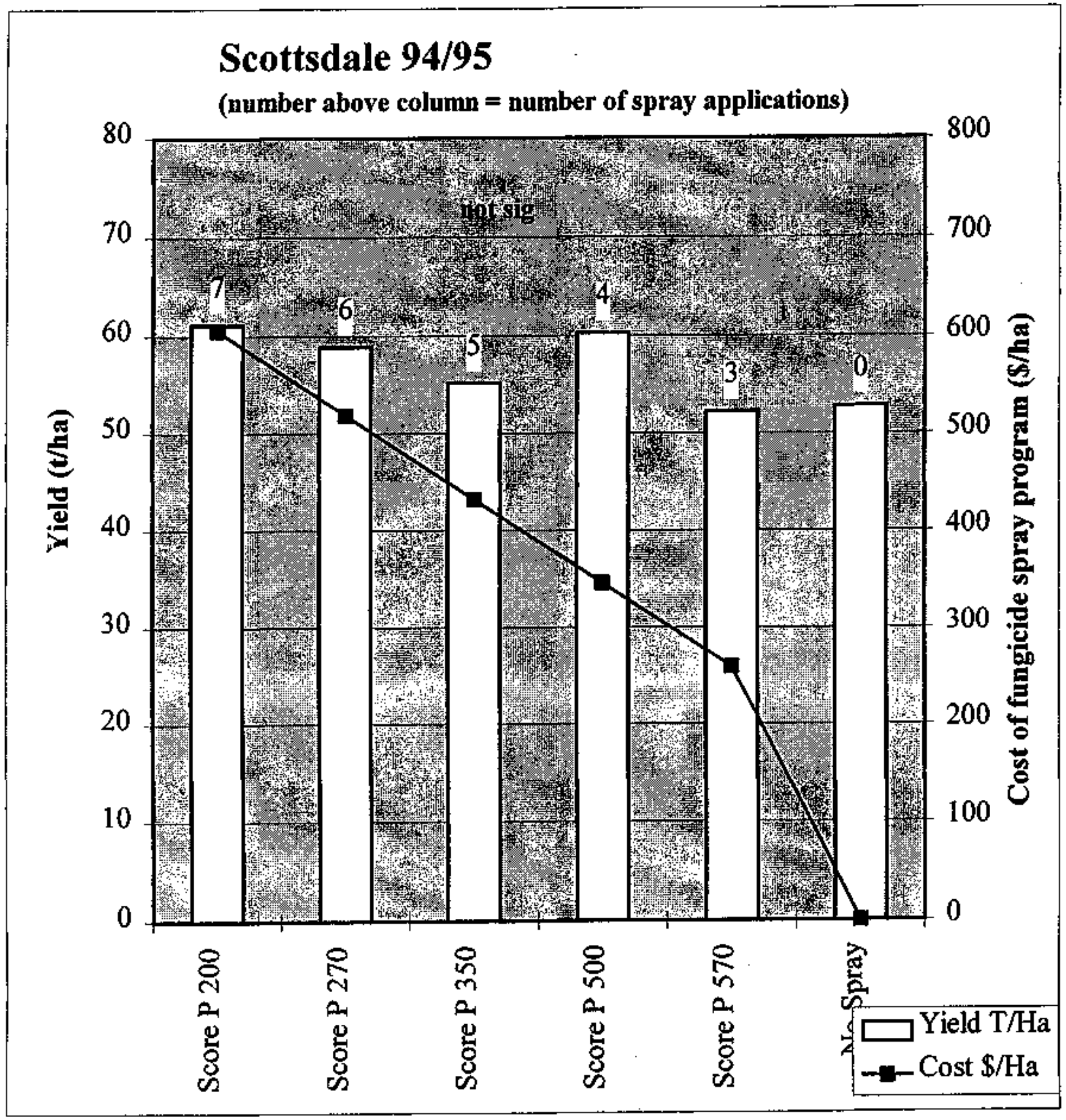
1. Spray Score after P 200 days and later at 10-14 day intervals
2. Spray Score after P 270 days and later at 10-14 day intervals
3. Spray Score after P 350 days and later at 10-14 day intervals.
4. Spray Score after P 500 days and later at 10-14 day intervals.
5. Spray Score after P 570 days and later at 10-14 day intervals.
6. Control (no fungicide spray).

### Spray Schedule

Scottsdale Ex. 5
Spray Dates

| | T1 | T2 | T3 | T4 | T5 | T6 |
|---|---|---|---|---|---|---|
| 14/12/94 | Score | | | | | |
| 23/12/94 | Score | Score | | | | |
| 3/01/95 | Score | Score | Score | | | |
| 23/01/95 | Score | Score | Score | Score | | |
| 1/02/95 | Score | Score | Score | Score | Score | |
| 13/02/95 | Score | Score | Score | Score | Score | |
| 24/02/95 | Score | Score | Score | Score | Score | |

| Treatment | Emergence - 1st Spray Days | 1st Spray - Scenes |
|---|---|---|
| 1 | 39 | 79 |
| 2 | 48 | 70 |
| 3 | 59 | 59 |
| 4 | 79 | 39 |
| 5 | 88 | 30 |
| 6 | No Spray | |


Scottsdale 94/95
(number above column = number of spray applications)
Yield (t/ha)
Cost of fungicide spray program ($/ha)
not sig
7
6
5
4
3
0
Score P 200
Score P 270
Score P 350
Score P 500
Score P 570
No Spray
Yield T/Ha
Cost $/Ha
0
10
20
30
40
50
60
70
80
0
100
200
300
400
500
600
700
800

## FVRS (95/96)

**Effect of application of Score and Dithane M-45 (mancozeb) at different times on the incidence and severity of target spot and Irish blight and yield of potatoes.**

| | |
|---|---|
| Location: | FVRS (Forthside Vegetable Research Station), Tasmaina |
| Potato cultivar: | Russet Burbank |
| Date of planting: | 16 October 1995 |
| Date of emergence: | 7 November 1995 |
| Date of scenes: | 13 February 1996 |
| Replicates: | Four |
| Experiment design: | Complete randomised block |

### Treatments

1. Spray Score after P 300 days and later at 10-14 day intervals
2. Spray Score after P 350 days and later at 10-14 day intervals.
3. Spray Score after sign of first lesion and later at 10-14 day intervals.
4. Spray Score after threshold level of 5 lesions/10 m row and later at 10-14 day intervals.
5. Spray Score as an eradicant within 24 h leaf wetness of 8 h @ 15°C or 12 h @ 10°C, if after 10 days from the last spray.
6. Spray Score after 50% flowering and later at 10-14 day intervals
7. Spray Dithane on 7-10 day interval following row closure.
8. Control (no fungicide spray).

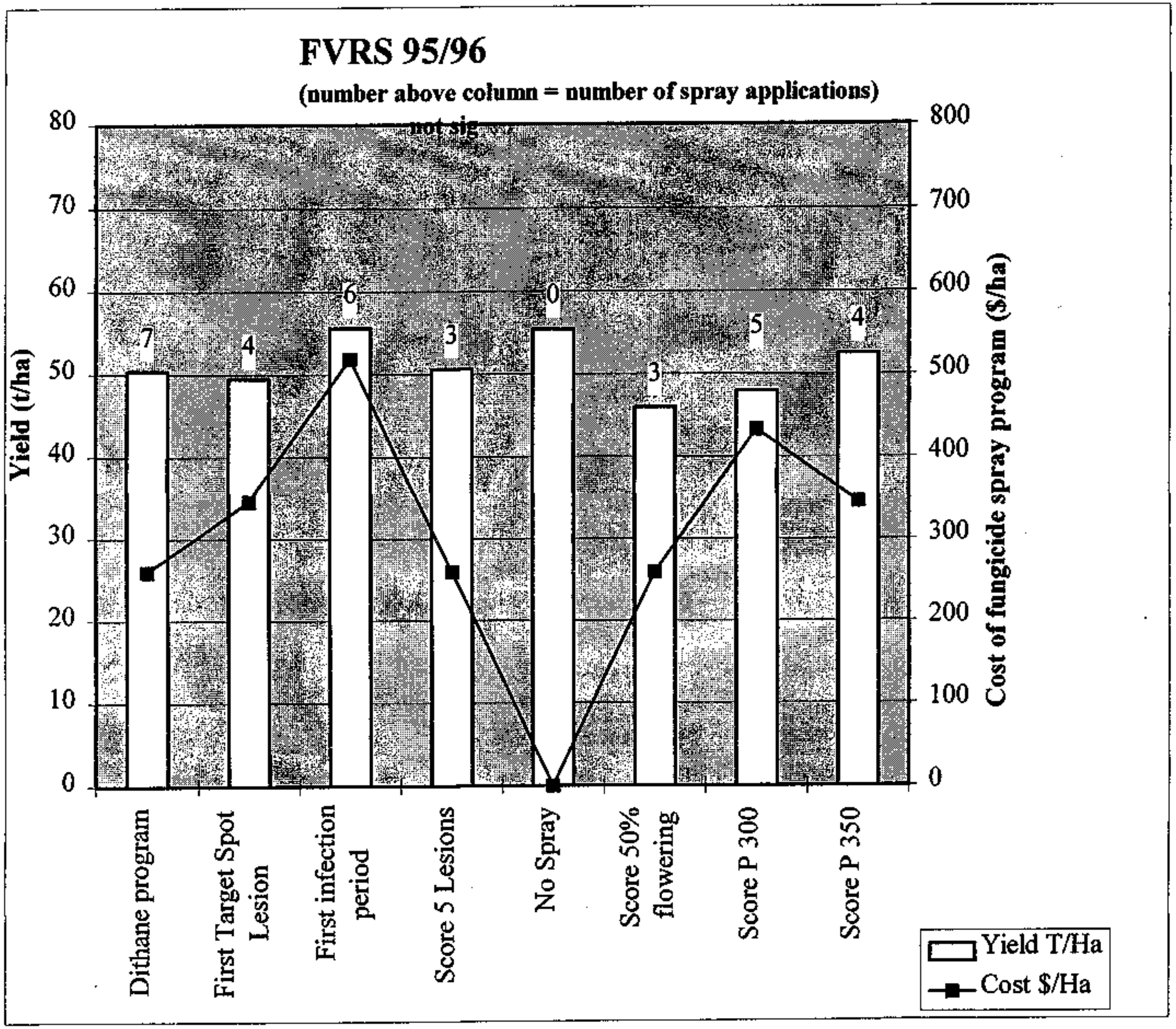
### Spray Schedule

FVRS 95/96 Ex. 6

Spray Dates

| | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 |
|---|---|---|---|---|---|---|---|---|
| 15/12/95 | Score | | | | | | | |
| 22/12/95 | | Score | | | Score | | Dithane | |
| 29/12/95 | Score | | | | | | Dithane | |
| 6/01/96 | | Score | Score | | Score | | Dithane | |
| 12/01/96 | Score | | | | Score | Score | Dithane | |
| 18/01/96 | | Score | Score | Score | Score | | Dithane | |
| 29/01/96 | Score | | Score | Score | Score | Score | Dithane | |
| 6/02/96 | Score | Score | Score | Score | Score | Score | Dithane | |

| Treatment | Emergence - 1st Spray Days | 1st Spray - Scenes |
|---|---|---|
| 1 | 38 | 60 |
| 2 | 45 | 53 |
| 3 | 60 | 38 |
| 4 | 72 | 26 |
| 5 | 44 | 54 |
| 6 | 66 | 32 |
| 7 | 45 | 53 |
| 8 | No spraying | |



FVRS 95/96
(number above column = number of spray applications)
not sig
Yield (t/ha)
Cost of fungicide spray program ($/ha)
80
70
60
50
40
30
20
10
0
800
700
600
500
400
300
200
100
0
7
4
6
3
0
3
5
4
Dithane program
First Target Spot Lesion
First infection period
Score 5 Lesions
No Spray
Score 50% flowering
Score P 300
Score P 350
Yield T/Ha
Cost $/Ha

## Sisters Creek (95/96)

**Effect of application of Score and Dithane M-45 (mancozeb) at different times on the incidence and severity of target spot and Irish blight and yield of potatoes.**

| | |
|---|---|
| Location: | Sisters Creek, Tasmania |
| Potato cultivar: | Russet Burbank |
| Date of planting: | 14 November 1995 |
| Date of emergence: | 8 December 1995 |
| Date of scenes: | 28 March 1996 |
| Replicates: | Four |
| Experimental design; | Complete Randomise block |

**Treatments**

1. Spray Score after P 300 days and later at 10-14 day intervals
2. Spray Score after P 350 days and later at 10-14 day intervals.
3. Spray Score after sign of first lesion and later at 10-14 day intervals.
4. Spray Score after threshold level of 5 lesions/10 m row and later at 10-14 day intervals.
5. Spray Score as an eradicant within 24 h leaf wetness of 8 h @ 15°C or 12 h @ 10°C, if after 10 days from the last spray.
6. Spray Score after 50% flowering and later at 10-14 day intervals
7. Spray Dithane on 7-10 day interval following row closure.
8. Control (no fungicide spray).

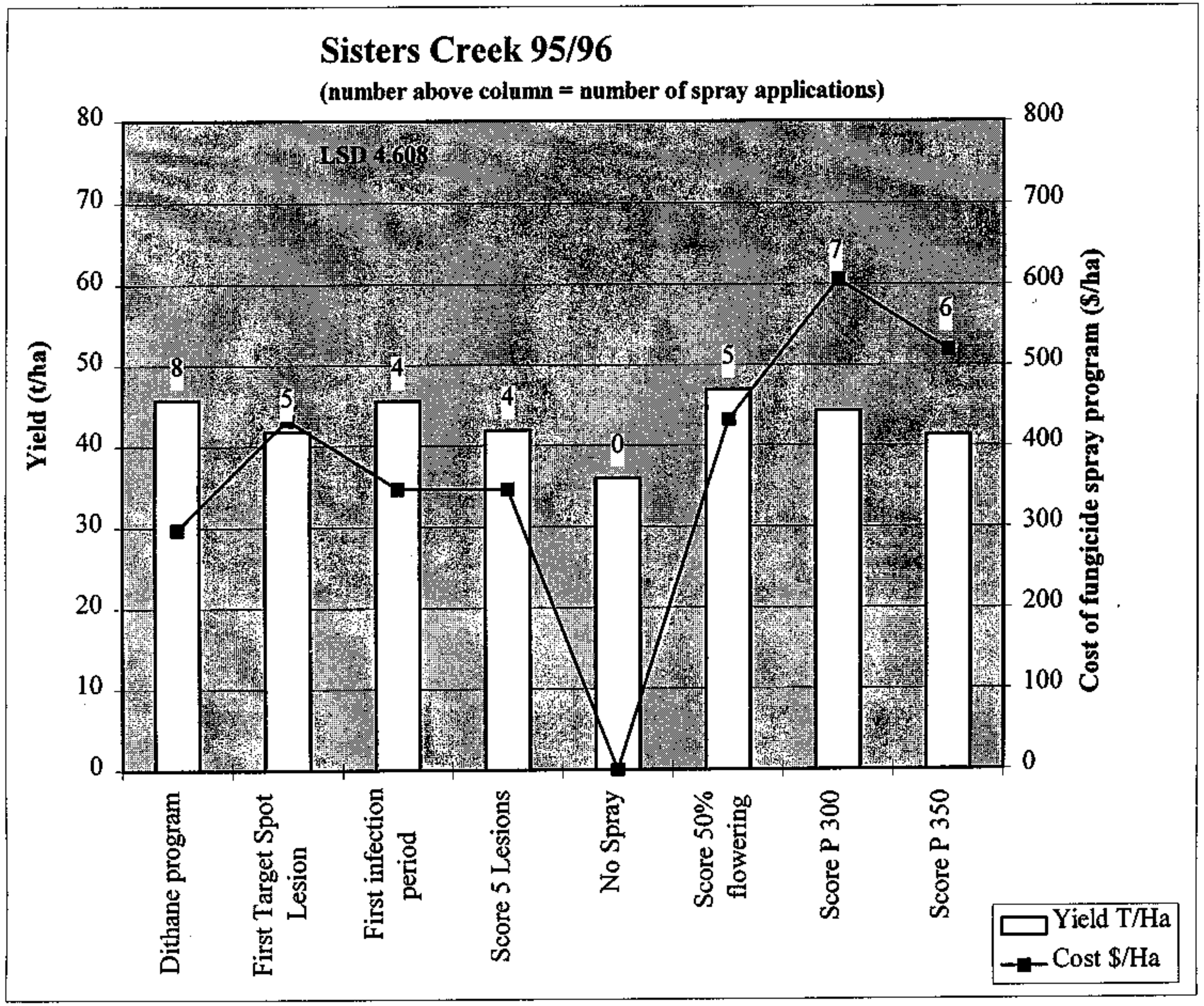
**Spray Schedule**

Sisters Creek Ex.7

Spray Dates

| | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 |
|---|---|---|---|---|---|---|---|---|
| 11/01/96 | Score | | | | | | | |
| 18/01/96 | | Score | | | | | Dithane | |
| 25/01/96 | Score | | Score | | | Score | Dithane | |
| 2/02/96 | | Score | | Score | | | Dithane | |
| 12/02/96 | Score | | Score | | Score | Score | Dithane | |
| 20/02/96 | | | | Score | | | | |
| 22/02/96 | Score | Score | | | | | Dithane | |
| 27/02/96 | Score | Score | Score | Score | | Score | Dithane | |
| 28/02/96 | | | | | Score | | | |
| 7/03/96 | Score | Score | Score | Score | Score | Score | Dithane | |
| 21/03/96 | Score | Score | Score | Score | Score | Score | Dithane | |

| Treatment [illegible] | Emergence - 1st Spray (Da[illegible]) [illegible] | 1st Spray - Scenes [illegible] |
|---|---|---|
| 1 | 34 | 77 |
| 2 | 41 | 70 |
| 3 | 48 | 63 |
| 4 | 56 | 55 |
| 5 | 66 | 45 |
| 6 | 48 | 63 |
| 7 | 41 | 70 |
| 8 | No spraying | |


Sisters Creek 95/96
(number above column = number of spray applications)
LSD 4.608
Yield (t/ha)
Cost of fungicide spray program ($/ha)
0
10
20
30
40
50
60
70
80
100
200
300
400
500
600
700
800
8
5
4
4
0
5
7
6
Dithane program
First Target Spot Lesion
First infection period
Score 5 Lesions
No Spray
Score 50% flowering
Score P 300
Score P 350
Yield T/Ha
Cost $/Ha

## FVRS 1 (96/97)

**Effect of application of Score and Dithane M-45 (mancozeb) at different times on the incidence of target leaf spot, Irish blight and yield of potatoes.**

| | |
|---|---|
| Location: | FVRS (Forthside Vegetable Research Station), Tasmania |
| Potato cultivar: | Russet Burbank |
| Date of planting: | 6 November 1996 |
| Date of emergence: | 18 November 1996 |
| Date of scenes: | 17 March 1997 |
| Replicates: | Three |
| Experiment design: | Complete randomised block |

### Treatments

1. Control (no fungicide spray).
2. Spray Score after sign of first lesion and later at 10-14 day intervals.
3. Spray Dithane on 7-10 day interval following row closure.
4. Spray Score as an eradicant within 24 h leaf wetness of 8 h @ 15°C or 12 h @ 10°C, if after 10 days from the last spray.

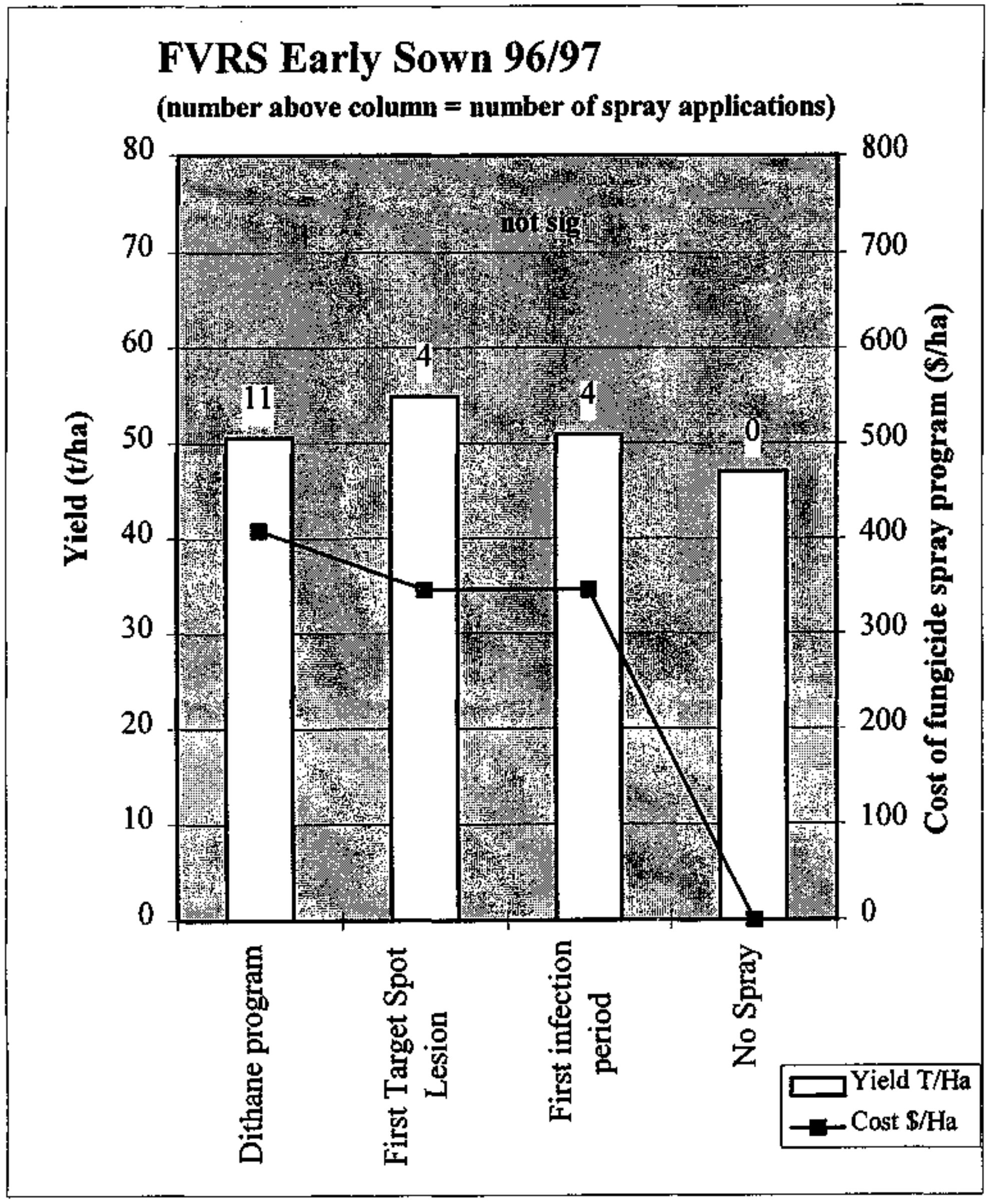
### Spray Schedule

FVRS Early Ex. 8

Spray Dates

| T1 | T2 | T3 | T4 |
|---|---|---|---|
| 31/12/96 | | Dithane | |
| 7/01/97 | | Dithane | |
| 13/01/97 | | Dithane | |
| 18/01/97 | | Dithane | |
| 23/01/97 | | | Score |
| 24/01/97 | | Dithane | |
| 30/01/97 | Score | | |
| 31/01/97 | | Dithane | |
| 6/02/97 | | | Score |
| 8/02/97 | | Dithane | |
| 13/02/97 | Score | | |
| 14/02/97 | | Dithane | |
| 20/02/97 | | | Score |
| 24/02/97 | | Dithane | |
| 27/02/97 | Score | | |
| 4/03/97 | | Dithane | |
| 6/03/97 | | | Score |
| 10/03/97 | | Dithane | |
| 13/03/97 | Score | | |

| Treatment | Emergence - 1st Spray Days | 1st Spray - Scenes |
|---|---|---|
| 1 | No spraying | |
| 2 | 73 | 46 |
| 3 | 43 | 75 |
| 4 | 66 | 53 |


FVRS Early Sown 96/97
(number above column = number of spray applications)
Yield (t/ha)
0
10
20
30
40
50
60
70
80
Cost of fungicide spray program ($/ha)
0
100
200
300
400
500
600
700
800
not sig
11
4
4
0
Dithane program
First Target Spot Lesion
First infection period
No Spray
Yield T/Ha
Cost $/Ha

## FVRS 2 (96/97)

**Effect of application of Score and Dithane M-45 (mancozeb) at different times on the incidence of target leaf spot, Irish blight and yield of potatoes.**

| | |
|---|---|
| Location: | FVRS (Forthside Vegetable Research Station), Tasmania |
| Potato cultivar: | Russet Burbank |
| Date of planting: | 22 November 1996 |
| Date of emergence: | 11 December 1996 |
| Date of scenes: | 31 March 1997 |
| Replicates: | Three |
| Experiment design: | Complete randomised block |

**Treatments**

1. Control (no fungicide spray).
2. Spray Dithane on 7-10 day interval following row closure.
3. Spray Score as an eradicant beginning within 24 h leaf wetness of 8 h @ 15°C or 12 h @ 10°C, then on 10-14 day interval..
4. Spray Score after sign of first lesion and later at 10-14 day intervals
5. Spray Score after threshold level of 5 lesions/10 m row and later at 10-14 day intervals.
6. Spray Score (500mL/ha) as an eradicant within 24 h leaf wetness of 8 h @ 15°C or 12 h @ 10°C, if after 14 days from the last spray.
7. Spray Score (300mL/ha) as an eradicant within 24 h leaf wetness of 8 h @ 15°C or 12 h @ 10°C, if after 7 days from the last spray.

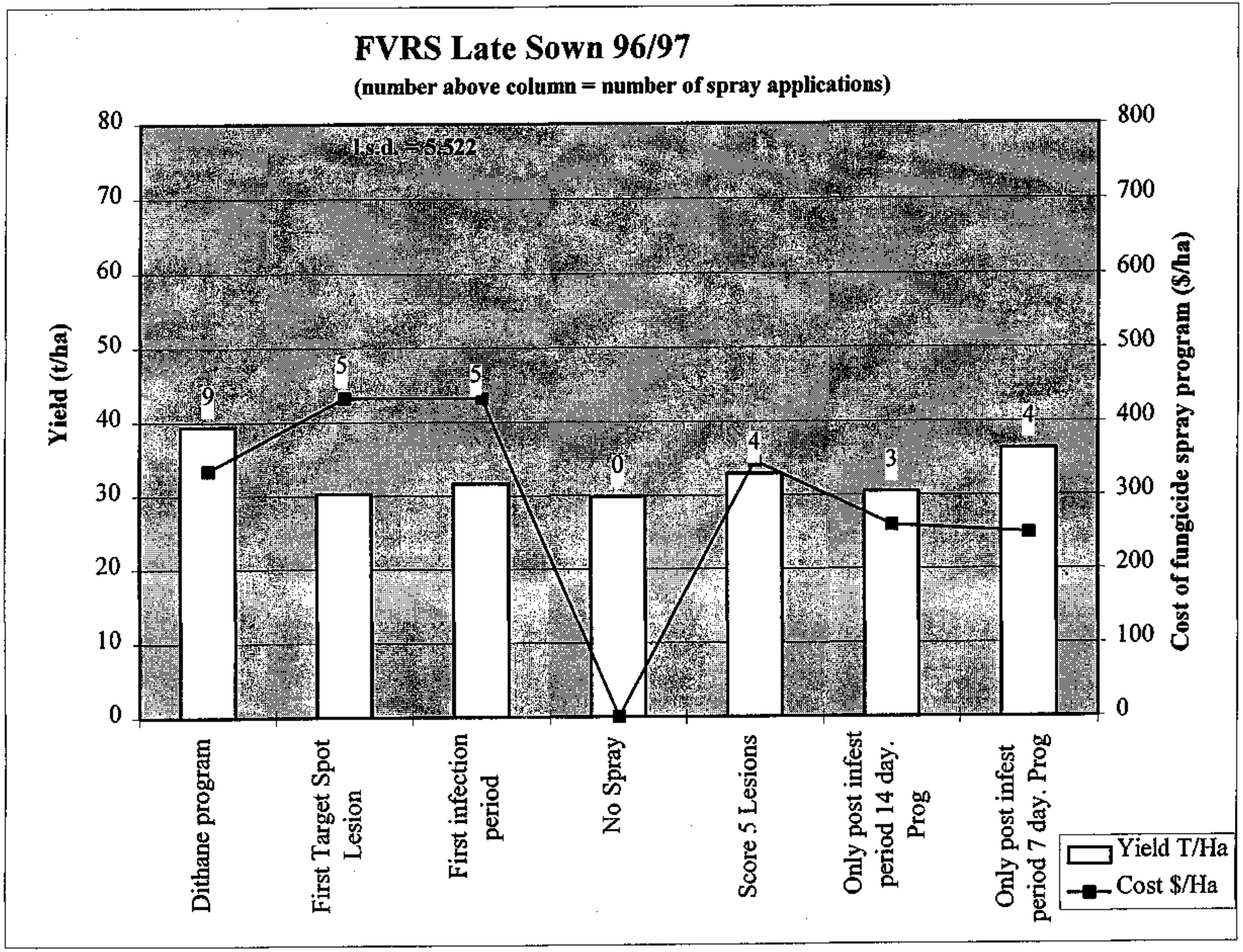
**Spray Schedule**

FVRS Late Ex. 9

Spray Dates

| T1 | T2 | T3 | T4 | T5 | T6 | T7 |
|---|---|---|---|---|---|---|
| 18/01/97 | Dithane | | | | | |
| 23/01/97 | | Score | | | Score | Score |
| 24/01/97 | Dithane | | | | | |
| 30/01/97 | | | Score | | | |
| 31/01/97 | Dithane | | | | | |
| 6/02/97 | | Score | | | | |
| 8/02/97 | Dithane | | | | | |
| 10/02/97 | | | Score | Score | Score | Score |
| 14/02/97 | Dithane | | | | | |
| 20/02/97 | | Score | | | | |
| 21/02/97 | | | | | | Score |
| 24/02/97 | Dithane | | Score | Score | | |
| 4/03/97 | Dithane | | | | | |
| 6/03/97 | | Score | | | | |
| 10/03/97 | Dithane | | Score | Score | | |
| 12/03/97 | | | | | Score | Score |
| 18/03/97 | Dithane | | | | | |
| 20/03/97 | | Score | | | | |
| 24/03/97 | | | Score | Score | | |

| Treatment [illegible] | Emergence – 1st Spray Day [illegible] | 1st Spray – Scenes [illegible] |
|---|---|---|
| 1 | No spraying | |
| 2 | 38 | 72 |
| 3 | 43 | 67 |
| 4 | 50 | 60 |
| 5 | 61 | 49 |
| 6 | 43 | 67 |
| 7 | 43 | 67 |



FVRS Late Sown 96/97
(number above column = number of spray applications)
l.s.d. = 5.522
Yield (t/ha)
0
10
20
30
40
50
60
70
80
Cost of fungicide spray program ($/ha)
0
100
200
300
400
500
600
700
800
9
5
5
0
4
3
4
Dithane program
First Target Spot Lesion
First infection period
No Spray
Score 5 Lesions
Only post infest period 14 day. Prog
Only post infest period 7 day. Prog
Yield T/Ha
Cost $/Ha

# APPENDIX 2 - EXPERIMENTAL DETAILS - SOUTH AUSTRALIA

## Introduction

Experiments were carried out at the Lenswood Horticultural Centre, approximately 30 km east of Adelaide and on commercial potato farms in Virginia, Purnong and Currency Creek, approximately 60 km north, 130 km east and 80 km south east of Adelaide respectively. The rainfall, temperature and leaf wetness was recorded at approximately 30 cm above the soil and inside the potato canopy in or near the trial site using a Measurement Engineering Unidata weather station.

Except for fungicide and some insecticide applications, all operations such as fertiliser application, irrigation and cultivation were carried out by the grower collaborator or by Horticultural Centre staff using operations similar to commercial practice. The main fungicides used were Score (250 g/L a.i. Difenoconazole), Bravo (500 g/L a.i. chlorothalonil) and Rovral (500g/L a.i. iprodione), applied at 500 ml, 2.6 L/Ha and 2 L/Ha respectively with a knapsack sprayer using between 400 to 800 L of liquid per Ha.

Plots varied in size at each experimental site but were usually arranged in a randomised block design with at least 4 replicates per treatment. The development of disease from natural infections was assessed up to 6 times during the growing season by picking a leaf from the mid third of each of 10 plants selected at random from each plot, and assessing leaf area diseased by referring to standard keys as shown in appendix 1. Data were analysed using analysis of variance of a randomised block design in the statistical analysis program STATISTIX (NH Analytical Software, Roseville, MN USA).

Treatments in these experiments included the application of fungicides following the development of around 300 physiological "P" days (Pscheidt and Stevenson, 1986). This treatment was compared with the conventional treatment where fungicide applications are commenced around flowering or row "closure", when the first Target spot lesions were observed or where a certain threshold level of disease had developed in a crop. The threshold level of around 5 *A. solani* lesions every 10 m of row was based on the work of Schtienberg(1992), who used a level of 0.01 lesion per plant to recommend the application of fungicides to control *Alternaria* leaf spot in cotton. Another treatment evaluated the curative activity of the fungicide Score (Dahman and Staub, 1992) by applying the fungicide only after conditions suitable for infection were recorded. This was based on leaf wetness periods of at least 8 hr or 12 hrs at 15°C and 10°C respectively and did not take into consideration the level of inoculum (Rotem, 1994) (Appendix 4).

## Field Trials - 1993/94

### *Lenswood*

In this experiment, the main treatments compared Score or Bravo applied at 7-10 day intervals after varying initial spray times (Table 1). Tubers cv. Winlock were planted on 16th December 1993 in double row plots 13.5 m long with an untreated row separating other treated rows. Each treatment was replicated 6 times.

Table 1. Fungicide treatments and spray dates, cv Winlock - Lenswood 1994

| | Spray dates | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | **February** | | | | | | **March** | | | | **April** | | | **no. sprays** |
| | **9** | **11** | **18** | **21** | **25** | **28** | **8** | **15** | **22** | **29** | **8** | **15** | **21** | **applied** |
| Score - eradicant | - | S | - | - | S | - | - | - | - | - | S | - | S | 4 |
| Bravo every 7-10 days after flowering | B | - | B | - | - | B | B | B | B | B | B | B | B | 10 |
| Score every 7-10 days after flowering | S | - | S | - | - | S | S | S | S | S | S | S | S | 10 |
| Score every 7-10 days after 300 P days | - | S | - | S | - | S | S | S | S | S | S | S | S | 9 |
| Score every 7-10 days after threshold* | - | - | - | S | - | S | S | S | S | S | S | S | S | 10 |
| Bravo every 7-10 days after threshold* | - | - | - | B | - | B | B | B | B | B | B | B | B | 9 |

S = Score, B = Bravo, - = no treatment, * = after 5 lesion/10m of row

The plots were assessed for the level of disease on three occasions and harvested on May 11. Target spot developed extensively in the unsprayed plots of this experiment and by the end of April most plants in these plots were completely defoliated (Fig 1). By comparison all fungicide treatments suppressed the development of the disease with the Bravo applied only after the appearance of 5 lesions/m of row being the least effective.

Four applications of Score applied only after infection were as effective as 10 applications of Score or Bravo applied on a protective programme (Fig. 2). The eradicant Score program could have been more effective if one of the infection periods in March had not been missed. The phone line allowing modem access to the weather monitoring equipment had not been installed, so the data could not be checked daily as required.

Measurements of lesion size in the various treatments showed that lesions were significantly smaller on those plants regularly treated with Score compared to those of other fungicides (Fig 3).

Figure 1. Mean infection of midleaf after treatment with different fungicide regimes, cv Winlock Lenswood 1994

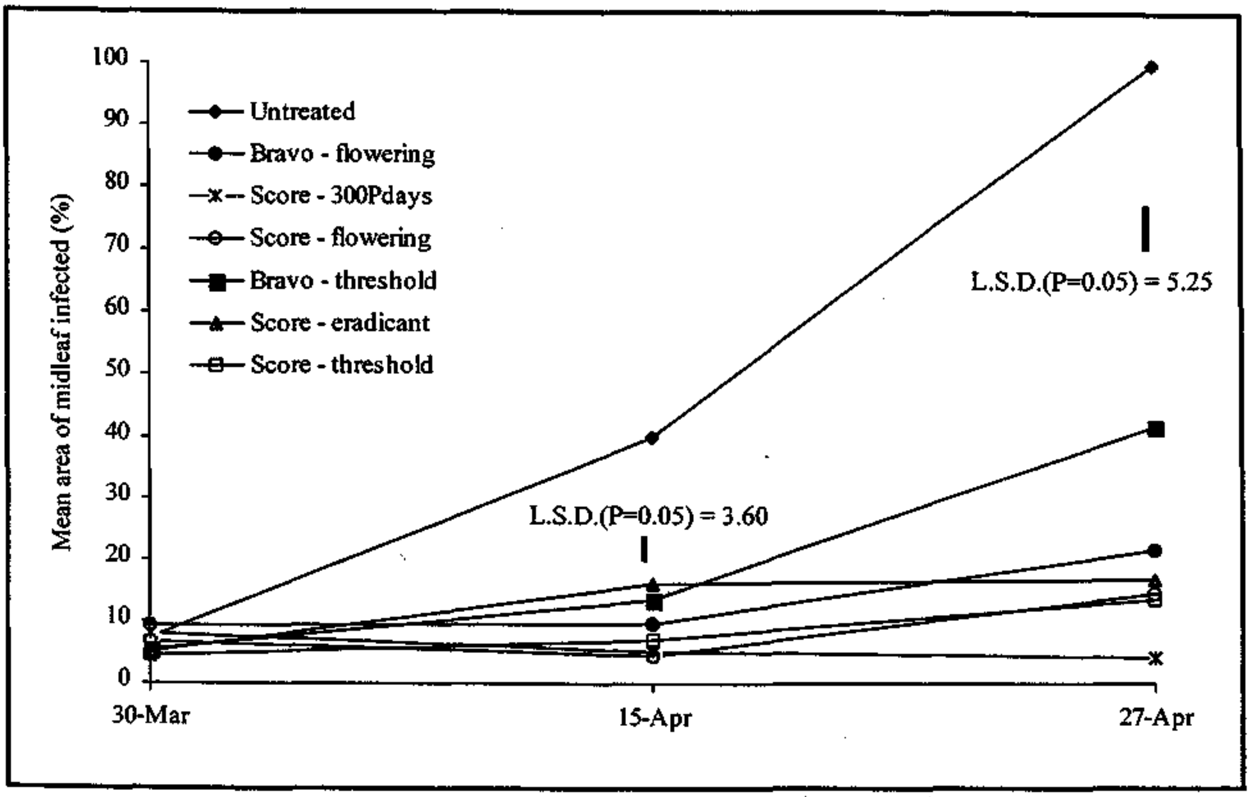



Fig 2. Area of leaf infected on 27th April after treatment with different fungicide regimes, cv Winlock Lenswood 1994

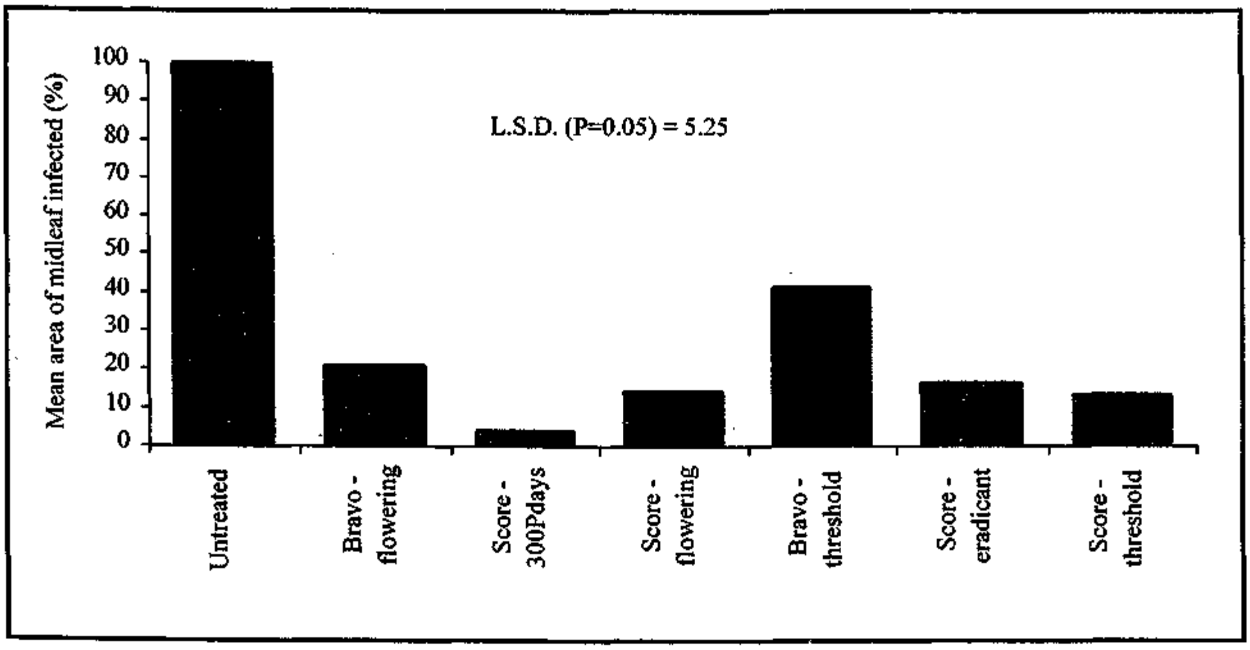
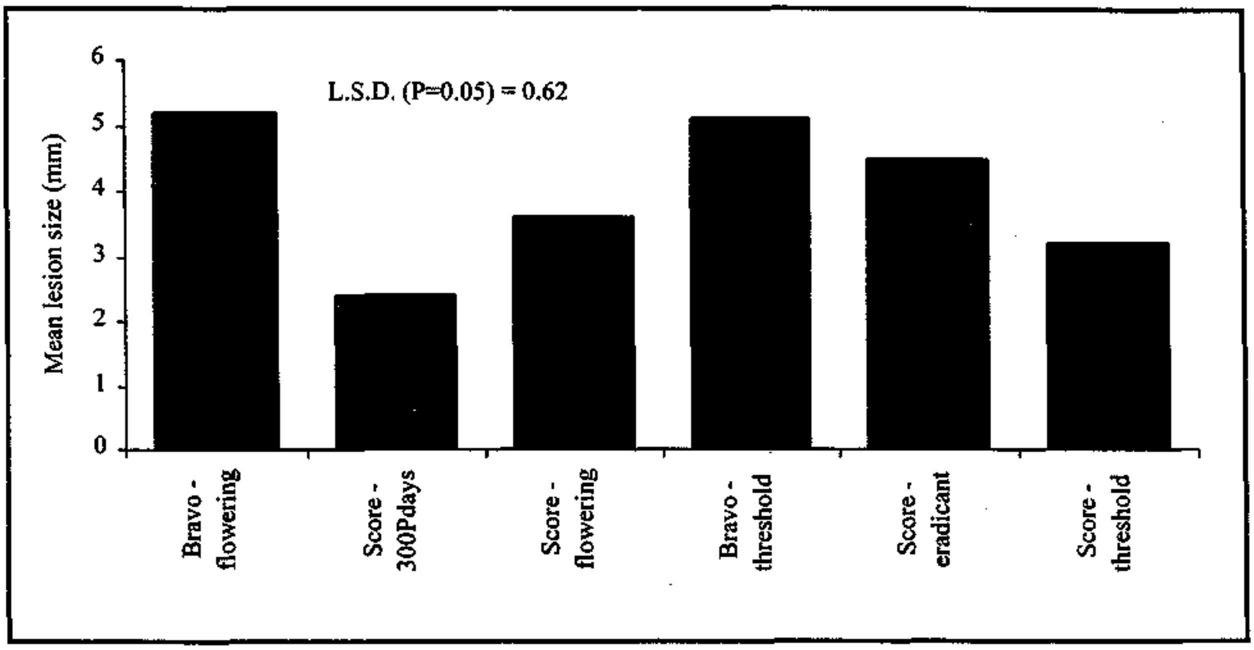


Fig 3. Mean lesion size on midleaf, 24th April, after treatment with different fungicide regimes cv Winlock - Lenswood 1994.




There was no significant differences in the yield between treatments (Table 2).

Table 2. Yield of tubers after treatment with different fungicide regimes, cv Winlock Lenswood 1994.

| **Treatment** | **Mean yield per plot (Kg)** | **Mean no tubers per plot** |
|---|---|---|
| Untreated | 60.3 | 397 |
| Bravo every 7-10 days after flowering | 72.1 | 506 |
| Bravo every 7-10 days after threshold* | 68.4 | 456 |
| Score - eradicant | 73.9 | 483 |
| Score every 7-10 days after threshold* | 62.2 | 431 |
| Score every 7-10 days after flowering | 74.0 | 506 |
| Score every 7-10 days after 300 Pdays | 69.2 | 452 |

* = threshold of 5-10 lesions per 10m of row

*Currency Creek*

Two experiments were set up in a commercial property where a large "centre pivot" area of cv. Atlantic was planted, half on 12 January and half 2 weeks later. The plots were 12 m long and 4 rows wide, the outer 2 rows used as barriers. All treatments were replicated 5 times. The first experiment in the earlier planting compared spray schedules of 7-10 days using different mixes of Score and Bravo applied after first signs of the disease were observed. The second experiment in the later planting compared different spray schedules of Score and/or Bravo applied only after 300 Pdays. The treatments and dates of application for experiments 1 & 2 are shown in Table 3.

The midleaf disease levels in experiment 1 were assessed twice and were compared with levels in the adjacent planting, where the grower applied 5 Bravo sprays. Target spot levels were high in both the unsprayed and the eradicant treated plots (Fig 4). The eradicant spray schedule depended on rapid detection of infection periods, and as the weather monitoring equipment could not be accessed remotely, several infection periods caused by heavy dew were missed and sprays not applied. As in previous experiments, the smallest lesions developed on leaves sprayed with Score (Fig 5).

Table 3. Fungicide treatments and spray dates, cv Atlantic - Currency Creek 1994

| Treatments | Spray dates | | | | | | | | Total no. sprays applied |
|---|---|---|---|---|---|---|---|---|---|
| | February | March | | | | April | | | |
| | 25 | 7 | 16 | 23 | 30 | 5 | 14 | 19 | |
| **(a) Experiment 1** | | | | | | | | | |
| Score - eradicant | S | - | - | - | - | S | - | | 2 |
| Score/Bravo alternating every 7-10 days | S | B | S | B | S | B | S | | S (4) (3) |
| Score x3 after threshold 1 then Bravo (7-10 days) | S | S | S | B | B | B | B | | S (3) B (4) |
| Bravo, Score x3 after threshold 2 then Bravo (7-10 days) | B | B | B | S | S | S | B | | S (3) B (4) |
| **(b) Experiment 2** | | | | | | | | | |
| Bravo every 7-10 days after 300 Pdays | - | B | B | B | B | B | B | B | 7 |
| Score every 7-10 days after 300 Pdays | - | S | S | S | S | S | S | S | 7 |
| Score every 14 days after 300 P days | - | S | - | S | - | S | - | S | 4 |
| Score eradicant | | S | - | - | - | S | - | S | 3 |
| Score x3 after 300 Pdays then Bravo every 7 to 10 days | - | S | S | S | B | B | B | B | S (3) B (4) |

S = Score, B = Bravo, - = no treatment, threshold 1 = after 5 lesions/10m of row, threshold 2 = after 10 lesions/10m of row

Figure 4. Area of midleaf infected after treatment with different fungicides regimes, cv Atlantic Currency Creek 1994.

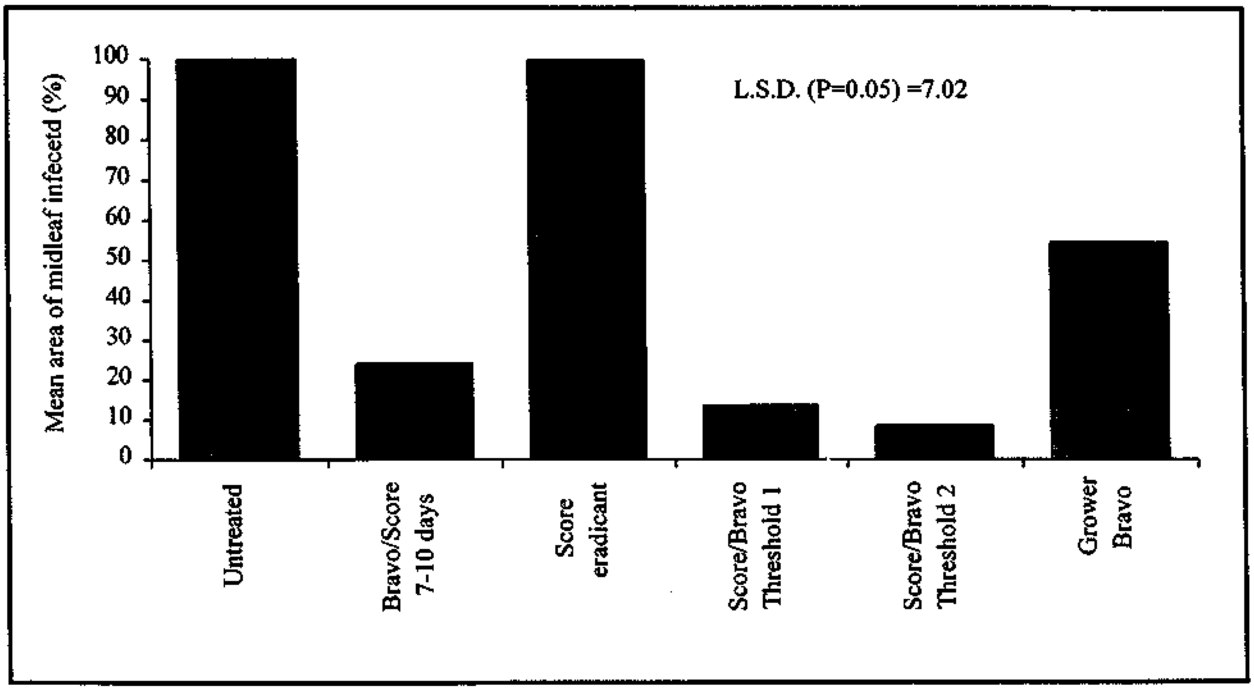
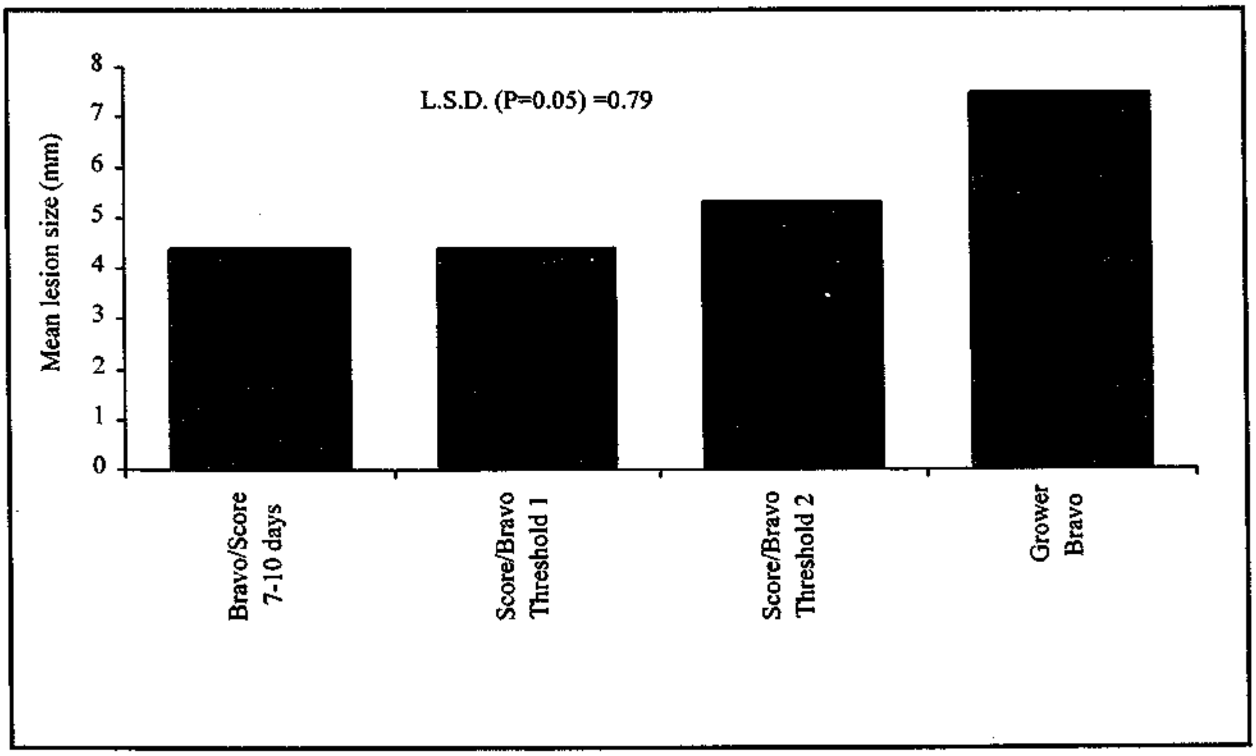



Figure 5. Mean lesion size after treatment with different fungicide regimes, cv Atlantic Currency Creek 1994.



Yield was assessed in the treatments with the highest and lowest disease levels at the final assessment, being Bravo/Score 7-10 days and untreated respectively. Two 5m long rows within each plot were hand dug and the tubers weighed and counted. 5 replicates of 2x5m rows were hand dug from the growers planting for comparison. Yields were lowest in the untreated plots, however the growers yield was significantly higher than those from the experimental plot (Table 4). This difference could be due to the physical damage caused to the plants when walking between rows while spraying.

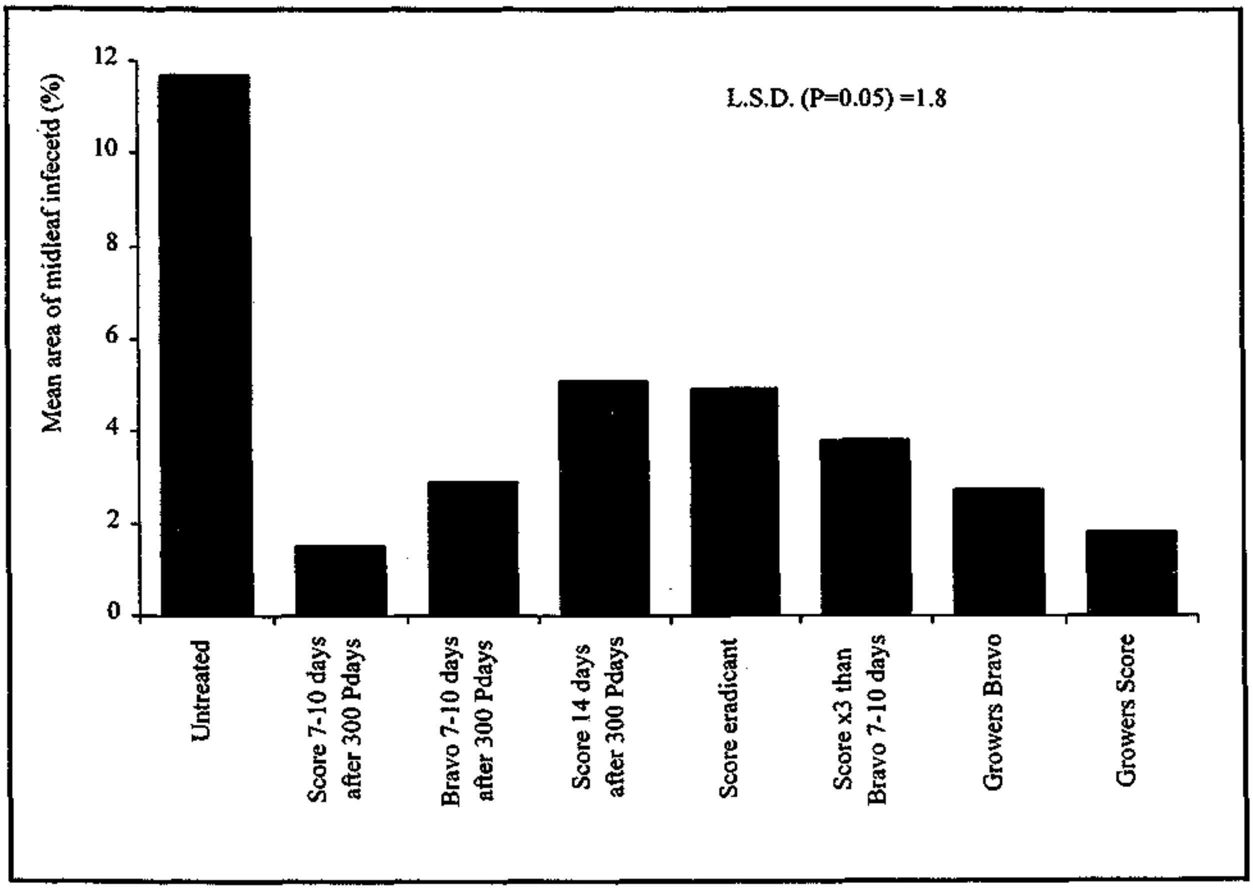
Table 4. Yield from 10m of row, cv Atlantic - Currency Creek 1994

| **Treatment** | **Weight of tubers per 10m (Kg)** | **Number of tubers per 10m** | **Mean tuber weight (g)** |
|---|---|---|---|
| Untreated | 30.6 | 312 | 99 |
| Bravo/Score 7-10 days | 32.4 | 315 | 103 |
| Growers | 36.9 | 341 | 111 |
| L.S.D. (P=0.05) | 4.1 | n.s. | n.s. |

n.s. = not significant

In experiment 2 the level of disease on the midleaf was assessed on 3 occasions and compared with the adjacent planting's, where the grower applied 5 sprays of Bravo in one area and 5 sprays of Score in another. By the end of April plants in the untreated plots in experiment 2 were dead, and as it was difficult to determine if the necrosis was due to Target spot or Black dot, no yield data was taken. However the earlier assessment showed that all treatments controlled Target spot, with the 7-10 day Score spray applied after 300 Pdays being the most effective (Fig 6).

Figure 6. Area of midleaf infected after treatment with different fungicides regimes, cv Atlantic Currency Creek 1994.



## Field trials - 1994/95

### *Currency Creek*

Two experiments were set up on a commercial property used the previous year. Both experiments compared various combinations of Score and Bravo, with sprays in experiment 1 initiated after appearance of first lesion and in experiment 2 initial spray timings were varied (Table 5).

Table 5. Fungicide treatments and spray dates, cv Atlantic - Currency Creek 1995

| | Spray dates | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | | | **March** | | | | | **April** | | **May** | **no. sprays** |
| | 3 | 10 | 14 | 17 | 23 | 30 | 11 | 18 | 28 | 8 | **applied** |
| **(a) Experiment 1** | | | | | | | | | | | |
| Score - eradicant | S | - | - | - | - | S | - | - | - | - | 2 |
| Score x2 then Bravo (7-10 days) | S | S | - | B | B | B | - | - | - | - | S (2) B (3) |
| Score x2 at 7-10days, then at 14 days | S | S | | - | S | - | - | - | - | - | 3 |
| Score every 14 days | S | - | | S | - | S | - | - | - | - | 3 |
| Bravo/Score alternating (7-10 days) | B | S | | B | S | B | - | - | - | - | S (2) B(3) |
| **(b) Experiment 2** | | | | | | | | | | | |
| Score x2 at first lesions then Bravo (7-10 days) | - | S | - | S | B | B | B | B | B | B | S (2) B (6) |
| Score x2 at threshold* then Bravo (7-10 days) | - | - | - | S | S | B | B | B | B | B | S (2) B (5) |
| Score x2 at 280 P days then Bravo (7-10 days) | - | - | - | - | S | S | B | B | B | B | S (2) B (4) |
| Score x2 at flowering then Bravo (7-10 days) | - | - | S | - | S | B | B | B | B | B | S (2) B (5) |
| Score - eradicant | - | S | - | - | - | S | S | - | - | S | 5 |

S = Score, B = Bravo, - = no treatment, * = threshold level of 5-10 lesions per 10m row

Experiment 1 was set out in half a pivot with cv. Atlantic planted on 30 December 1994, and experiment 2 in the opposite half pivot cv Atlantic planted 2 February 1995. The plots were 12m long and 4 rows wide, the centre 2 rows used for disease assessment. Experiment 1 was not assessed, as Target spot infection did not occur until past flowering and a combination of Black Dot (*Colletotrichum)* and *Verticillium* wilt again caused premature senescence. The level of disease in experiment 2 was assessed on four occasions, and on the second assessment 65 days after emergence (April 18th), significant differences in lesion numbers between treated and untreated plots were obvious with these differences persisting until the completion of the experiment (Fig 7). All fungicide treatments inhibited the development of the disease with Score applied after infection being the most effective treatment (Fig 8). This illustrates how effective post infection sprays can be when infection periods are accurately predicted by daily monitoring of the weather equipment via modem.

Figure 7. Mean number of lesions per midleaf after treatment with different fungicide regimes, cv Atlantic, Currency Creek 1995

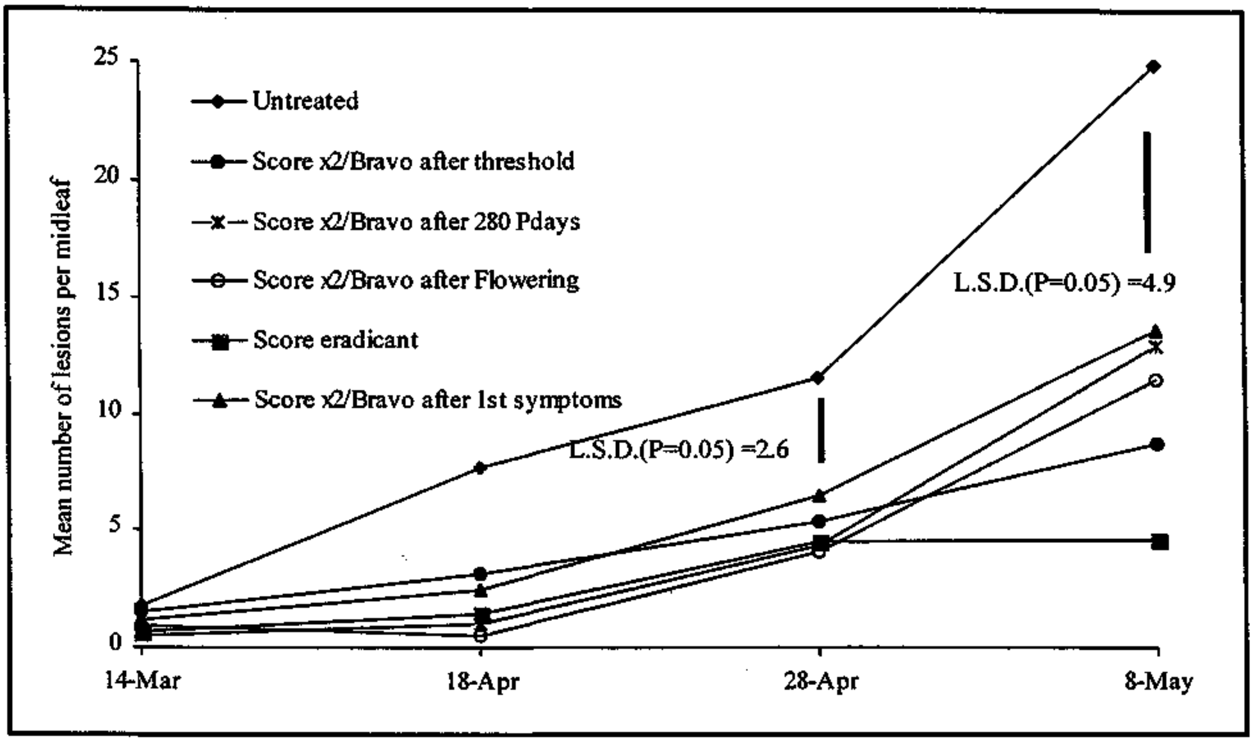
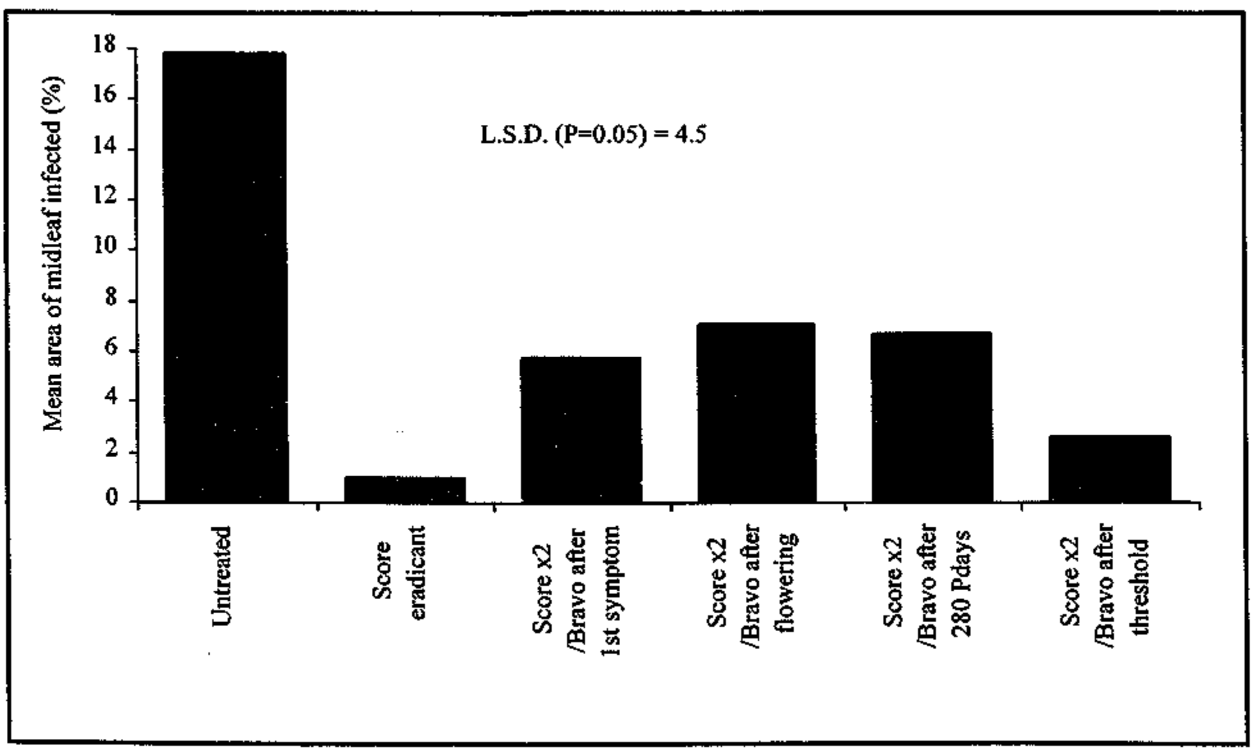



Fig 8. Area of leaf infected on 8th May after treatment with different fungicide regimes cv Atlantic Currency Creek 1994



The yield of the control and best treatment (Score eradicant) were obtained by hand digging 2x5m of row from each plot on 5th July. These were compared with the growers yield by hand digging 5 x 10m rows in the main planting adjacent to the trial. Yields were not significantly different between the best and worst treatments in experiment 2 (Table 5), with the growers area again yielding the highest. As the disease level in this trial was relatively low, yield differences were not expected.

Table 5. Mean plot yield from 10m of row per plot, cv Atlantic - Currency Creek 1995

| Treatment | Mean total yield per 10m (Kg) | Mean tuber weight (g) |
|---|---|---|
| Untreated | 17.4 | 83 |
| Score - eradicant | 21.8 | 94 |
| Growers area | 24.8 | 102 |
| L.S.D. (P=0.05) | 5.7 | 14 |

*Lenswood*

cv. Atlantic was planted on 2 February in plots 12m long and 4 rows wide. Treatments were replicated 8 times, and compared Score at 7-10 days initiated at various times with Rovral at 7-10 days from 280 Pdays (Table 6).

Table 6. Fungicide treatments and spray dates, cv Atlantic - Lenswood 1995

| **Treatments** | **Spray dates** | | | | | | | | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| | **April** | | | | **May** | | | | **no. sprays** |
| | **5** | **11** | **21** | **28** | **8** | **16** | **23** | **29** | **applied** |
| Score at 7-10 days after 280 Pdays | S | S | S | S | S | S | S | S | 8 |
| Rovral at 7-10 days after 280 Pdays | R | R | R | R | R | R | R | R | 8 |
| Score at 7-10 days after first sign of lesions | - | S | S | S | S | S | S | S | 8 |
| Score at 7-10 days after flowering | - | - | S | S | S | S | S | S | 6 |

S = Score, R = Rovral, - = no treatment

The area of midleaf with lesions and the number of lesions per leaf were assessed on 4 occasions. By the third assessment on 29th May, 86 days after emergence, the disease level was significantly lower in the plots where Score was applied every 7-10 days either after the first Target spot lesions were observed or after 280 Pdays (Fig 9). By the end of the trial at 100 days after emergence there was no significant differences between the disease levels in any of the treatments (Fig 10), and all controlled Target Spot compared to the unsprayed plots. Yield data was not measured as with the low levels of disease there was not expected to be any differences between treatments.

Figure 9. Disease levels 86 days after emergence after treatment with different fungicide regimes, cv Atlantic, Lenswood 1995

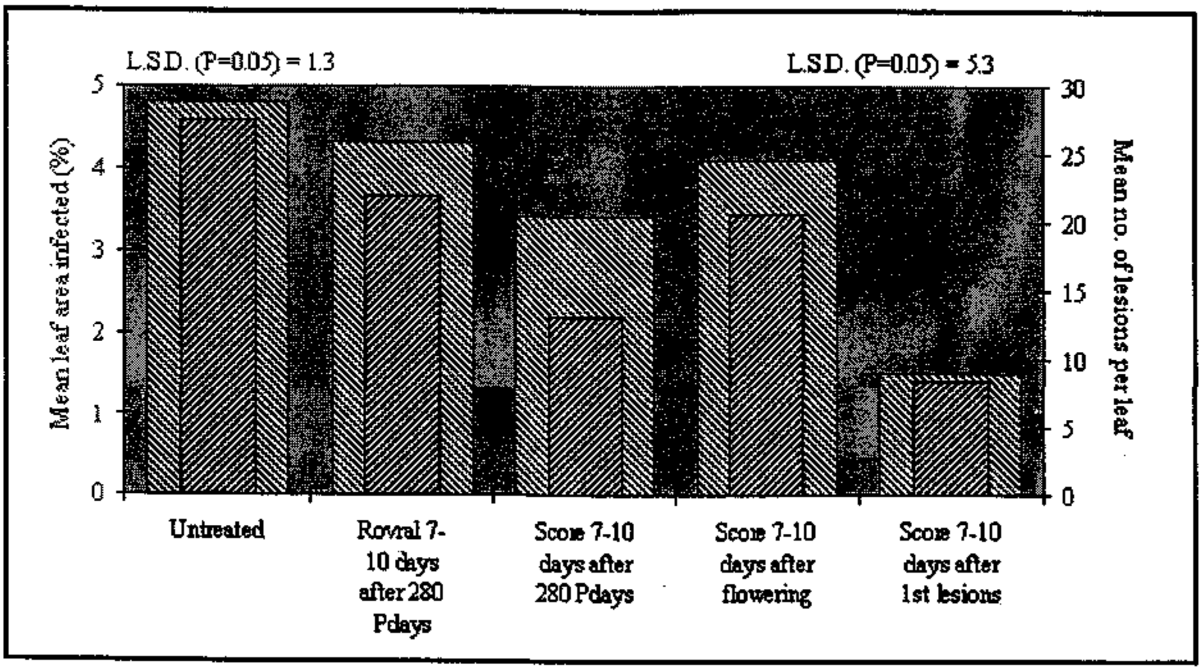
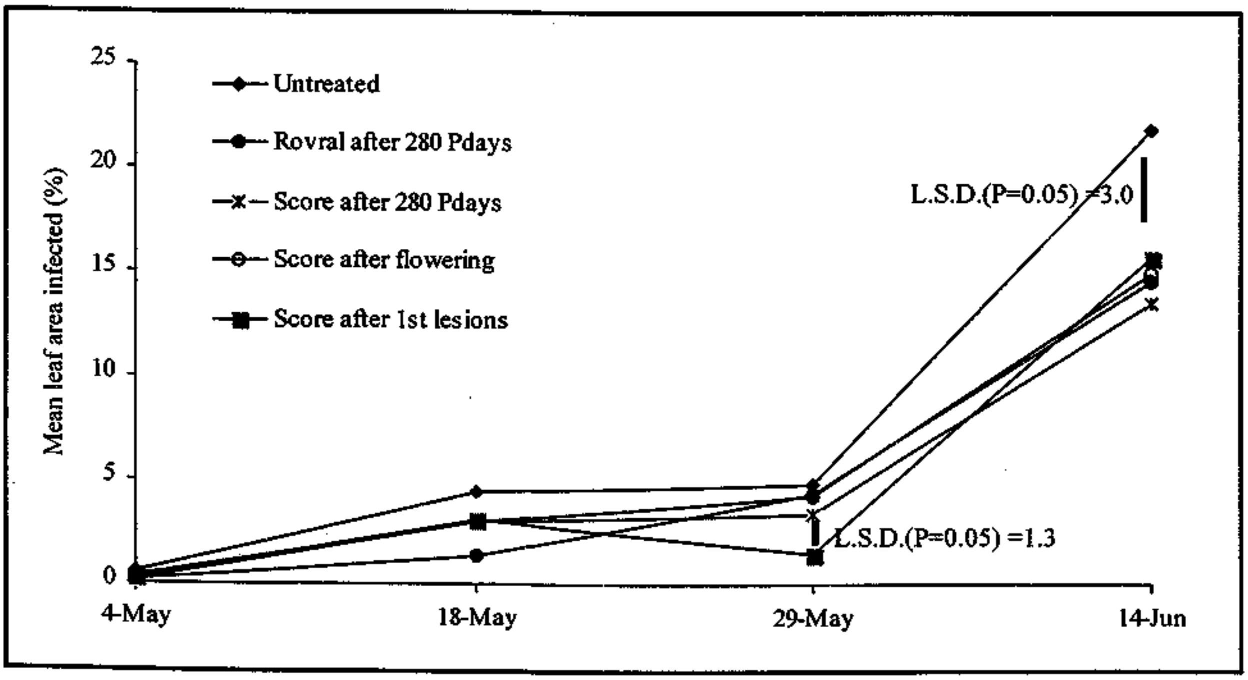



Figure 10. Area of leaf infected after treatment with different fungicide regimes, cv Atlantic Lenswood, 1995



*Virginia*

The cv. Sequoia was planted on a commercial property on March 17, with 15 m long plots consisting of 2 sprayed rows separated by a buffer row . Treatments were replicated 6 times, and compared sprays of Score at 2 rates and different timings initiated either at 350 Pdays or when the grower started his spray regime at late flowering (Table 7).

Table 7. Fungicide treatments and spray dates, cv Sequoia - Virginia 1995

| | Spray dates | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| **Treatments** | **May** | | **June** | | | | **July** | **no. sprays** |
| | **18** | **29** | **9** | **13** | **20** | **26** | **4** | **applied** |
| Score (0.4 ml/L) every 7-10 days after flowering | S | S | S | S | S | S | S | 7 |
| Score (0.6 ml/L) every 7-10 days after flowering | S | S | S | S | S | S | S | 7 |
| Score (0.6 ml/L) every 10-14 days after flowering | S | | S | - | S | - | S | 4 |
| Score (0.4 ml/L) every 7-10 days after 350 Pdays | - | S | S | S | S | S | S | 6 |
| Score (0.6 ml/L) every 14 days after 350 Pdays | - | S | - | S | - | S | - | 3 |
| Score (0.6 ml/L) x2 then Bravo every 7-10 days after 350 P days | - | S | S | B | B | B | B | S (2) B (4) |

S = Score, B = Bravo, - = no treatment

The level of disease on the midleaves was assessed on 4 occasions, and compared to that in the adjacent growers paddock, sprayed with Bravo by air every 10 days from mid May. All treatments reduced the disease level compared to the unsprayed plots, and at 75 days after emergence (15th June) the 7-10 day sprays initiated at flowering had the lowest disease level (Fig 11). However by the end of the trial (20th June), only the high rate of Score applied every 7-10 days from flowering was significantly better (Fig 12).

Figure 11. Disease levels 75 days after emergence after treatment with different fungicide regimes cv Sequoia - Virginia 1995

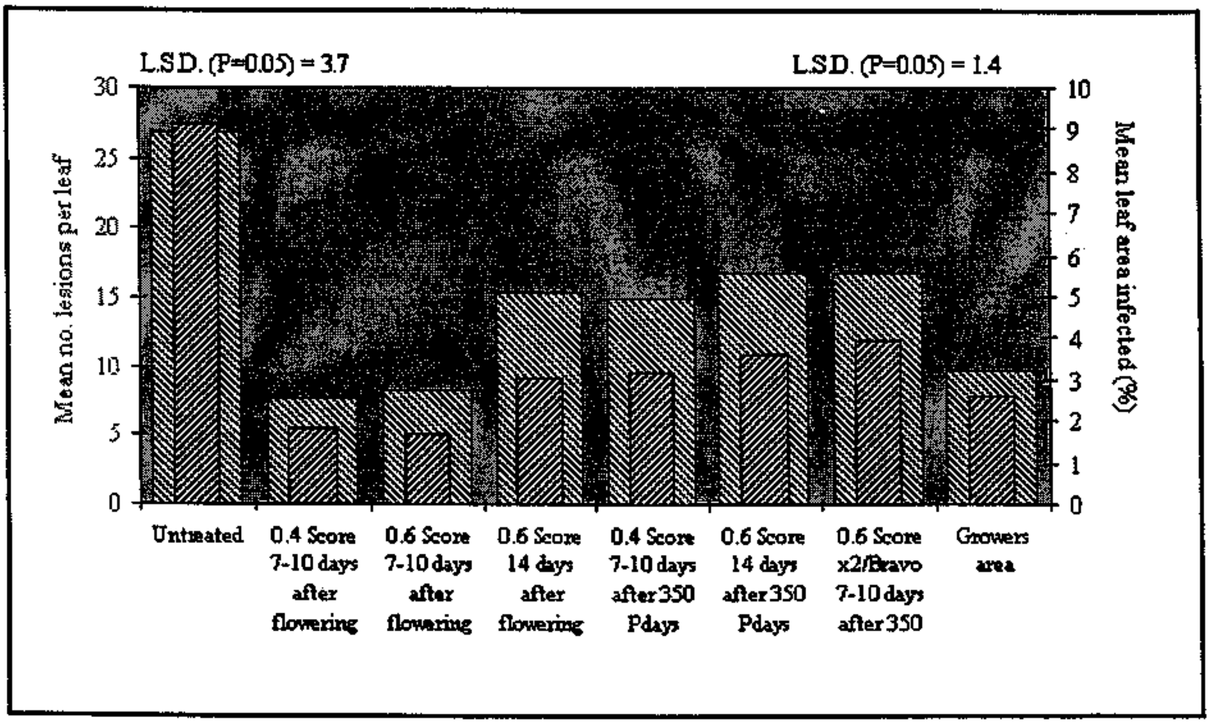
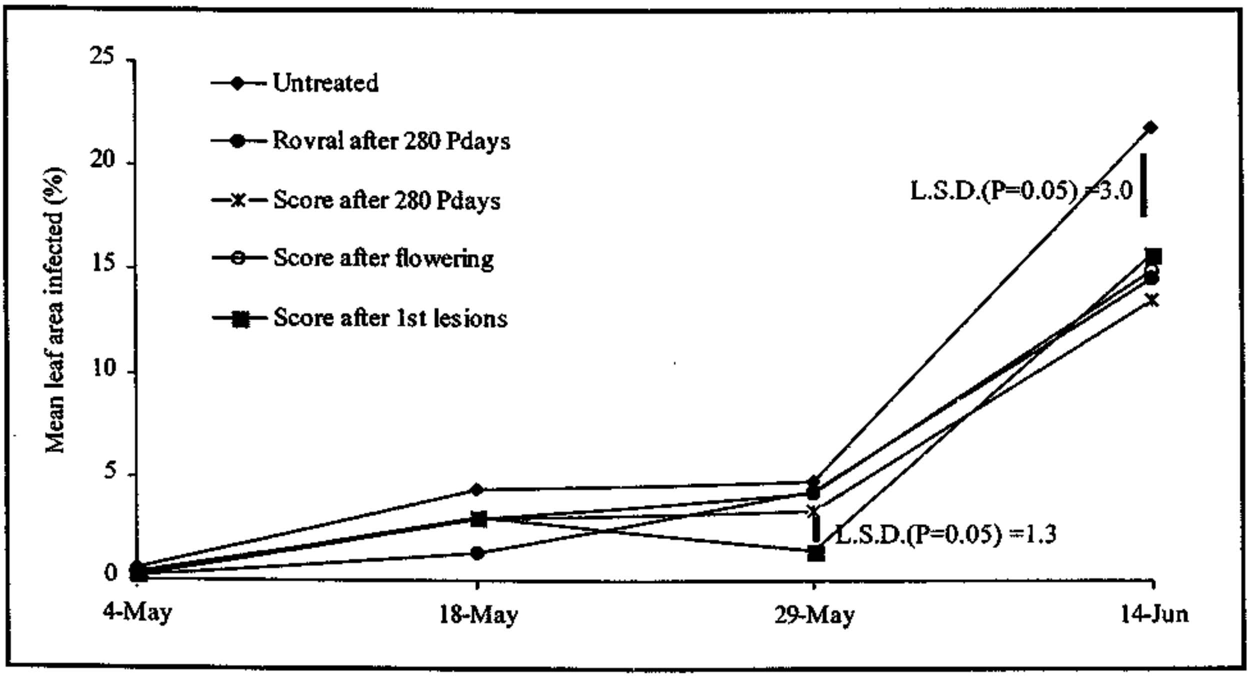



Figure 12. Area of leaf infected after treatment with different fungicide regimes, cv Sequoia Virginia 1995



## *Purnong Landing*

This experiment was conducted on a commercial property where cv. Coliban was planted on 28 July. Treatments were replicated 4 times and compared mixed Score and Rovral sprays with different initiation times (Table 8).

Table 8. Fungicide treatments and spray dates, cv Coliban - Purnong Landing 1995

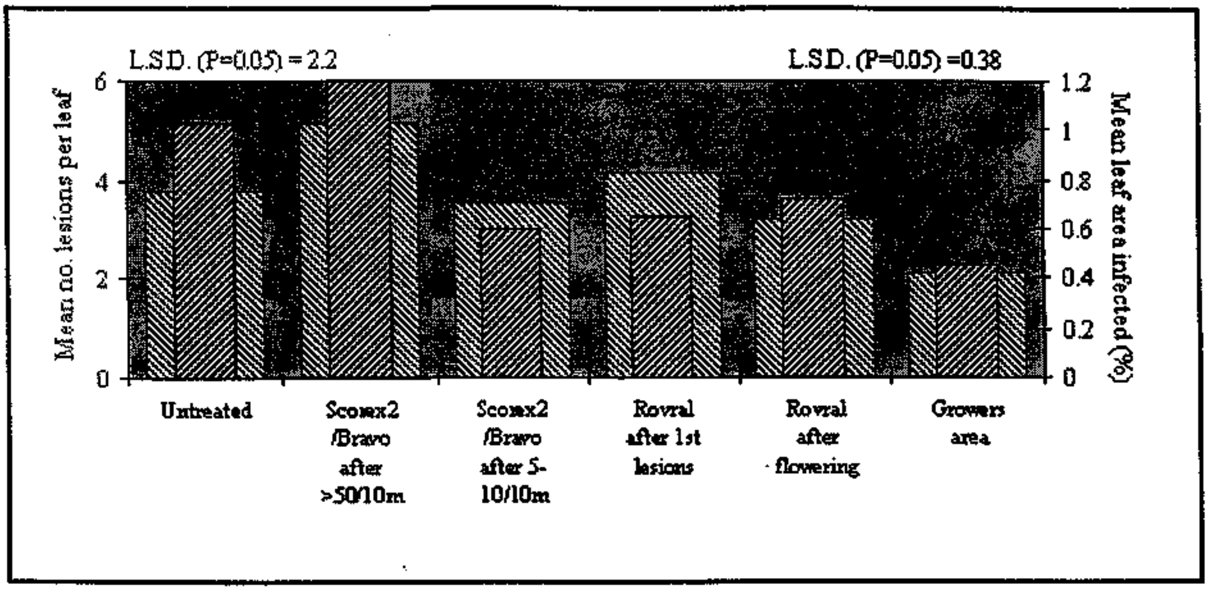
| Treatments | Spray dates | | | | | | Total no. sprays applied |
|---|---|---|---|---|---|---|---|
| | October | | | November | | | |
| | 16 | 23 | 31 | 7 | 15 | 22 | |
| Rovral at 7-10 days from flowering | R | R | R | R | R | R | 6 |
| Rovral at 7-10 days from first sign, substituted by Score x2 at threshold 1 | - | R | S | S | R | R | R (3) S (2) |
| Score x2 after threshold 2 then Rovral (7-10 days) | - | - | - | - | S | S | 2 |
| Score x2 at threshold 3 then Rovral (7-10 days) | - | - | S | S | R | R | S (2) R (2) |

R = Rovral, S = Score, - = no treatment,
threshold 1 = 10-20 lesions per 10 m, threshold 2= >50 lesions per 10 m, threshold 3 = 5-10 lesions per 10m

The plots consisted of 4 sprayed rows, and the level of disease was assessed in the centre two rows after the final spray was applied on 22 November. The levels of Target spot in this trial were very low, with between 0 and 6% of the midleaf infected in the untreated plots 103 days after emergence (23 Nov). Only the Score/Rovral treatment initiated after 5-10 lesion threshold had significantly less disease than the untreated plots (Fig 13).

There were only 2 detectable infection periods in the life of this trial, both early in the spray schedule, so this trial was not a good test of the spray regimes. The adjacent growers paddock received 2 Rovral sprays, one a day before the first infection period and the next the day after the 2nd infection period. This provided control equivalent to the best experimental regimes, but with 2 less sprays. It is in situations like this with such low levels of infection, that a combination of disease and weather monitoring would be ideal. A single eradicant spray of Score immediately after the second infection period, when the threshold level was below 10 lesions per 10m of row, should have been sufficient to provide the level of control achieved in this trial.

Figure 13. Disease levels 103 days after emergence after treatment with different fungicide regimes cv Coliban - Purnong 1995



## Field Trials - 1995/96

### *Currency Creek*

The pivot with cv. Atlantic was planted 16th January on the commercial property used in previous experiments. The plots, 15m long and 4 rows wide, were sprayed with either Rovral or a mixture of Rovral and Score using the spray schedule indicated by the PCM computer program with different initial spray times (Table 9).

Table 9 Fungicide treatments and spray dates, cv Atlantic - Currency Creek 1996

| Treatments | Spray dates | | | | Total no of sprays |
|---|---|---|---|---|---|
| | March | | April | | |
| | 22 | 31 | 11 | 19 | |
| Score - eradicant | S | - | S | S | 3 |
| Rovral at PCM times after first symptoms | R | R | R | R | 4 |
| Rovral at PCM times after first symptoms, plus Score* | S | R | S | S | S(2) R(2) |
| Rovral at PCM times after threshold | - | R | R | R | 3 |
| Rovral at PCM times after threshold plus Score* | - | R | S | S | S(1) R(2) |

S = Score, R = Rovral, threshold=5-10 lesions/10m of row, *= Rovral replaced by Score if an infection period had occurred since the last spray

Treatments were replicated 4 times and midleaf infection was assessed on 4 occasions. The trial was finished prematurely and no yield data was obtained as a combination of wind damage and Black dot caused early senescence of the crop. The first lesions were observed on 22 March, 55 days after emergence at late flowering. A low incidence of Target spot (8%) was detected in the unsprayed plots, however after a further 3 weeks the disease was detected in 92% of plants in the untreated plots, compared to 48% in the growers area (Figure 14).

All treatments significantly reduced the level of disease (Fig 15). The replacement of Rovral with Score if an infection period had occurred since the last spray did not decrease the amount of disease. The timing of the initial spray had the greatest effect, with all treatments initiated at the first signs of the disease giving the best control (Fig 16). The grower sprayed the adjacent paddock with Score at flowering (14 Mar), when the first lesions were noted (22 Mar) and with Rovral in early April. This provided control equivalent to that of the best treatments.

Figure 14. Percentage of plants infected after treatment with different fungicide regimes cv Atlantic Currency Creek 1996

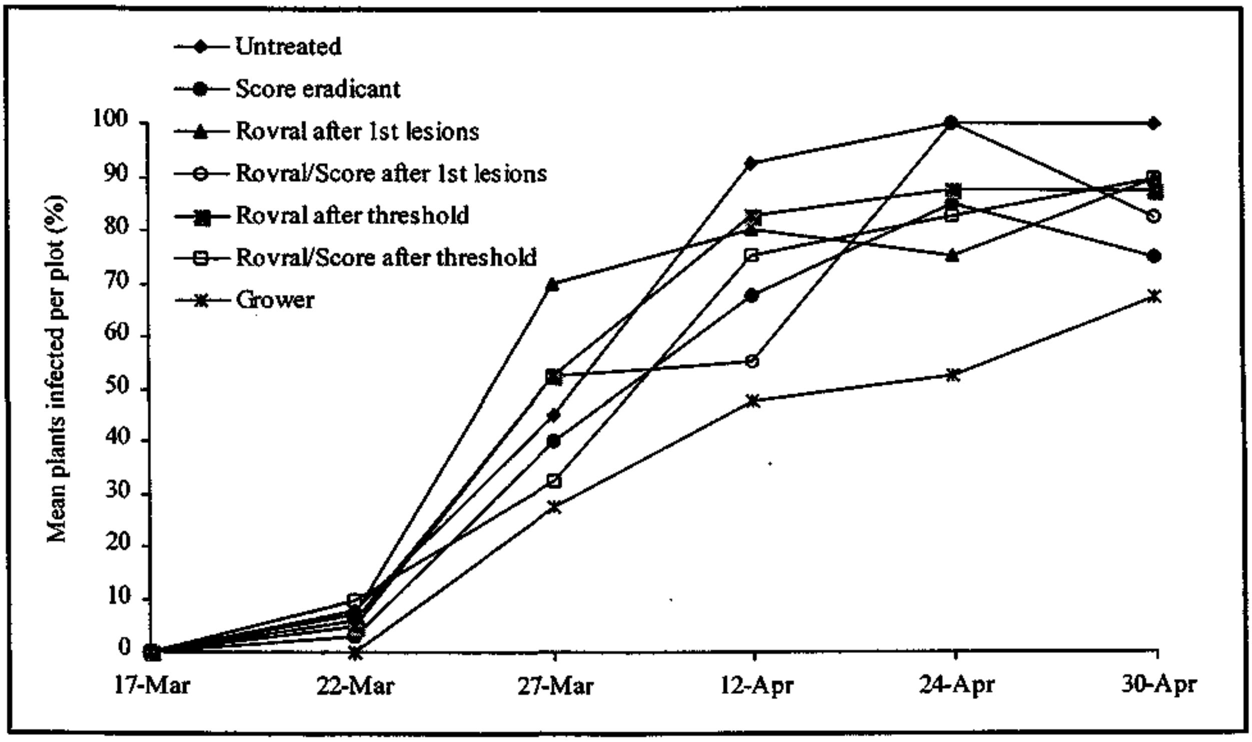



Figure 15. Area of leaf infected after treatment with different fungicide regimes, cv Atlantic Currency Creek 1996

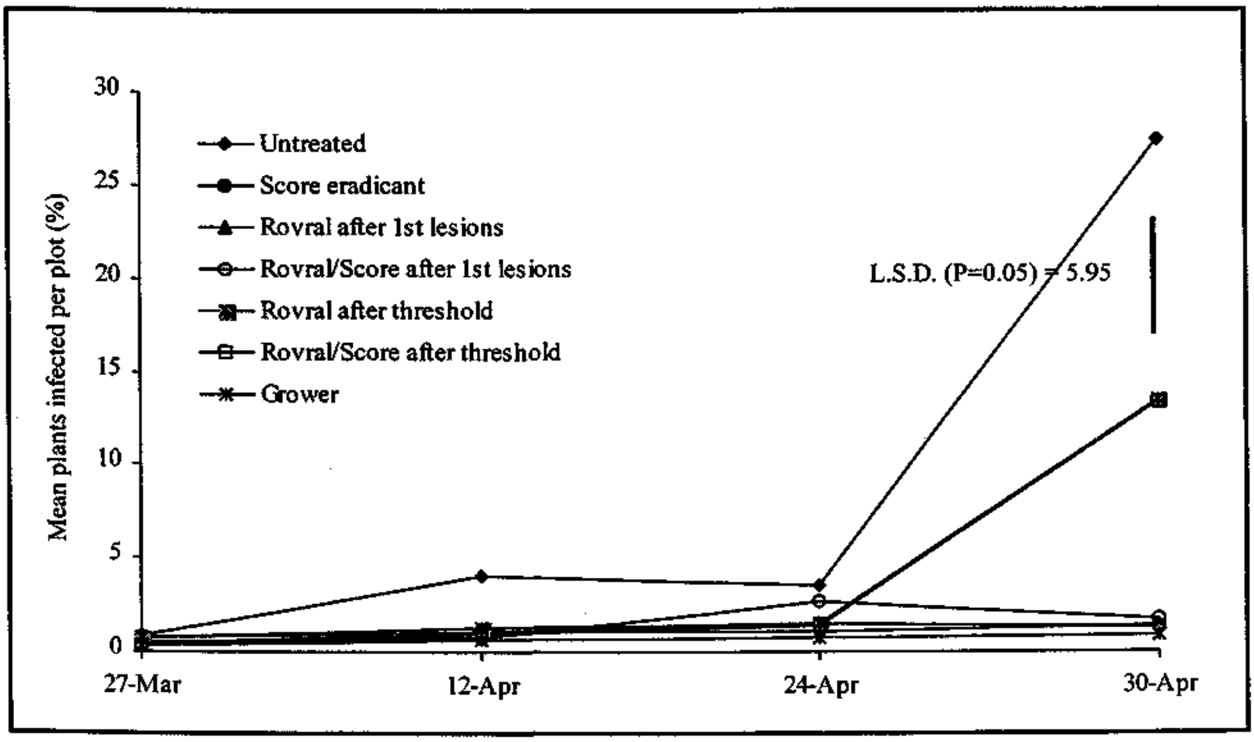
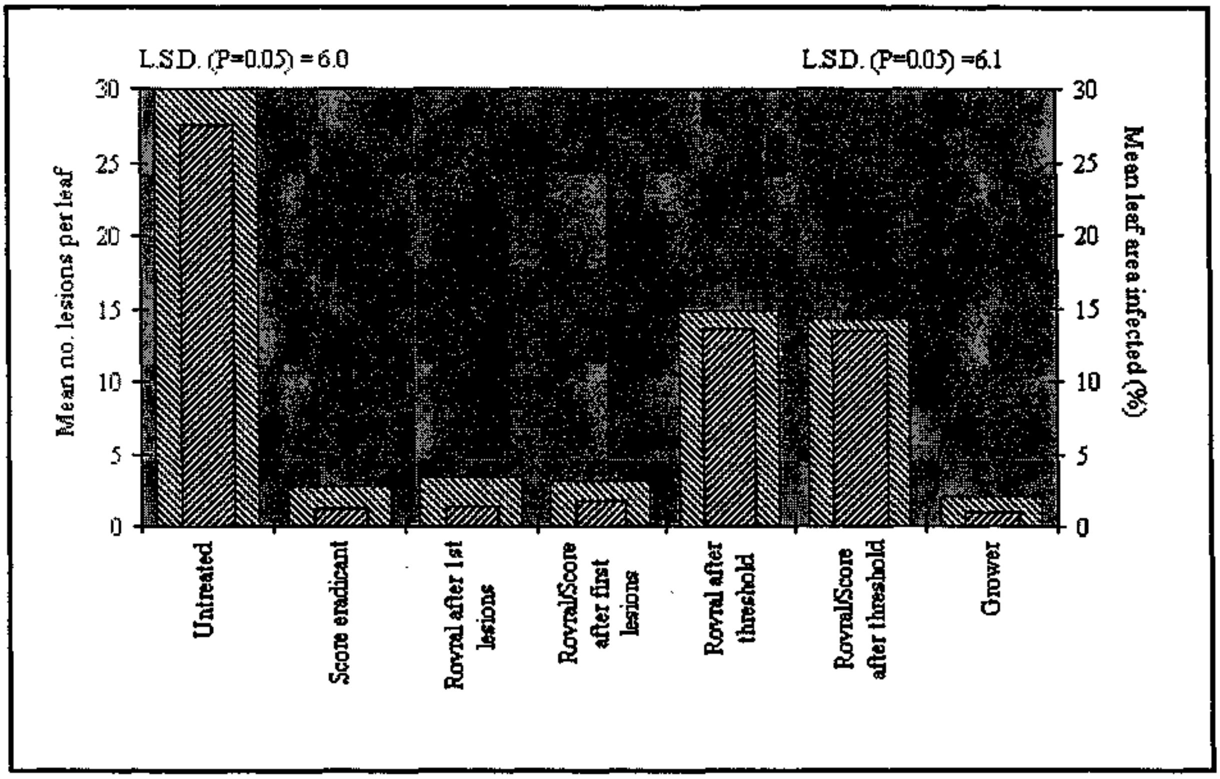


Figure 16. Disease levels 94 days after emergence after treatment with different fungicide regimes cv Atlantic, Currency Creek 1996



### *Lenswood*

The cv. Coliban was planted 28th November 1995 in 3 row plots, 12m long. Treatments were replicated 4 times and were the same as the Currency Creek 1996 trial (Table 10).

Table 10. Fungicide treatments and spray dates, cv Coliban - Lenswood 1996

| | **Spray dates** | | | | | | | | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | **Jan** | **Feb** | | | **March** | | | **April** | **no. sprays** |
| | **29** | **12** | **22** | **4** | **14** | **21** | **25** | **10** | **applied** |
| Score - eradicant | - | S | S | S | - | S | - | - | 4 |
| Rovral at PCM times after first symptoms | R | R | R | R | R | - | R | R | 7 |
| Rovral at PCM times after first symptoms plus Score* | R | S | R | R | R | - | S | S | S(3) R(4) |
| Rovral at PCM times after threshold | | R | R | R | R | - | R | R | 6 |
| Rovral at PCM times after threshold plus Score* | | S | R | R | R | - | S | S | S(3) R(3) |

S = Score, R = Rovral, threshold=5-10 lesions/10m of row, *= Rovral replaced by Score after an infection period occurred

The midleaf disease level in the centre row of each plot was assessed on 4 occasions, and the trial was harvested 22 April. The first lesions were observed on 1 February, 35 days after emergence at early flowering. By the 14th March, 76 days after emergence, Target spot was widespread, with over 50% of the plants infected (Fig 17). However the severity in the treated plots was very low, with the highest disease level by the end of the trial being 11.8% midleaf area infected in the Score eradicant treatment (Fig 18). All fungicide treatments inhibited disease development compared to the unsprayed plots, with Score as an eradicant schedule being the least effective fungicide program. The addition of Score into the Rovral program after an infection period increased the level of control slightly (Fig. 19), but the differences were not statistically significant.

The control treatment had a significantly lower yield than that of the best treatment, Rovral initiated after the first lesions with Score substituted after an infection period (Fig 20).

Figure 17. Mean percentage of plants infected after treatment with different fungicide regimes cv Coliban - Lenswood 1996

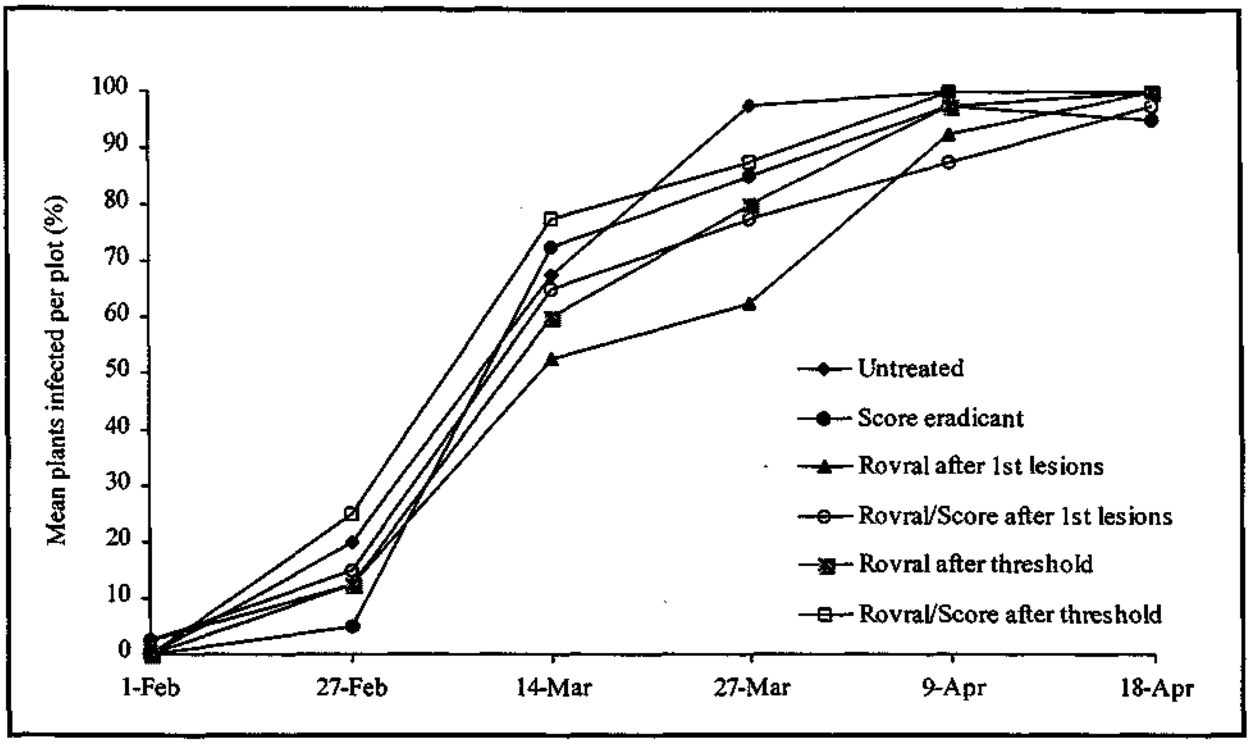



Figure 18. Mean percent area of midleaf infected after treatment with different fungicide regimes cv Coliban - Lenswood 1996

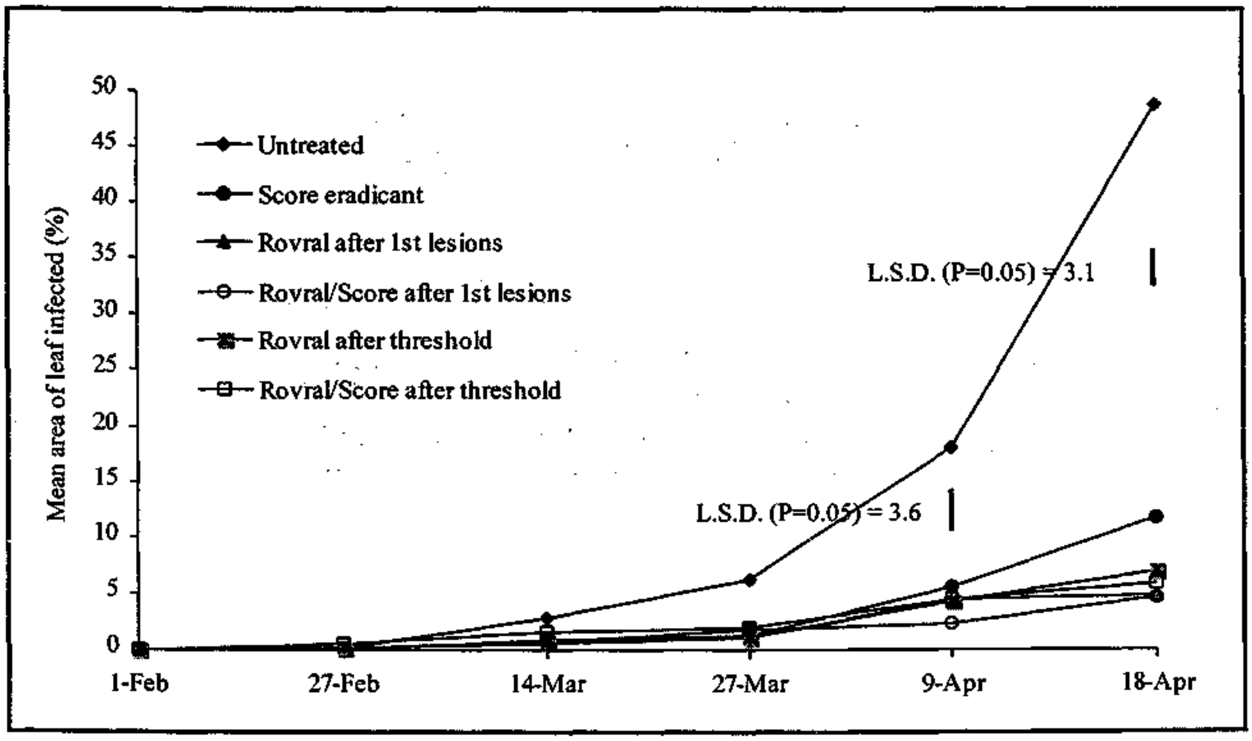


Figure 19. Disease levels 113 days after emergence after treatment with different fungicide regimes cv Coliban - Lenswood 1996

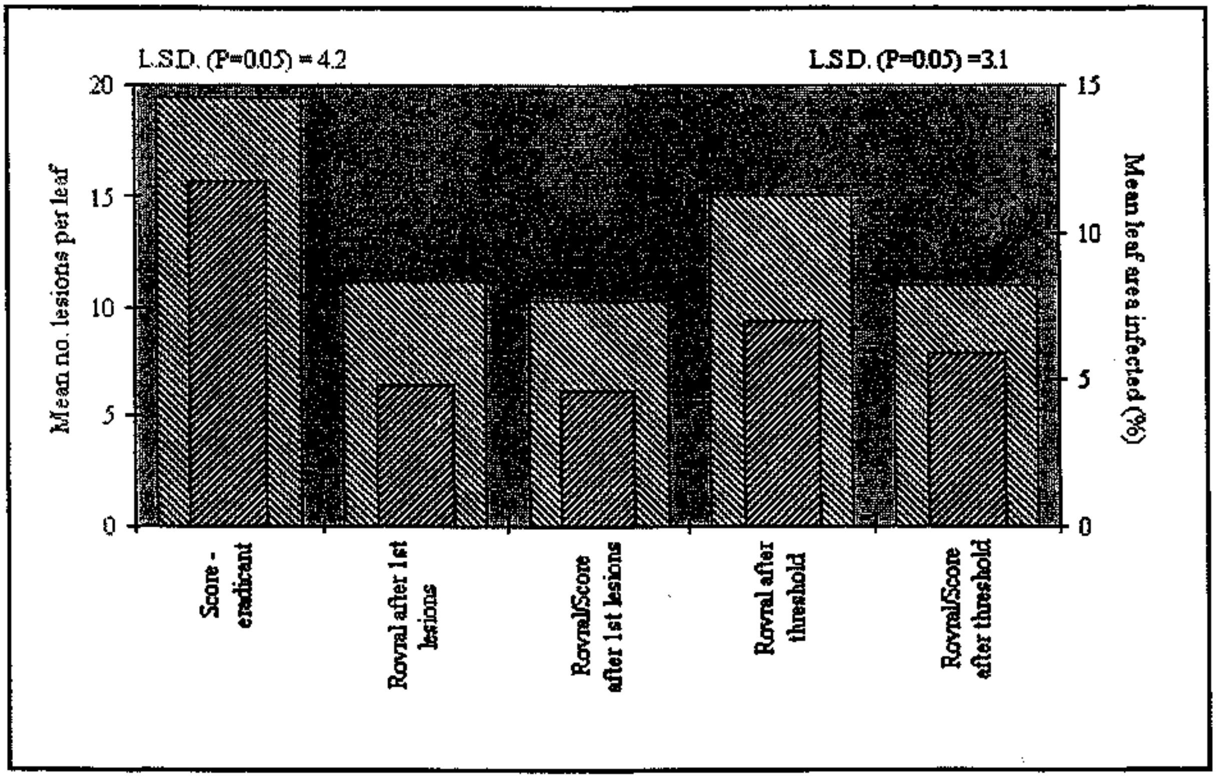
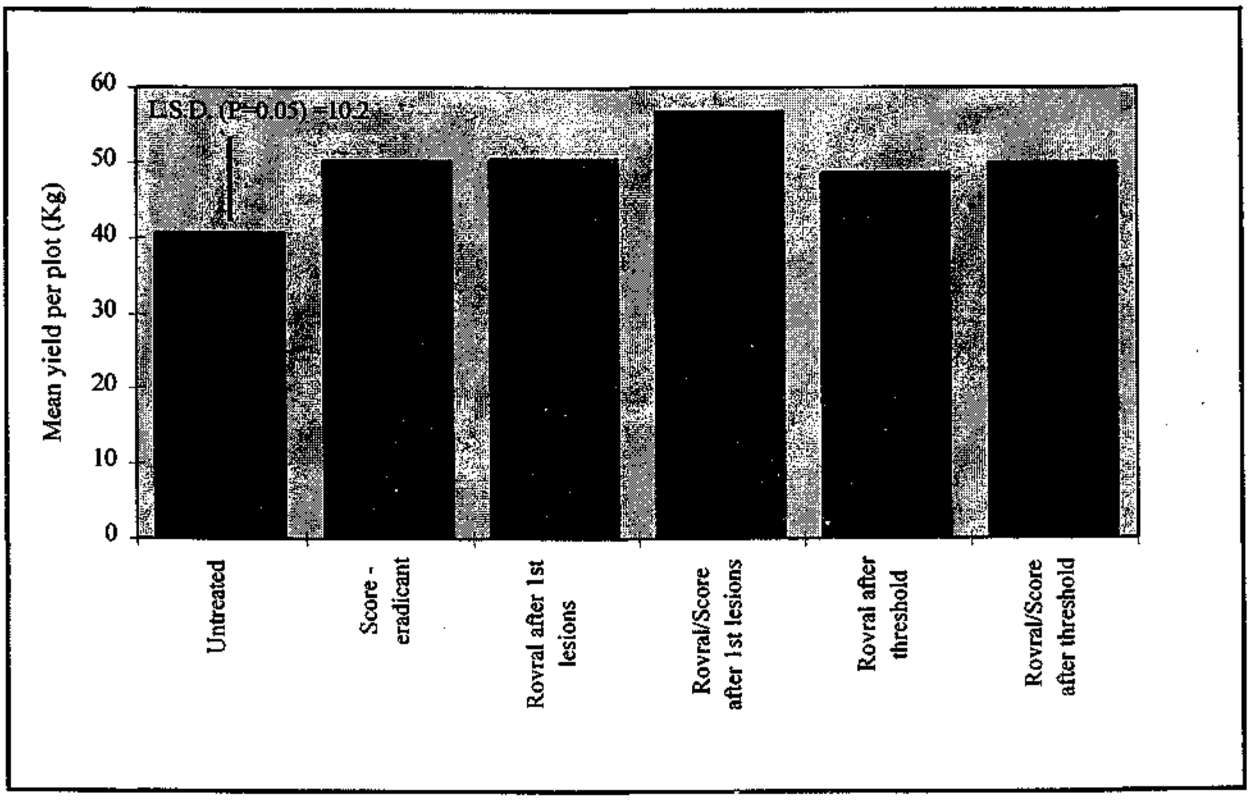


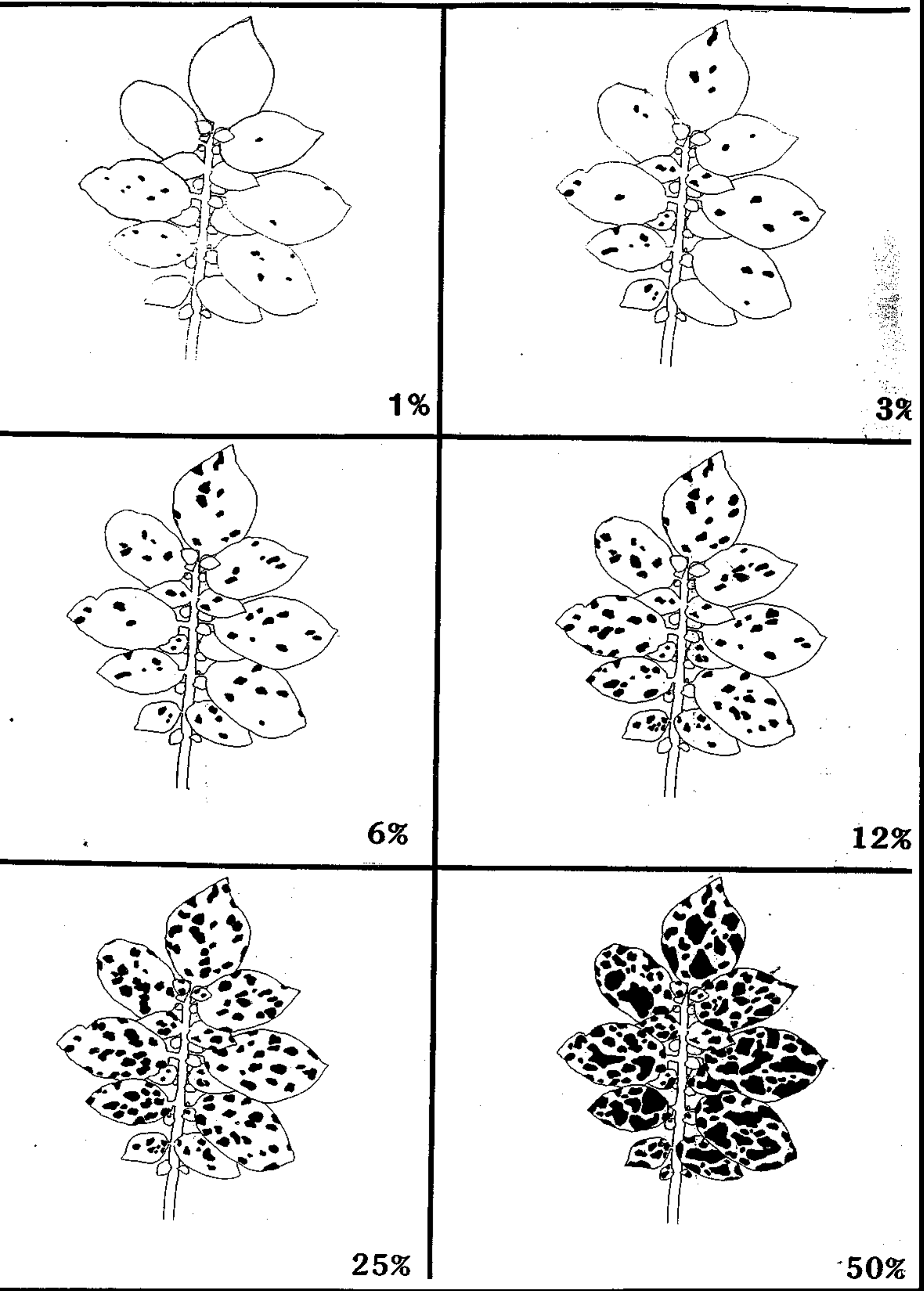

Figure 20. Yield after treatment with various fungicide regimes, cv Coliban - Lenswood 1996



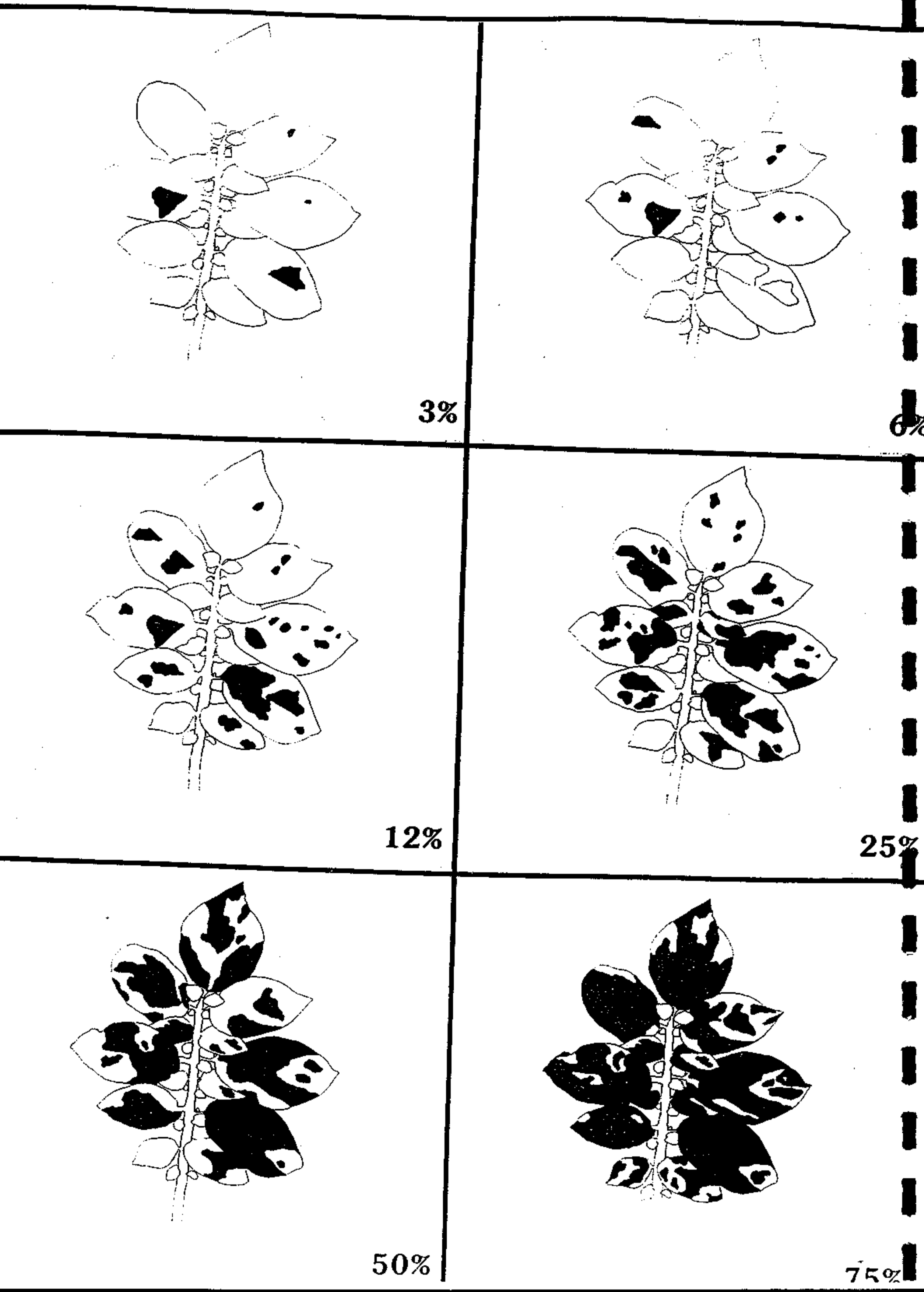
## Appendix 3. - Assessment Keys

Assessment keys for leaf area infected with Target spot.

# TARGET-SPOT ASSESSMENT



# TARGET-SPOT ASSESSMENT



# Appendix 4. - Determination of infection periods

Effect of wetting period and temperature on infection of potato by *A solani*. (Rotem, 1994)

Interactions between WP, temperature, and inoculum dose were demonstrated in an experiment with potato early blight, replicated from an identical experiment conducted previously with potato late blight (Rotem et al, 1971). The test plants were inoculated with various doses of *A. solani* spores and were wetted for 6, 12, 24, and 48 h at various temperatures measured and controlled with thermocouples clipped to their leaves. Under the least favorable conditions for infection, with the shortest WP (6 h)

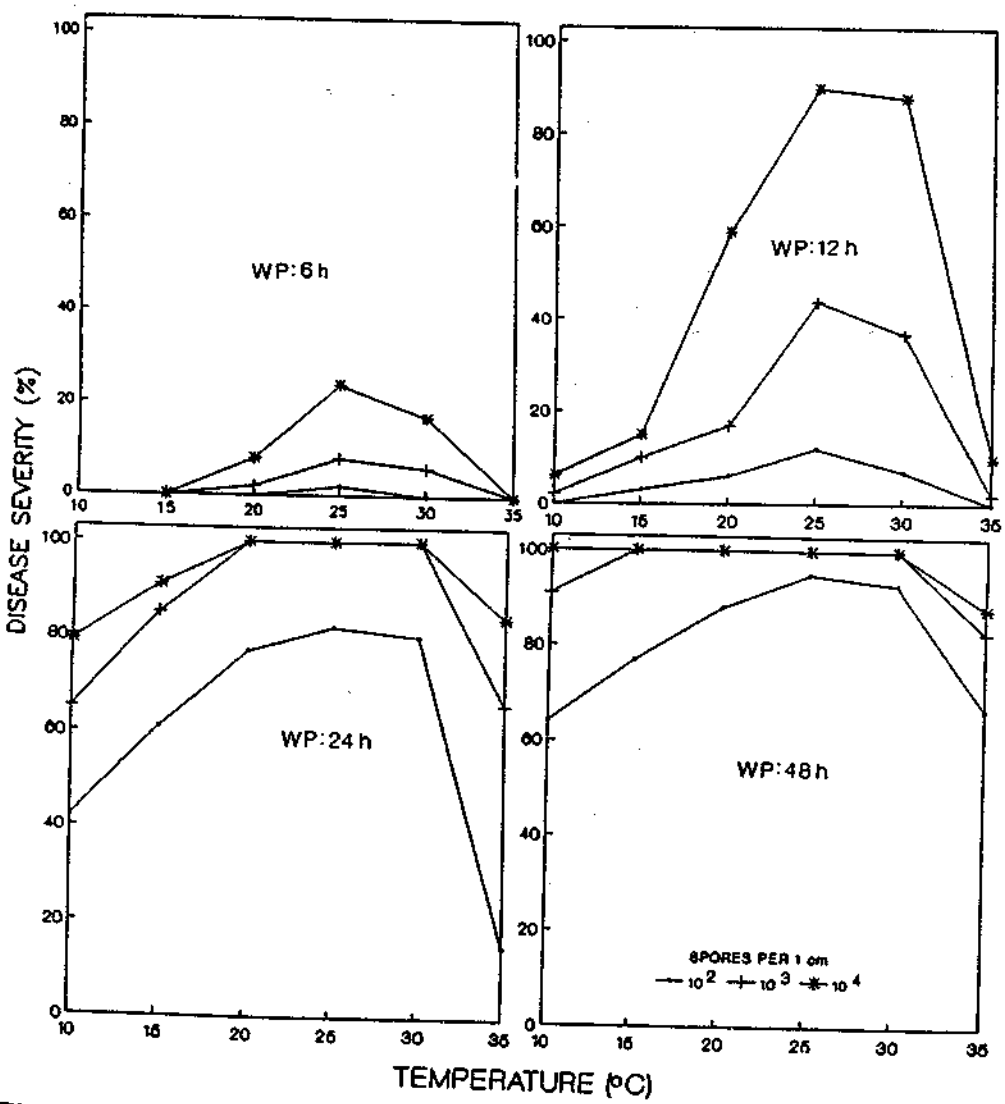



**Figure 5.2.** Effects of wetting period (WP), inoculum dose (number of spores per 1 cm$^2$), and temperature on infection of potato by *Alternaria solani*. Interactions between the wetting period, inoculum dose, and temperature determine the level of infection and show that minimum, optimum, and maximum conditions do not have fixed values. A favorable level of one factor compensates for a less favorable level of another factor and widens the range of successful infections.

# PT341
## Integrated management of early and late potato blights in Australia

## Volume 2

# CONTENTS

## INDUSTRY SUMMARY

A Potato Crop Management Program (PCM), developed by the University of Wisconsin, was tested in South Australia and Tasmania as a tool to control Target spot (Early blight) and Late blight (Irish blight) in potatoes. The program uses weather data to predict initiation and timing of fungicide applications, so trials were set up to evaluate the effectiveness of different spray regimes against these diseases. Over the three years very little late blight occurred, so the emphasis, especially in South Australia, was on controlling Target spot. Weather stations to monitor temperature, rainfall and leaf wetness were placed at trial sites and in commercial crops and the data used both for running the PCM program and to correlate the weather conditions with the level of Target spot.

The PCM program was a worthwhile tool, as long as the initial spray was correctly timed. The program uses physiological days (Pdays), based on the maximum and minimum ambient temperatures which determine the growth of the potato plant, to determine the spray timings. The Pdays used to initiate spraying are entered into the PCM program, and can range between 200 and 400. There were between 5 and 9.5 Pday units in each 24 hour period in the crops evaluated in South Australia. Target spot first appeared at Pdays ranging from 177 to 439, depending on weather conditions and inoculum levels. Our trials suggest that the best time to initiate spraying for maximum control was appearance of first Target spot leaf symptoms. For this to be effective, regular and careful monitoring of the crop must be conducted from tuber initiation. Failure to detect when early leaf infections occur may result in poor disease control and significant reduction in yield.

The effectiveness of Score applied only after an infection period was extremely variable. Infection periods were defined as periods of 8 hours of leaf wetness at >15°C to 12 hours leaf wetness at >10°C that were likely to give rise to an infection. Accurate methods of determining infection periods are needed, as if only a few of these occur each season then an eradicant schedule may result in considerable savings in spraying costs. However where heavy dews are frequent or with regular rain events, many infection periods occur and spraying would be more appropriate on a protectant schedule. The manufacturers recommended that Score be sprayed no more than twice in a season to prevent resistant strains of the fungus developing. Applying the protectants Bravo or Rovral on a regular schedule and using Score only after infection periods showed promise, and was an effective program to minimise the use of Score during the season.

The incubation period which is the time from infection to the appearance of leaf spots, varied from 7 to 16 days. In most of the crops we measured the incubation was 8 days, however in colder weather the growth of the fungus was slowed down and leaf symptoms appeared up to 16 days after infection.

In most trials the development of Target spot was difficult to contain, particularly near the end of the growing season. The fungicide sprays controlled the disease to an acceptable level during the early and mid season but in all crops there was an increase in disease level at the end of the season with no apparent effect on yield.

## TECHNICAL SUMMARY

Ten field trials were conducted over 3 years to evaluate the effectiveness of different spray regimes to control Target spot (Early blight) in potatoes, and included varying the initiation times, fungicides and type of spray schedules. Weather stations to monitor temperature, rainfall and leaf wetness were placed at trial sites and in commercial crops and the data used to run the disease forecasting system, the Potato Crop Management Program (PCM), developed by the University of Wisconsin. The spray schedule recommended by the program, based on physiological days (Pdays), was compared using protectant and eradicant spray schedules.

The most effective spray schedule initiated spraying when the first target spot lesions were observed in the leaves. The PCM program initiated spraying on a Pday value between 200 and 400, manually entered into the program. On the crops evaluated in South Australia, Target spot leaf lesions first appeared at Pdays ranging from 177 to 439, depending on weather conditions and inoculum levels. For the program to be effective, monitoring of crops from tuber initiation is essential to determine the Pday when leaf lesions are first observed.

Infection periods were defined as periods of 8 hours of leaf wetness at >15°C to 12 hours leaf wetness at >10°C that were likely to give rise to an infection. Accurate methods of determining infection periods are needed, as if only a few of these occur each season then an eradicant schedule where Score is only applied after an infection period may result in considerable savings in spraying costs. In all crops monitored, and in all trials, the development of Target spot increased near the end of the growing season with no apparent effect on yield. In most of the trials no significant effect on yield could be demonstrated between treatments.

The incubation period which is the time from infection to the appearance of leaf spots, varied from 7 to 16 days. In most crops measured the incubation was 8 days, however in colder weather the growth of the fungus was slowed down and leaf symptoms appeared up to 16 days after infection.

## TECHNICAL REPORT

### Introduction

Target spot or Early blight, caused by the fungus *Alternaria solani,* is a major disease of potatoes in Australia and elsewhere. The fungus mainly attacks the leaves causing premature defoliation that results in yield reductions of more than 30% (Fedderson 1962 and Wicks - unpublished data). A recent survey in South Australia showed that many growers apply up to 8 sprays per season (Dillard et al, 1993) and that fungicides applied to control this disease make up the major share of pesticides applied to potatoes.

Despite the frequent application of fungicides few growers obtain good control of the disease. The reasons for this are thought to be mistimed spray applications and in particular starting the spray programmes after the disease is well established. In most years this could cost growers between $2,000 to $3,000 per Ha in potential yield loss as well as more than $200 per Ha in spray costs.

Disease forecast systems for Target spot which are based on monitoring climatic conditions in the field have been developed overseas (Harrison 1992, Rotem 1994) and need to be evaluated and adopted to Australian conditions. A system developed in the USA is now widely used commercially (Pscheidt and Stevenson *et al*, 1986) and is marketed as an integrated systems approach to potato crop management. In Tasmania, a spray warning system has been developed in the onion industry, but a similar approach has not been adequately tested for potatoes.

This project evaluated a forecast system based on physiological "P" days (PCM program) and compared this with systems based on curative or protective programmes. The aim of this was to ultimately recommend a system that allowed more timely applications of fungicides, improved disease control, increased yields as well as reduced pesticide use on potatoes throughout Australia.

The initial project included both Early blight (*Alternaria solani*) and Late blight (*Phytophthora infestans*), but since the later disease did not develop during the extent of the project, all emphasis was placed on Early blight.

**Field Trials - Introduction**

Experiments were carried out at the Lenswood Horticultural Centre, approximately 30 km east of Adelaide and on commercial potato farms in Virginia, Purnong and Currency Creek, approximately 60 km north, 130 km east and 80 km south east of Adelaide respectively. The rainfall, temperature and leaf wetness was recorded at approximately 30 cm above the soil and inside the potato canopy in or near the trial site using a Measurement Engineering Unidata weather station.

Except for fungicide and some insecticide applications, all operations such as fertiliser application, irrigation and cultivation were carried out by the grower collaborator or by Horticultural Centre staff using operations similar to commercial practice. The main fungicides used were Score (250 g/L a.i. Difenoconazole), Bravo (500 g/L a.i. chlorothalonil) and Rovral (500g/L a.i. iprodione), applied at 500 ml, 2.6 L/Ha and 2 L/Ha respectively with a knapsack sprayer using between 400 to 800 L of liquid per Ha.

Plots varied in size at each experimental site but were usually arranged in a randomised block design with at least 4 replicates per treatment. The development of disease from natural infections was assessed up to 6 times during the growing season by picking a leaf from the mid third of each of 10 plants selected at random from each plot, and assessing leaf area diseased by referring to standard keys as shown in appendix 1. Data were analysed using analysis of variance of a randomised block design in the statistical analysis program STATISTIX (NH Analytical Software, Roseville, MN USA).

Treatments in these experiments included the application of fungicides following the development of around 300 physiological "P" days (Pscheidt and Stevenson, 1986). P days are calculated from daily ambient temperatures after emergence and are based on the minimum (7°C) and maximum (30°C) growth temperatures of the potato plant and have been used to predict bulking rate and yield of potatoes. Pscheidt and Stevenson (1986) found that spore concentrations of *A. solani* generally increase after 300 P days and that spray applications are most effective when they are initiated after this level of P days is reached. This treatment was compared with the conventional treatment where fungicide applications are commenced around flowering or row "closure", when the first Target spot lesions were observed or where a certain threshold level of disease had developed in a crop. The threshold level of around 5 *A. solani* lesions every 10 m of row was based on the work of Schtienberg(1992), who used a level of 0.01 lesion per plant to recommend the application of fungicides to control *Alternaria* leaf spot in cotton. Another treatment evaluated the curative activity of the fungicide Score (Dahman and Staub, 1992) by applying the fungicide only after conditions suitable for infection were recorded. This was based on leaf wetness periods of at least 8 hr or 12 hrs at 15°C and 10°C respectively and did not take into consideration the level of inoculum (Rotem, 1994) (Appendix 2).

## Field Trials - 1993/94

### *Lenswood*

In this experiment, the main treatments compared Score or Bravo applied at 7-10 day intervals after varying initial spray times (Table 1). Tubers cv. Winlock were planted on 16th December 1993 in double row plots 13.5 m long with an untreated row separating other treated rows. Each treatment was replicated 6 times.

Table 1. Fungicide treatments and spray dates, cv Winlock - Lenswood 1994

| Treatments | Spray dates | | | | | | | | | | | | | Total no. sprays applied |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | February | | | | | | March | | | | April | | | |
| | 9 | 11 | 18 | 21 | 25 | 28 | 8 | 15 | 22 | 29 | 8 | 15 | 21 | |
| Score - eradicant | - | S | - | - | S | - | - | - | - | - | S | - | S | 4 |
| Bravo every 7-10 days after flowering | B | - | B | - | - | B | B | B | B | B | B | B | B | 10 |
| Score every 7-10 days after flowering | S | - | S | - | - | S | S | S | S | S | S | S | S | 10 |
| Score every 7-10 days after 300 P days | - | S | - | S | - | S | S | S | S | S | S | S | S | 9 |
| Score every 7-10 days after threshold* | - | - | - | S | - | S | S | S | S | S | S | S | S | 10 |
| Bravo every 7-10 days after threshold* | - | - | - | B | - | B | B | B | B | B | B | B | B | 9 |

S = Score, B = Bravo, - = no treatment, * = after 5 lesion/10m of row

The plots were assessed for the level of disease on three occasions and harvested on May 11. Target spot developed extensively in the unsprayed plots of this experiment and by the end of April most plants in these plots were completely defoliated (Fig 1). By comparison all fungicide treatments suppressed the development of the disease with the Bravo applied only after the appearance of 5 lesions/m of row being the least effective.

Four applications of Score applied only after infection were as effective as 10 applications of Score or Bravo applied on a protective programme (Fig. 2). The eradicant Score program could have been more effective if one of the infection periods in March had not been missed. The phone line allowing modem access to the weather monitoring equipment had not been installed, so the data could not be checked daily as required.

Measurements of lesion size in the various treatments showed that lesions were significantly smaller on those plants regularly treated with Score compared to those of other fungicides (Fig 3).

There was no significant differences in the yield between treatments (Table 2).

Figure 1. Mean infection of midleaf after treatment with different fungicide regimes, cv Winlock Lenswood 1994

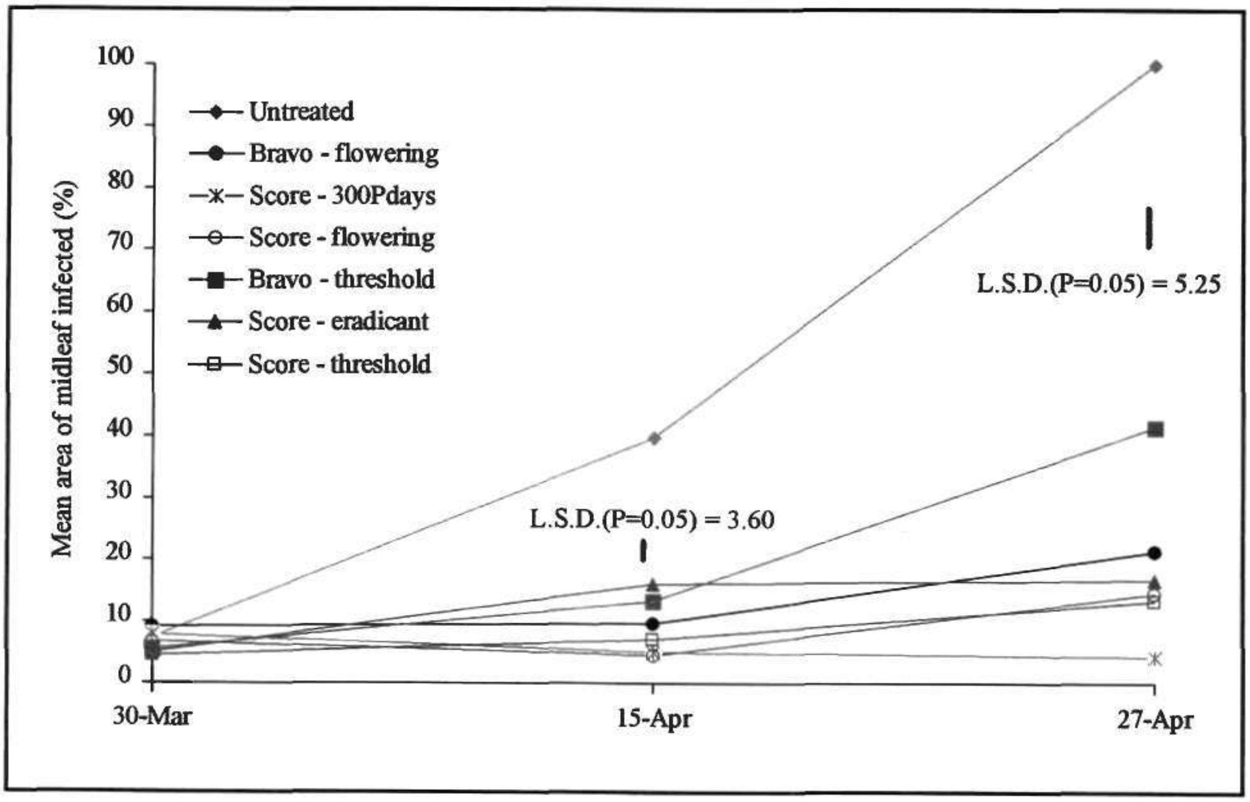



Fig 2. Area of leaf infected on 27th April after treatment with different fungicide regimes, cv Winlock Lenswood 1994

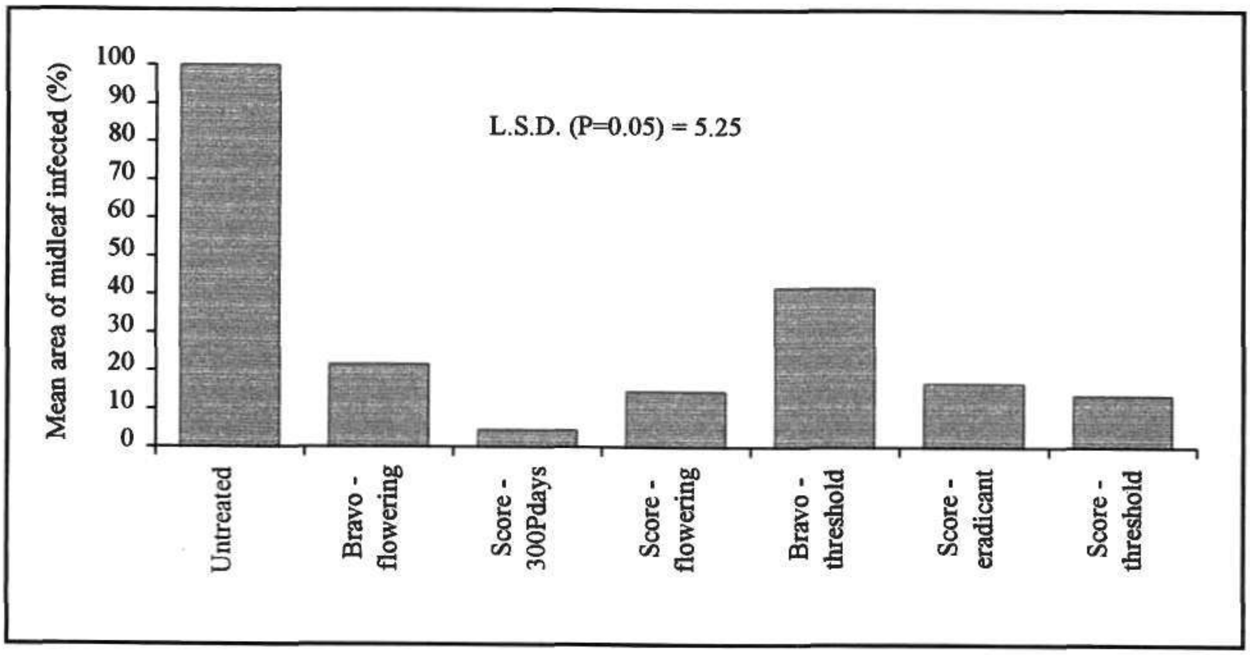
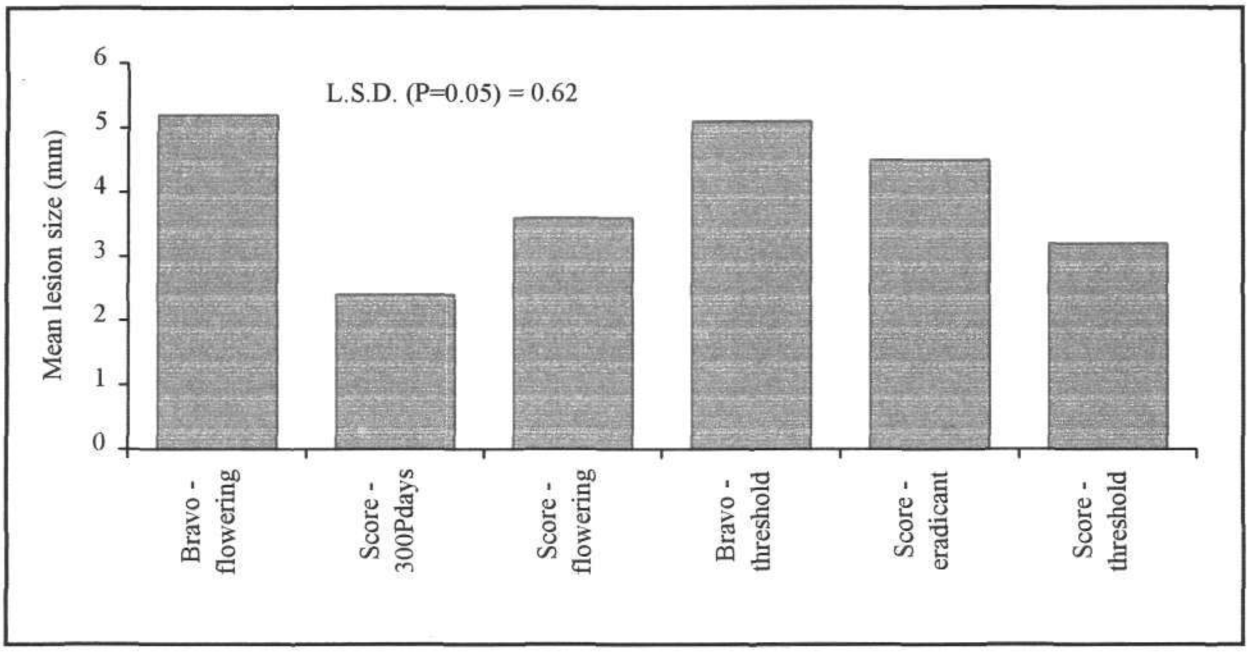


Fig 3. Mean lesion size on midleaf, 24th April, after treatment with different fungicide regimes cv Winlock - Lenswood 1994.




There was no significant differences in the yield between treatments (Table 2).

Table 2. Yield of tubers after treatment with different fungicide regimes, cv Winlock - Lenswood 1994.

| Treatment | Mean yield per plot (Kg) | Mean no tubers per plot |
|---|---|---|
| Untreated | 60.3 | 397 |
| Bravo every 7-10 days after flowering | 72.1 | 506 |
| Bravo every 7-10 days after threshold* | 68.4 | 456 |
| Score - eradicant | 73.9 | 483 |
| Score every 7-10 days after threshold* | 62.2 | 431 |
| Score every 7-10 days after flowering | 74.0 | 506 |
| Score every 7-10 days after 300 Pdays | 69.2 | 452 |

* = threshold of 5-10 lesions per 10m of row

*Currency Creek*

Two experiments were set up in a commercial property where a large "centre pivot" area of cv. Atlantic was planted, half on 12 January and half 2 weeks later. The plots were 12 m long and 4 rows wide, the outer 2 rows used as barriers. All treatments were replicated 5 times. The first experiment in the earlier planting compared spray schedules of 7-10 days using different mixes of Score and Bravo applied after first signs of the disease were observed. The second experiment in the later planting compared different spray schedules of Score and/or Bravo applied only after 300 Pdays. The treatments and dates of application for experiments 1 & 2 are shown in Table 3.

The midleaf disease levels in experiment 1 were assessed twice and were compared with levels in the adjacent planting, where the grower applied 5 Bravo sprays. Target spot levels were high in both the unsprayed and the eradicant treated plots (Fig 4). The eradicant spray schedule depended on rapid detection of infection periods, and as the weather monitoring equipment could not be accessed remotely, several infection periods caused by heavy dew were missed and sprays not applied. As in previous experiments, the smallest lesions developed on leaves sprayed with Score (Fig 5).

Table 3. Fungicide treatments and spray dates, cv Atlantic - Currency Creek 1994

| Treatments | Spray dates | | | | | | | | Total no. sprays applied |
|---|---|---|---|---|---|---|---|---|---|
| | **February** | **March** | | | | **April** | | | |
| | **25** | **7** | **16** | **23** | **30** | **5** | **14** | **19** | |
| **(a) Experiment 1** | | | | | | | | | |
| Score - eradicant | S | - | - | - | - | S | - | | 2 |
| Score/Bravo alternating every 7-10 days | S | B | S | B | S | B | S | | S (4)  (3) |
| Score x3 after threshold 1 then Bravo (7-10 days) | S | S | S | B | B | B | B | | S (3) B (4) |
| Bravo, Score x3 after threshold 2 then Bravo (7-10 days) | B | B | B | S | S | S | B | | S (3) B (4) |
| **(b) Experiment 2** | | | | | | | | | |
| Bravo every 7-10 days after 300 Pdays | - | B | B | B | B | B | B | B | 7 |
| Score every 7-10 days after 300 Pdays | - | S | S | S | S | S | S | S | 7 |
| Score every 14 days after 300 P days | - | S | - | S | - | S | - | S | 4 |
| Score eradicant | | S | - | - | - | S | - | S | 3 |
| Score x3 after 300 Pdays then Bravo every 7 to 10 days | - | S | S | S | B | B | B | B | S (3) B (4) |

S = Score, B = Bravo, - = no treatment, threshold 1 = after 5 lesions/10m of row, threshold 2 = after 10 lesions/10m of row

Figure 4. Area of midleaf infected after treatment with different fungicides regimes, cv Atlantic Currency Creek 1994.

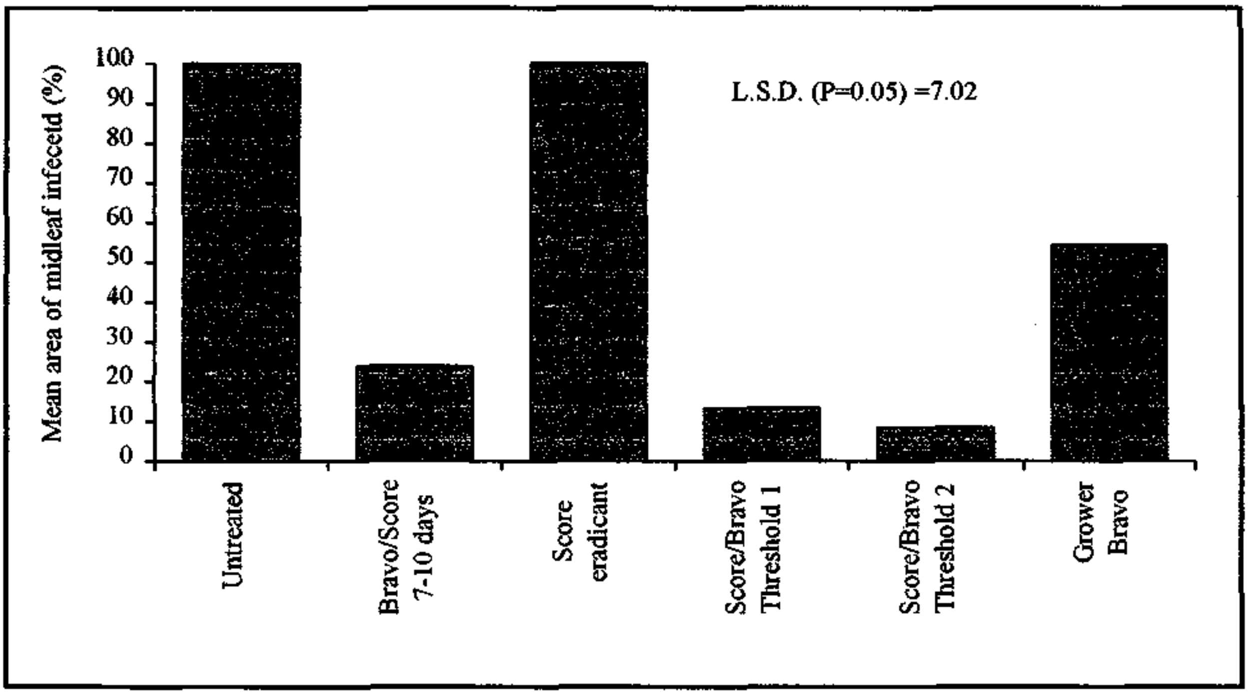
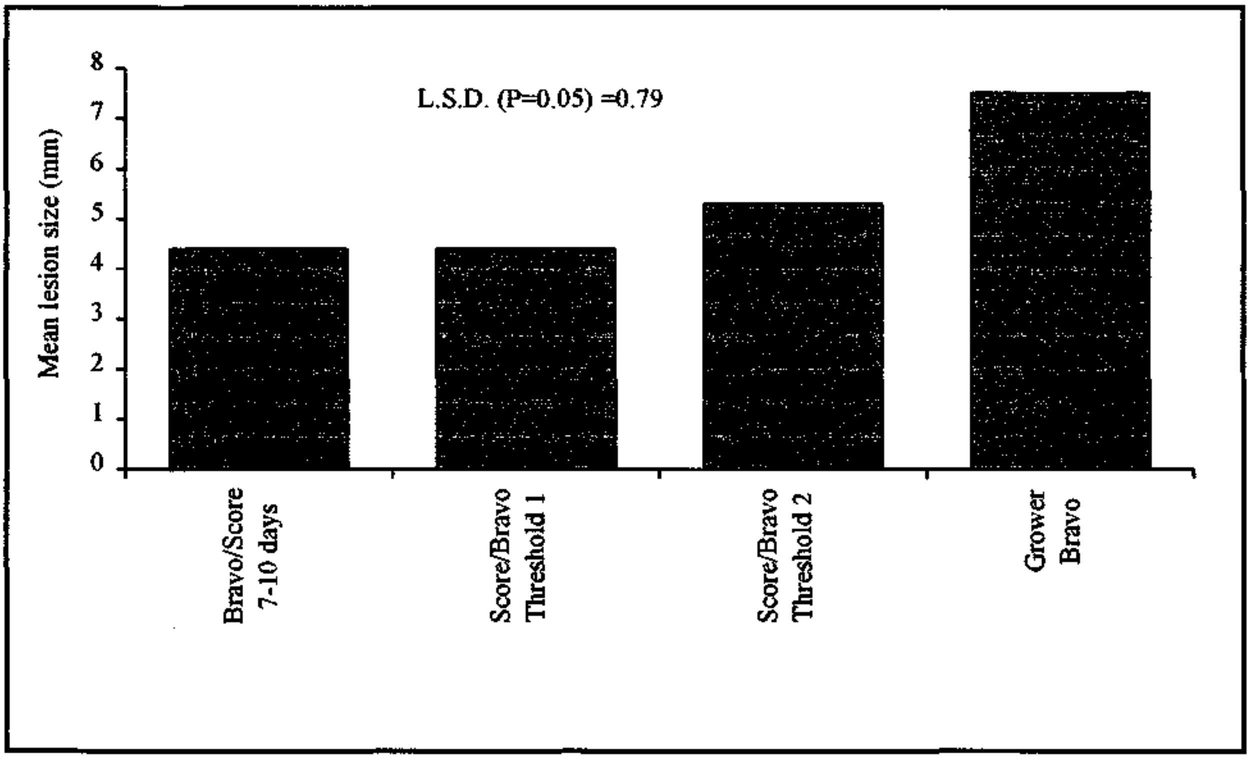



Figure 5. Mean lesion size after treatment with different fungicide regimes, cv Atlantic Currency Creek 1994.



Yield was assessed in the treatments with the highest and lowest disease levels at the final assessment, being Bravo/Score 7-10 days and untreated respectively. Two 5m long rows within each plot were hand dug and the tubers weighed and counted. 5 replicates of 2x5m rows were hand dug from the growers planting for comparison. Yields were lowest in the untreated plots, however the growers yield was significantly higher than those from the experimental plot (Table 4). This difference could be due to the physical damage caused to the plants when walking between rows while spraying.

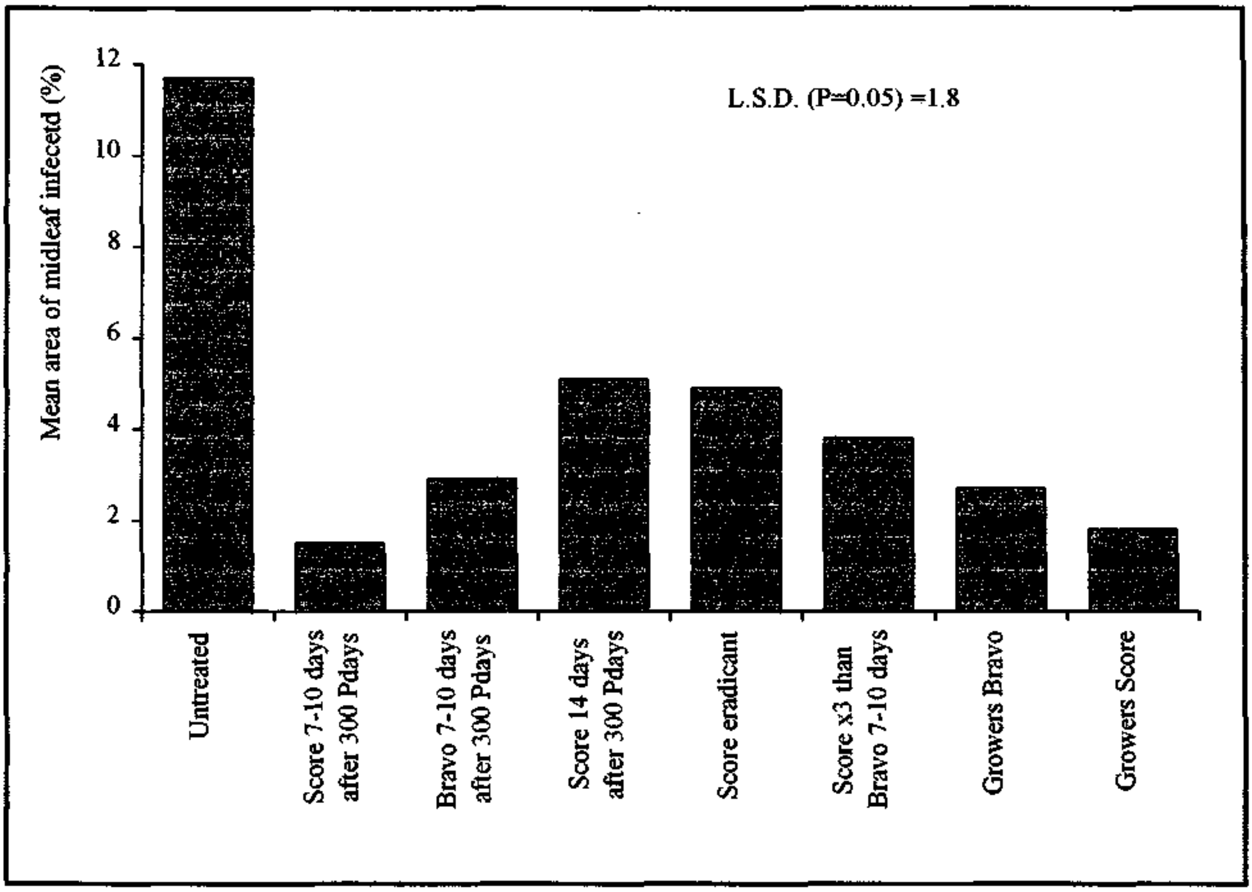
Table 4. Yield from 10m of row, cv Atlantic - Currency Creek 1994

| **Treatment** | **Weight of tubers per 10m (Kg)** | **Number of tubers per 10m** | **Mean tuber weight (g)** |
|---|---|---|---|
| Untreated | 30.6 | 312 | 99 |
| Bravo/Score 7-10 days | 32.4 | 315 | 103 |
| Growers | 36.9 | 341 | 111 |
| L.S.D. (P=0.05) | 4.1 | n.s. | n.s. |

n.s. = not significant

In experiment 2 the level of disease on the midleaf was assessed on 3 occasions and compared with the adjacent planting's, where the grower applied 5 sprays of Bravo in one area and 5 sprays of Score in another. By the end of April plants in the untreated plots in experiment 2 were dead, and as it was difficult to determine if the necrosis was due to Target spot or Black dot, no yield data was taken. However the earlier assessment showed that all treatments controlled Target spot, with the 7-10 day Score spray applied after 300 Pdays being the most effective (Fig 6).

Figure 6. Area of midleaf infected after treatment with different fungicides regimes, cv Atlantic Currency Creek 1994.



## Field trials - 1994/95

### *Currency Creek*

Two experiments were set up on a commercial property used the previous year. Both experiments compared various combinations of Score and Bravo, with sprays in experiment 1 initiated after appearance of first lesion and in experiment 2 initial spray timings were varied (Table 5).

Table 5. Fungicide treatments and spray dates, cv Atlantic - Currency Creek 1995

| Treatments | Spray dates | | | | | | | | | | Total no. sprays applied |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | March | | | | | | April | | | May | |
| | 3 | 10 | 14 | 17 | 23 | 30 | 11 | 18 | 28 | 8 | |
| **(a) Experiment 1** | | | | | | | | | | | |
| Score - eradicant | S | - | - | - | - | S | - | - | - | - | 2 |
| Score x2 then Bravo (7-10 days) | S | S | - | B | B | B | - | - | - | - | S (2) B (3) |
| Score x2 at 7-10days, then at 14 days | S | S | | - | S | - | - | - | - | - | 3 |
| Score every 14 days | S | - | | S | - | S | - | - | - | - | 3 |
| Bravo/Score alternating (7-10 days) | B | S | | B | S | B | - | - | - | - | S (2) B(3) |
| **(b) Experiment 2** | | | | | | | | | | | |
| Score x2 at first lesions then Bravo (7-10 days) | - | S | - | S | B | B | B | B | B | B | S (2) B (6) |
| Score x2 at threshold* then Bravo (7-10 days) | - | - | - | S | S | B | B | B | B | B | S (2) B (5) |
| Score x2 at 280 P days then Bravo (7-10 days) | - | - | - | - | S | S | B | B | B | B | S (2) B (4) |
| Score x2 at flowering then Bravo (7-10 days) | - | - | S | - | S | B | B | B | B | B | S (2) B (5) |
| Score - eradicant | - | S | - | - | - | S | S | - | - | S | 5 |

S = Score, B = Bravo, - = no treatment, * = threshold level of 5-10 lesions per 10m row

Experiment 1 was set out in half a pivot with cv. Atlantic planted on 30 December 1994, and experiment 2 in the opposite half pivot cv Atlantic planted 2 February 1995. The plots were 12m long and 4 rows wide, the centre 2 rows used for disease assessment. Experiment 1 was not assessed, as Target spot infection did not occur until past flowering and a combination of Black Dot (*Colletotrichum)* and *Verticillium* wilt again caused premature senescence. The level of disease in experiment 2 was assessed on four occasions, and on the second assessment 65 days after emergence (April 18th), significant differences in lesion numbers between treated and untreated plots were obvious with these differences persisting until the completion of the experiment (Fig 7). All fungicide treatments inhibited the development of the disease with Score applied after infection being the most effective treatment (Fig 8). This illustrates how effective post infection sprays can be when infection periods are accurately predicted by daily monitoring of the weather equipment via modem.

Figure 7. Mean number of lesions per midleaf after treatment with different fungicide regimes, cv Atlantic Currency Creek 1995

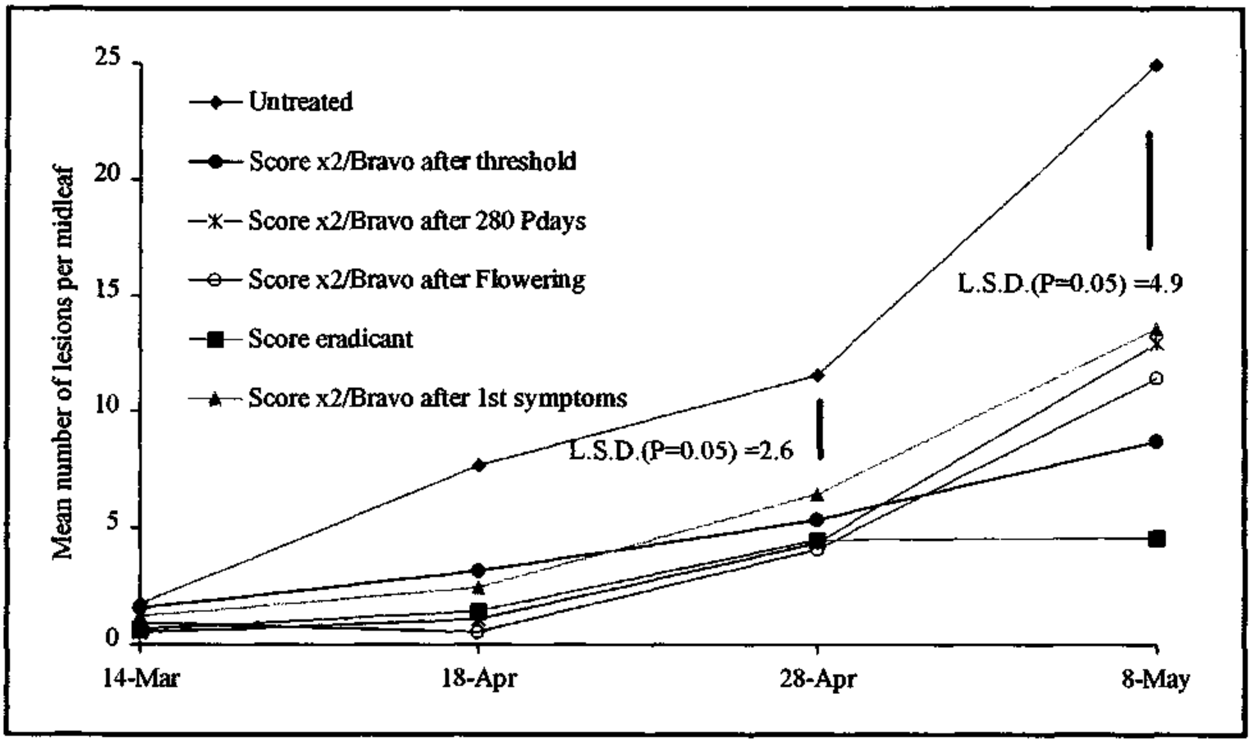
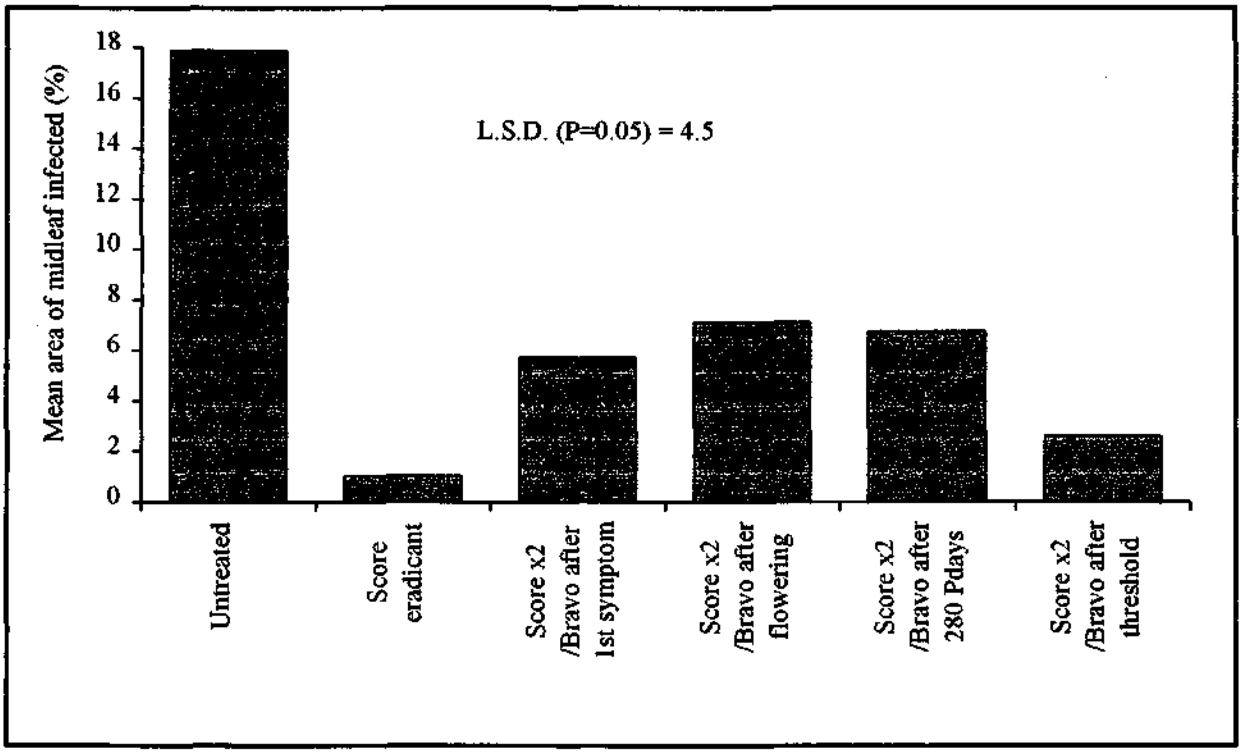


Fig 8. Area of leaf infected on 8th May after treatment with different fungicide regimes, cv Atlantic Currency Creek 1994




The yield of the control and best treatment (Score eradicant) were obtained by hand digging 2x5m of row from each plot on 5th July. These were compared with the growers yield by hand digging 5 x 10m rows in the main planting adjacent to the trial. Yields were not significantly different between the best and worst treatments in experiment 2 (Table 5), with the growers area again yielding the highest. As the disease level in this trial was relatively low, yield differences were not expected.

Table 5. Mean plot yield from 10m of row per plot, cv Atlantic - Currency Creek 1995

| Treatment | Mean total yield per 10m (Kg) | Mean tuber weight (g) |
|---|---|---|
| Untreated | 17.4 | 83 |
| Score - eradicant | 21.8 | 94 |
| Growers area | 24.8 | 102 |
| L.S.D. (P=0.05) | 5.7 | 14 |

*Lenswood*

cv. Atlantic was planted on 2 February in plots 12m long and 4 rows wide. Treatments were replicated 8 times, and compared Score at 7-10 days initiated at various times with Rovral at 7-10 days from 280 Pdays (Table 6).

Table 6. Fungicide treatments and spray dates, cv Atlantic - Lenswood 1995

| Treatments | Spray dates | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | April | | | | May | | | | no. sprays |
| | 5 | 11 | 21 | 28 | 8 | 16 | 23 | 29 | applied |
| Score at 7-10 days after 280 Pdays | S | S | S | S | S | S | S | S | 8 |
| Rovral at 7-10 days after 280 Pdays | R | R | R | R | R | R | R | R | 8 |
| Score at 7-10 days after first sign of lesions | - | S | S | S | S | S | S | S | 8 |
| Score at 7-10 days after flowering | - | - | S | S | S | S | S | S | 6 |

S = Score, R = Rovral, - = no treatment

The area of midleaf with lesions and the number of lesions per leaf were assessed on 4 occasions. By the third assessment on 29th May, 86 days after emergence, the disease level was significantly lower in the plots where Score was applied every 7-10 days either after the first Target spot lesions were observed or after 280 Pdays (Fig 9). By the end of the trial at 100 days after emergence there was no significant differences between the disease levels in any of the treatments (Fig 10), and all controlled Target Spot compared to the unsprayed plots. Yield data was not measured as with the low levels of disease there was not expected to be any differences between treatments.

Figure 9. Disease levels 86 days after emergence after treatment with different fungicide regimes, cv Atlantic, Lenswood 1995

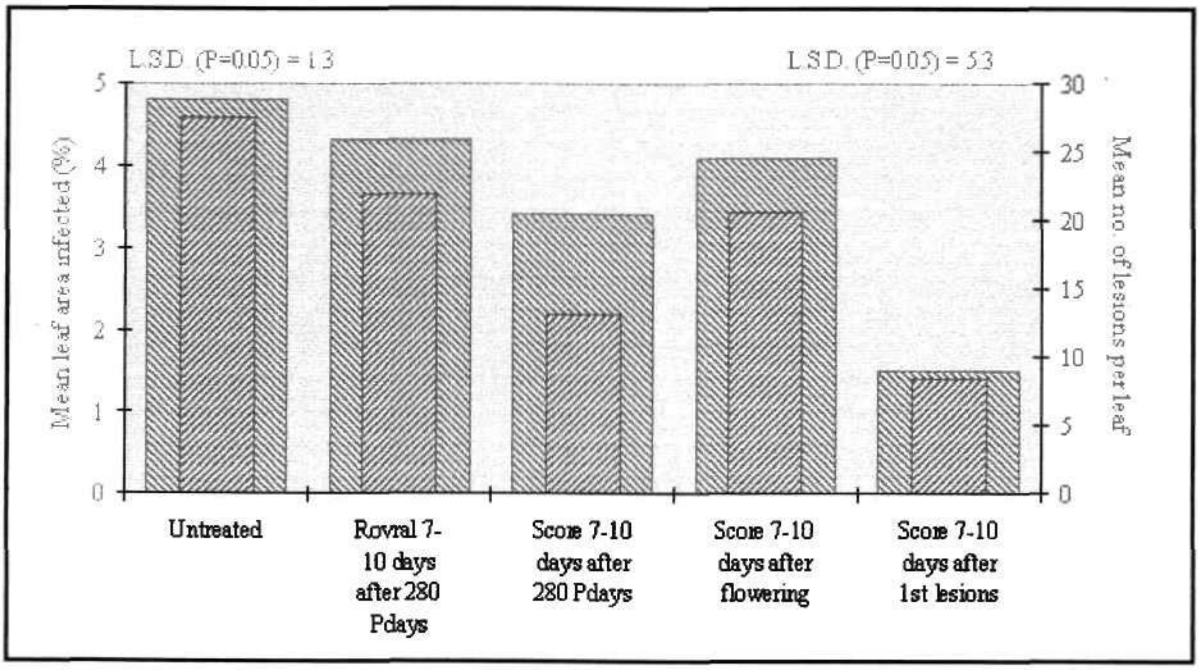
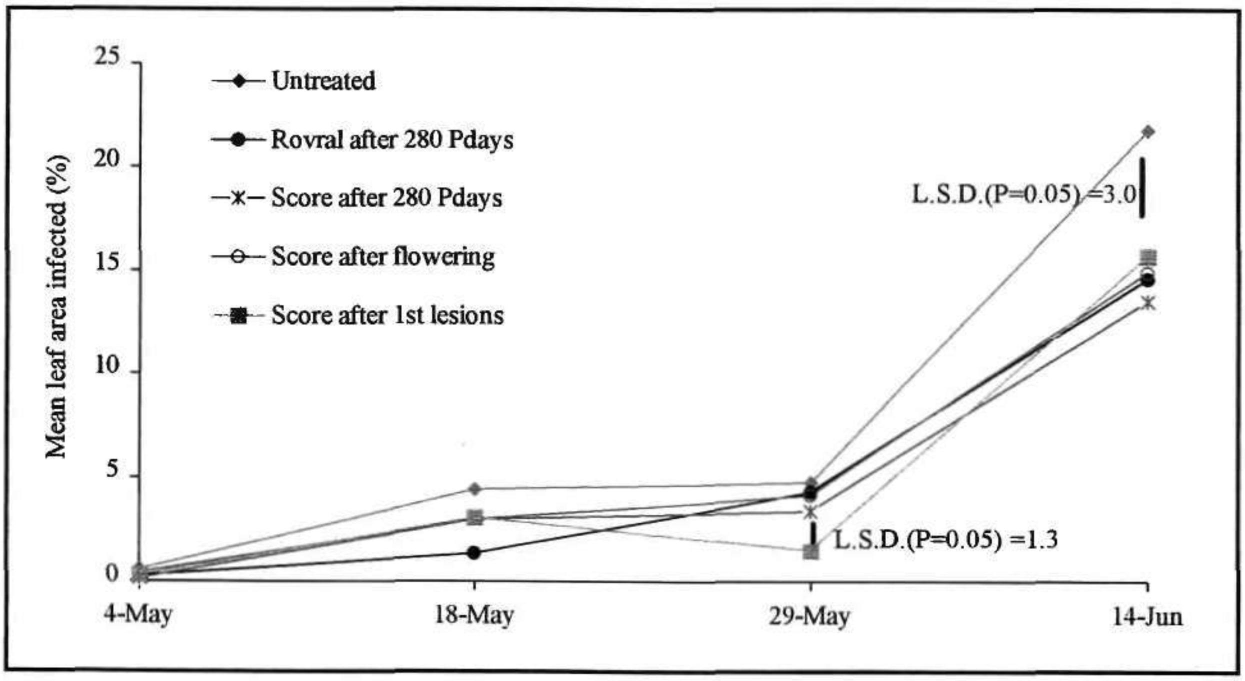



Figure 10. Area of leaf infected after treatment with different fungicide regimes, cv Atlantic Lenswood, 1995



### *Virginia*

The cv. Sequoia was planted on a commercial property on March 17, with 15 m long plots consisting of 2 sprayed rows separated by a buffer row . Treatments were replicated 6 times, and compared sprays of Score at 2 rates and different timings initiated either at 350 Pdays or when the grower started his spray regime at late flowering (Table 7).

Table 7. Fungicide treatments and spray dates, cv Sequoia - Virginia 1995

| Treatments | Spray dates | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | May | | June | | | | July | no. sprays |
| | 18 | 29 | 9 | 13 | 20 | 26 | 4 | applied |
| Score (0.4 ml/L) every 7-10 days after flowering | S | S | S | S | S | S | S | 7 |
| Score (0.6 ml/L) every 7-10 days after flowering | S | S | S | S | S | S | S | 7 |
| Score (0.6 ml/L) every 10-14 days after flowering | S | | S | - | S | - | S | 4 |
| Score (0.4 ml/L) every 7-10 days after 350 Pdays | - | S | S | S | S | S | S | 6 |
| Score (0.6 ml/L) every 14 days after 350 Pdays | - | S | - | S | - | S | - | 3 |
| Score (0.6 ml/L) x2 then Bravo every 7-10 days after 350 P days | - | S | S | B | B | B | B | S (2) B (4) |

S = Score, B = Bravo , - = no treatment

The level of disease on the midleaves was assessed on 4 occasions, and compared to that in the adjacent growers paddock, sprayed with Bravo by air every 10 days from mid May. All treatments reduced the disease level compared to the unsprayed plots, and at 75 days after emergence (15th June) the 7-10 day sprays initiated at flowering had the lowest disease level (Fig 11). However by the end of the trial (20th June), only the high rate of Score applied every 7-10 days from flowering was significantly better (Fig 12).

Figure 11. Disease levels 75 days after emergence after treatment with different fungicide regimes cv Sequoia - Virginia 1995

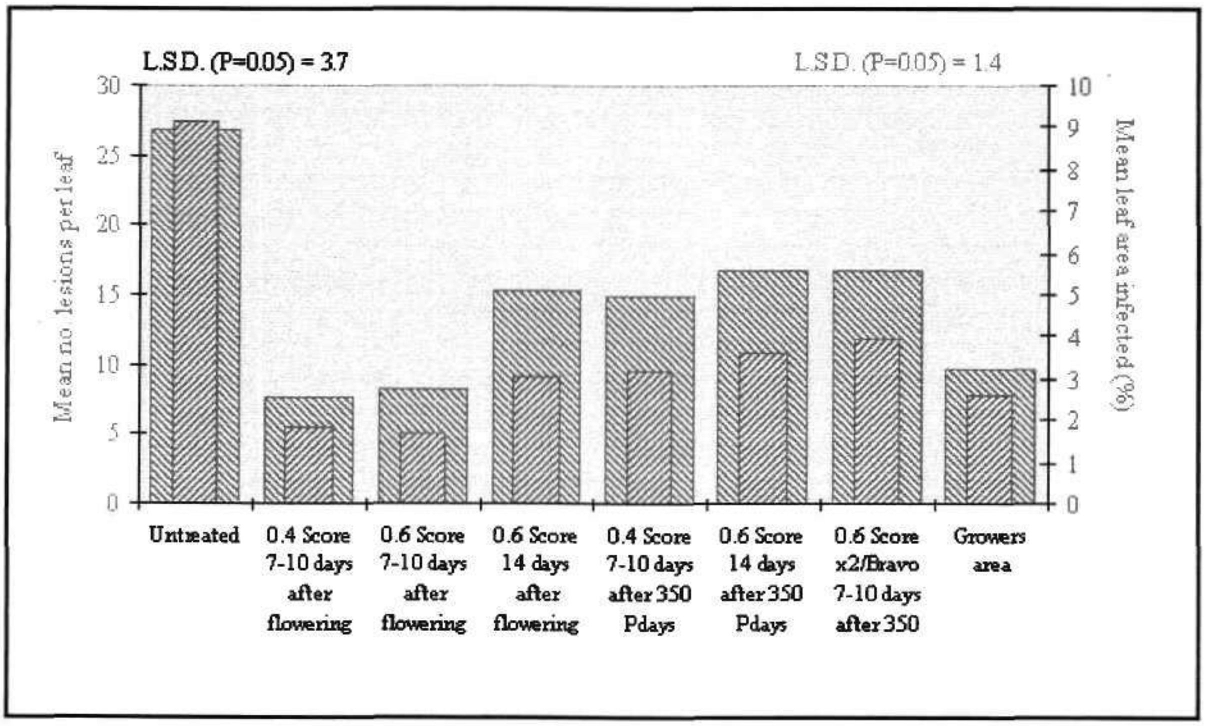
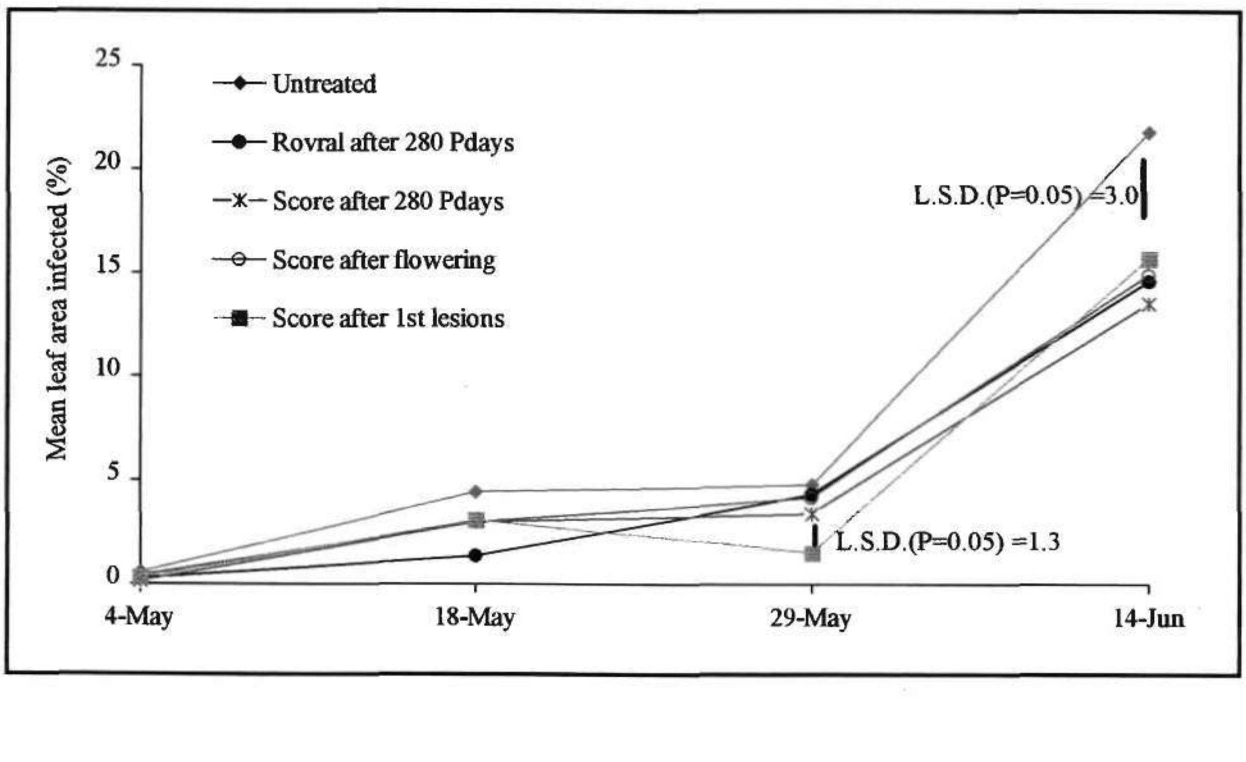



Figure 12. Area of leaf infected after treatment with different fungicide regimes, cv Sequoia Virginia 1995



*Purnong Landing*

This experiment was conducted on a commercial property where cv. Coliban was planted on 28 July. Treatments were replicated 4 times and compared mixed Score and Rovral sprays with different initiation times (Table 8).

Table 8. Fungicide treatments and spray dates, cv Coliban - Purnong Landing 1995

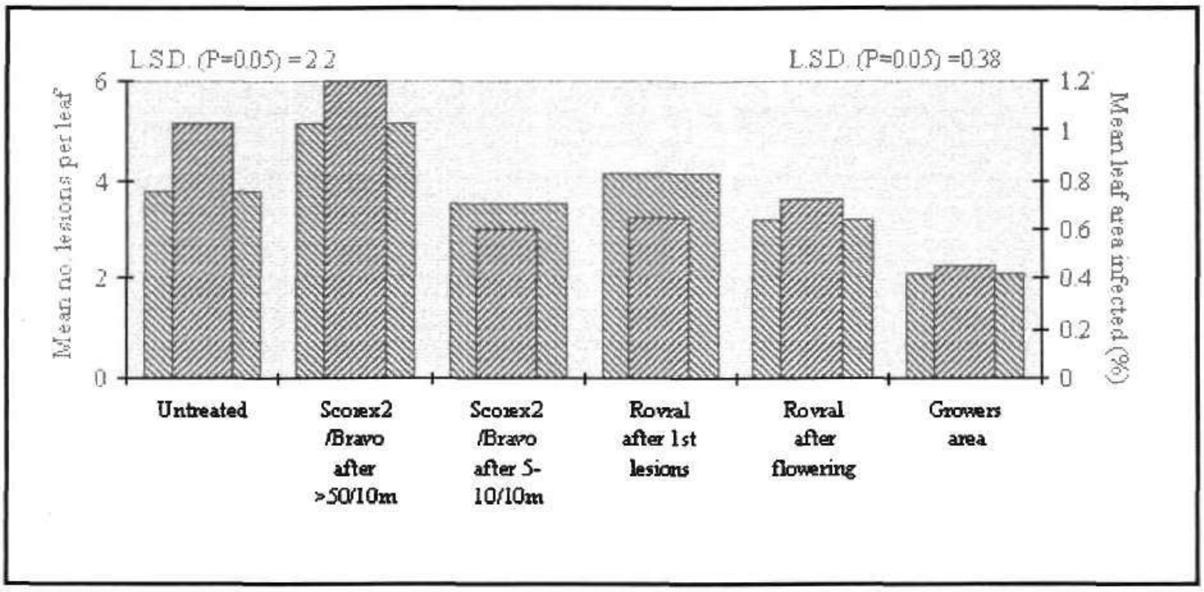
| Treatments | Spray dates | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | October | | | November | | | no. sprays |
| | 16 | 23 | 31 | 7 | 15 | 22 | applied |
| Rovral at 7-10 days from flowering | R | R | R | R | R | R | 6 |
| Rovral at 7-10 days from first sign , substituted by Score x2 at threshold 1 | - | R | S | S | R | R | R (3 S (2) |
| Score x2 after threshold 2 then Rovral (7-10 days) | - | - | - | - | S | S | 2 |
| Score x2 at threshold 3 then Rovral (7-10 days) | - | - | S | S | R | R | S (2) R (2) |

R = Rovral, S = Score, - = no treatment,
threshold 1 = 10-20 lesions per 10 m, threshold 2= >50 lesions per 10 m, threshold 3 = 5-10 lesions per 10m

The plots consisted of 4 sprayed rows, and the level of disease was assessed in the centre two rows after the final spray was applied on 22 November. The levels of Target spot in this trial were very low, with between 0 and 6% of the midleaf infected in the untreated plots 103 days after emergence (23 Nov). Only the Score/Rovral treatment initiated after 5-10 lesion threshold had significantly less disease than the untreated plots (Fig 13).

There were only 2 detectable infection periods in the life of this trial, both early in the spray schedule, so this trial was not a good test of the spray regimes. The adjacent growers paddock received 2 Rovral sprays, one a day before the first infection period and the next the day after the 2nd infection period. This provided control equivalent to the best experimental regimes, but with 2 less sprays. It is in situations like this with such low levels of infection, that a combination of disease and weather monitoring would be ideal. A single eradicant spray of Score immediately after the second infection period, when the threshold level was below 10 lesions per 10m of row, should have been sufficient to provide the level of control achieved in this trial.

Figure 13. Disease levels 103 days after emergence after treatment with different fungicide regimes cv Coliban - Purnong 1995



**Field Trials - 1995/96**

*Currency Creek*

The pivot with cv. Atlantic was planted 16th January on the commercial property used in previous experiments. The plots, 15m long and 4 rows wide, were sprayed with either Rovral or a mixture of Rovral and Score using the spray schedule indicated by the PCM computer program with different initial spray times (Table 9).

Table 9 Fungicide treatments and spray dates, cv Atlantic - Currency Creek 1996

| Treatments | Spray dates | | | | Total |
|---|---|---|---|---|---|
| | March | | April | | no of |
| | 22 | 31 | 11 | 19 | sprays |
| Score - eradicant | S | - | S | S | 3 |
| Rovral at PCM times after first symptoms | R | R | R | R | 4 |
| Rovral at PCM times after first symptoms, plus Score* | S | R | S | S | S(2) R(2) |
| Rovral at PCM times after threshold | - | R | R | R | 3 |
| Rovral at PCM times after threshold plus Score* | - | R | S | S | S(1) R(2) |

S = Score, R = Rovral, threshold=5-10 lesions/10m of row, *= Rovral replaced by Score if an infection period had occurred since the last spray

Treatments were replicated 4 times and midleaf infection was assessed on 4 occasions. The trial was finished prematurely and no yield data was obtained as a combination of wind damage and Black dot caused early senescence of the crop. The first lesions were observed on 22 March, 55 days after emergence at late flowering. A low incidence of Target spot (8%) was detected in the unsprayed plots, however after a further 3 weeks the disease was detected in 92% of plants in the untreated plots, compared to 48% in the growers area (Figure 14).

All treatments significantly reduced the level of disease (Fig 15). The replacement of Rovral with Score if an infection period had occurred since the last spray did not decrease the amount of disease. The timing of the initial spray had the greatest effect, with all treatments initiated at the first signs of the disease giving the best control (Fig 16). The grower sprayed the adjacent paddock with Score at flowering (14 Mar), when the first lesions were noted (22 Mar) and with Rovral in early April. This provided control equivalent to that of the best treatments.

Figure 14. Percentage of plants infected after treatment with different fungicide regimes, cv Atlantic Currency Creek 1996

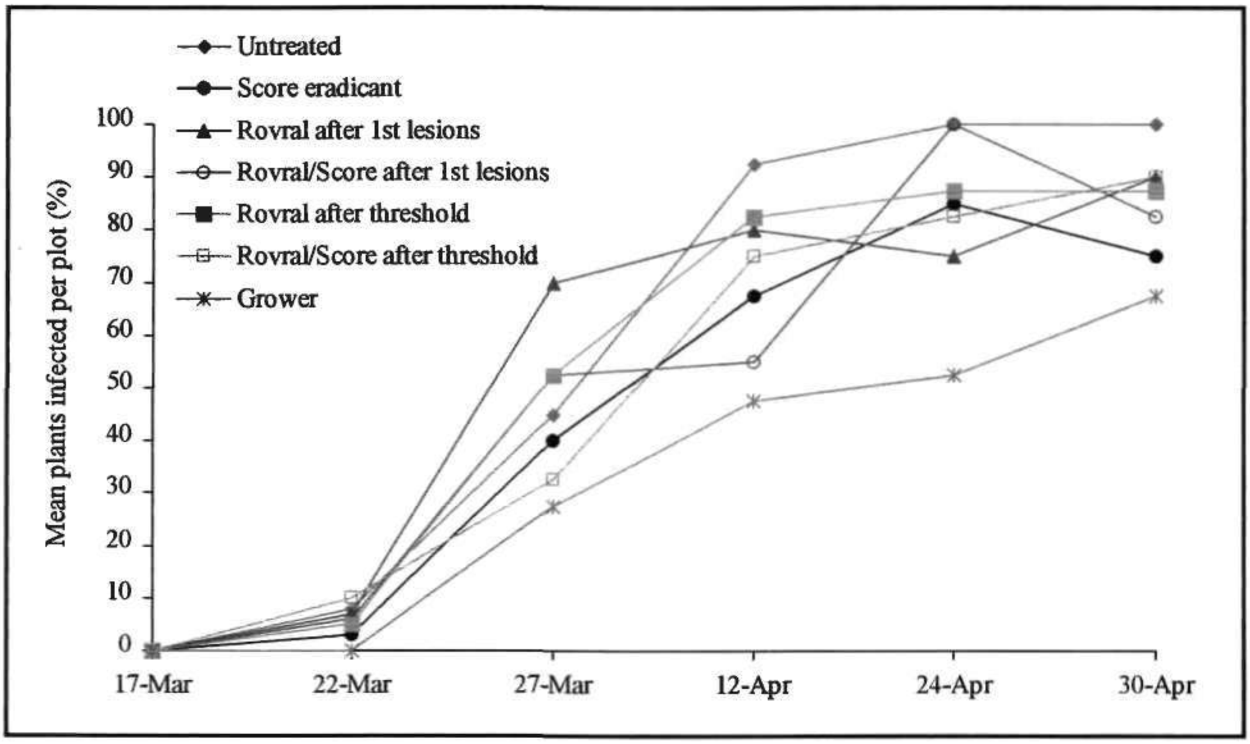



Figure 15. Area of leaf infected after treatment with different fungicide regimes, cv Atlantic Currency Creek 1996

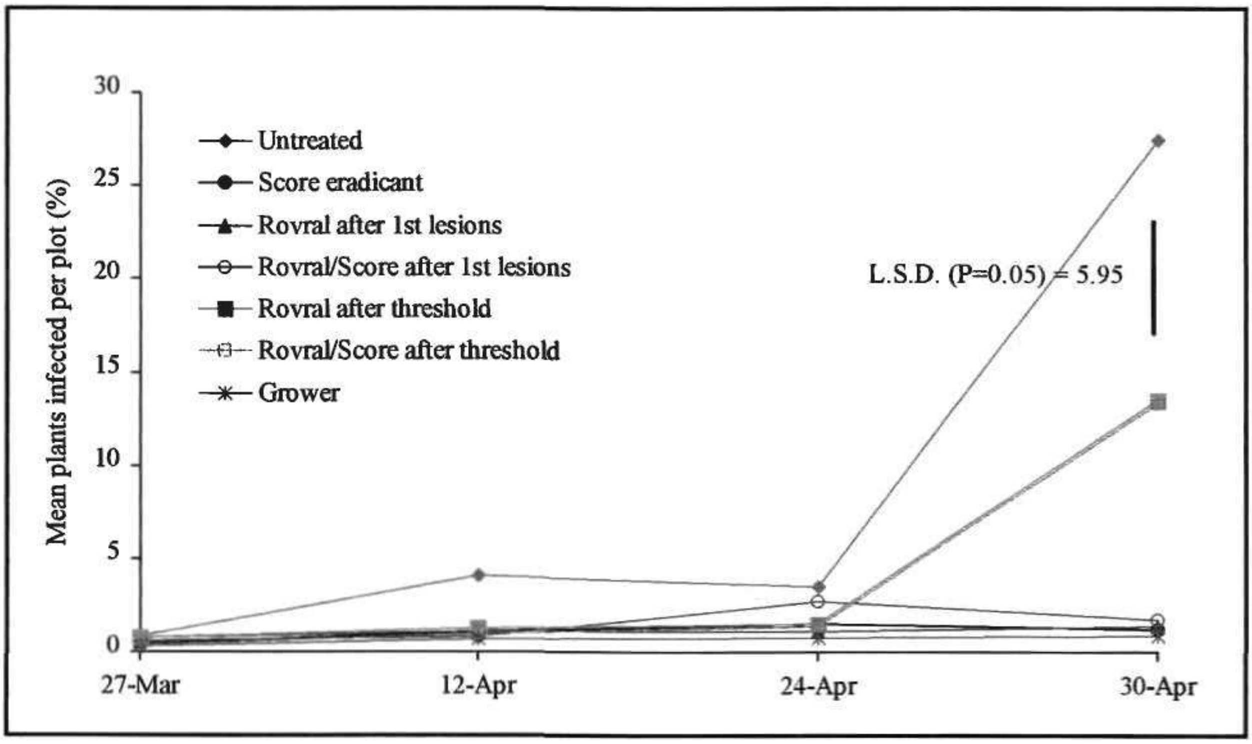
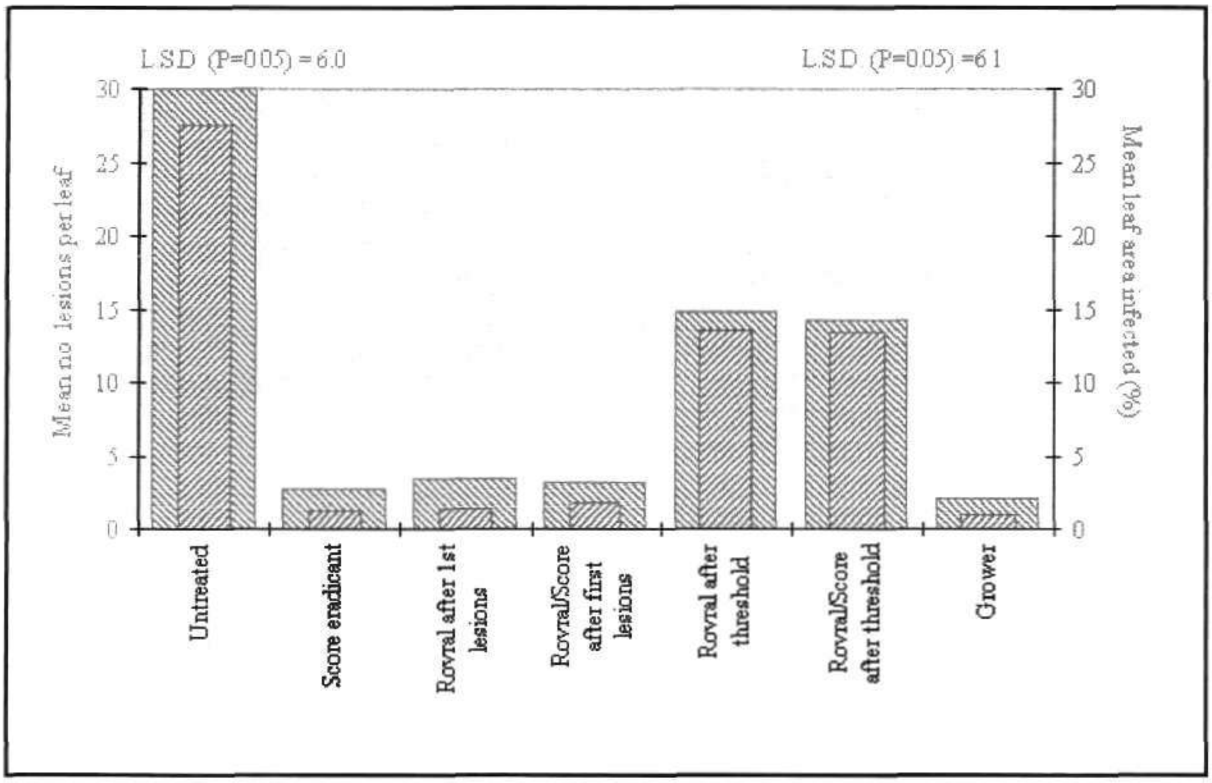


Figure 16. Disease levels 94 days after emergence after treatment with different fungicide regimes cv Atlantic, Currency Creek 1996



*Lenswood*

The cv. Coliban was planted 28th November 1995 in 3 row plots, 12m long. Treatments were replicated 4 times and were the same as the Currency Creek 1996 trial (Table 10).

Table 10. Fungicide treatments and spray dates, cv Coliban - Lenswood 1996

| Treatments | Spray dates | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | | March | | | | April | no. sprays |
| | 29 | 12 | 22 | 4 | 14 | 21 | 25 | 10 | applied |
| Score - eradicant | - | S | S | S | - | S | - | - | 4 |
| Rovral at PCM times after first symptoms | R | R | R | R | R | - | R | R | 7 |
| Rovral at PCM times after first symptoms plus Score* | R | S | R | R | R | - | S | S | S(3) R(4) |
| Rovral at PCM times after threshold | | R | R | R | R | - | R | R | 6 |
| Rovral at PCM times after threshold plus Score* | | S | R | R | R | - | S | S | S(3) R(3) |

S = Score, R = Rovral, threshold=5-10 lesions/10m of row, *= Rovral replaced by Score after an infection period occurred

The midleaf disease level in the centre row of each plot was assessed on 4 occasions, and the trial was harvested 22 April. The first lesions were observed on 1 February, 35 days after emergence at early flowering. By the 14th March, 76 days after emergence, Target spot was widespread, with over 50% of the plants infected (Fig 17). However the severity in the treated plots was very low, with the highest disease level by the end of the trial being 11.8% midleaf area infected in the Score eradicant treatment (Fig 18). All fungicide treatments inhibited disease development compared to the unsprayed plots, with Score as an eradicant schedule being the least effective fungicide program. The addition of Score into the Rovral program after an infection period increased the level of control slightly (Fig. 19), but the differences were not statistically significant.

The control treatment had a significantly lower yield than that of the best treatment, Rovral initiated after the first lesions with Score substituted after an infection period (Fig 20).

Figure 17. Mean percentage of plants infected after treatment with different fungicide regimes cv Coliban - Lenswood 1996

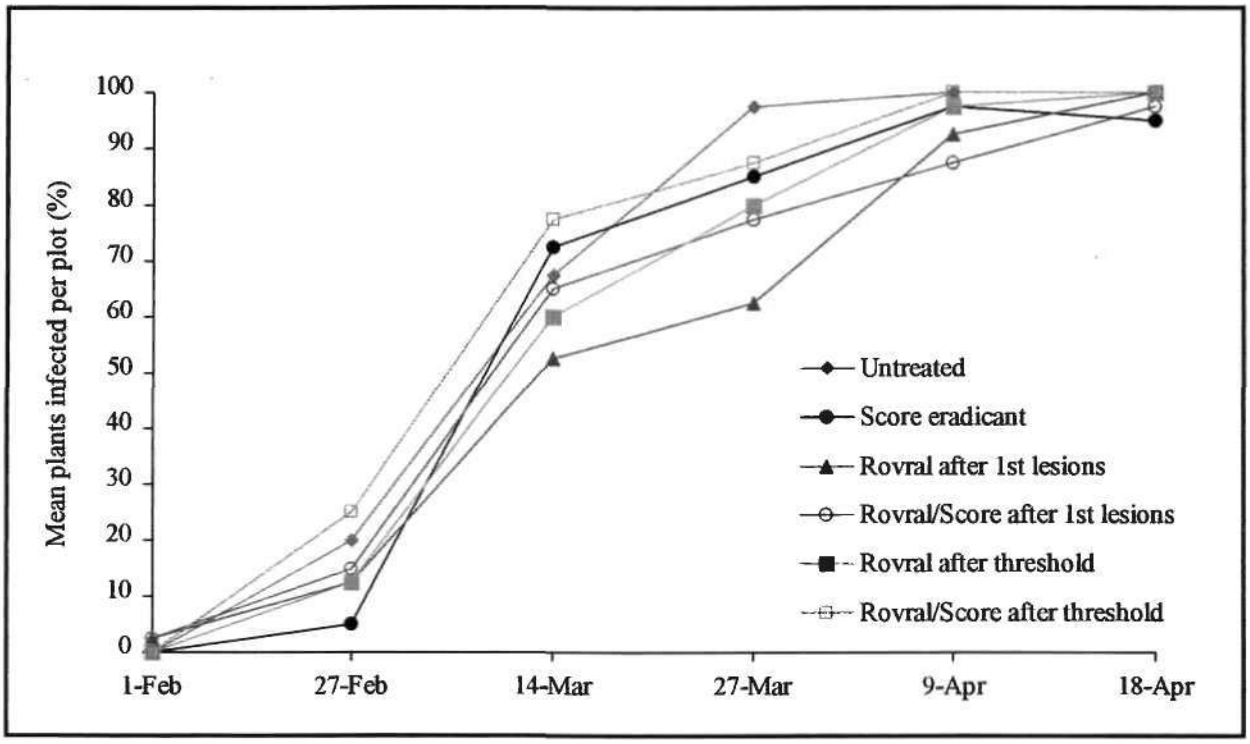



Figure 19. Mean percent area of midleaf infected after treatment with different fungicide regimes cv Coliban - Lenswood 1996

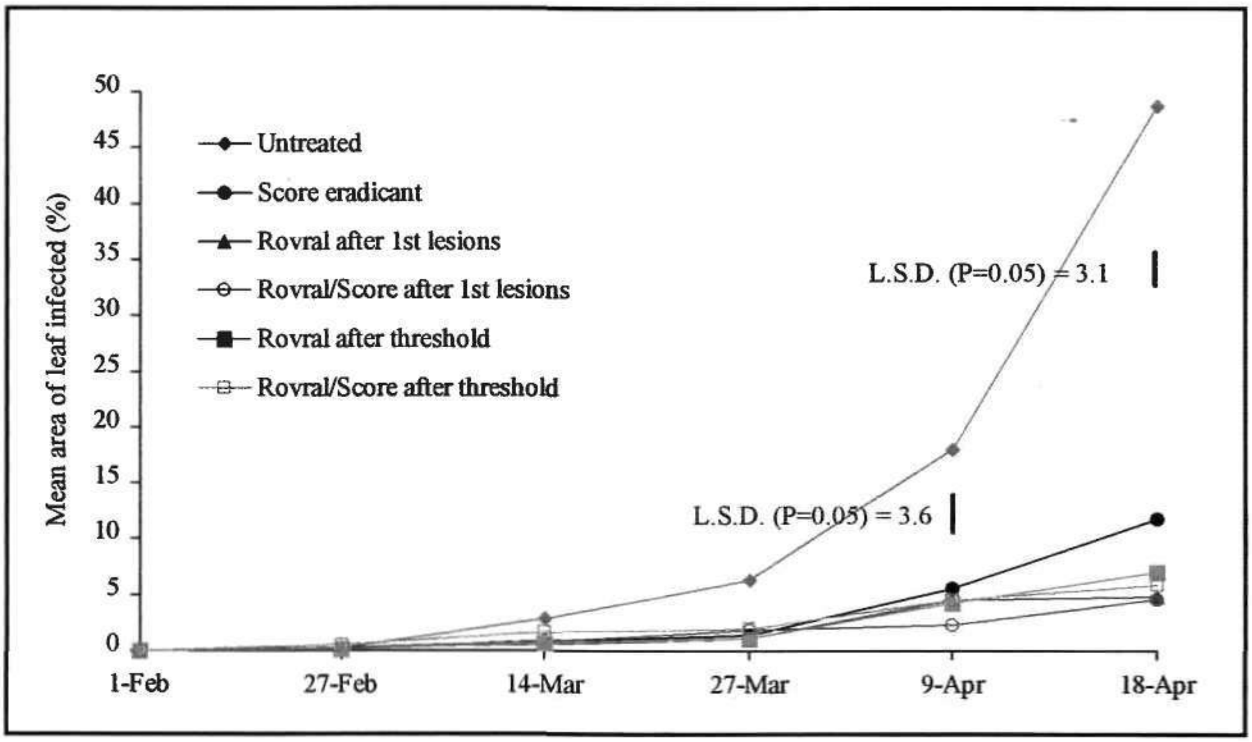


Figure 19. Disease levels 113 days after emergence after treatment with different fungicide regimes

cv Coliban - Lenswood 1996

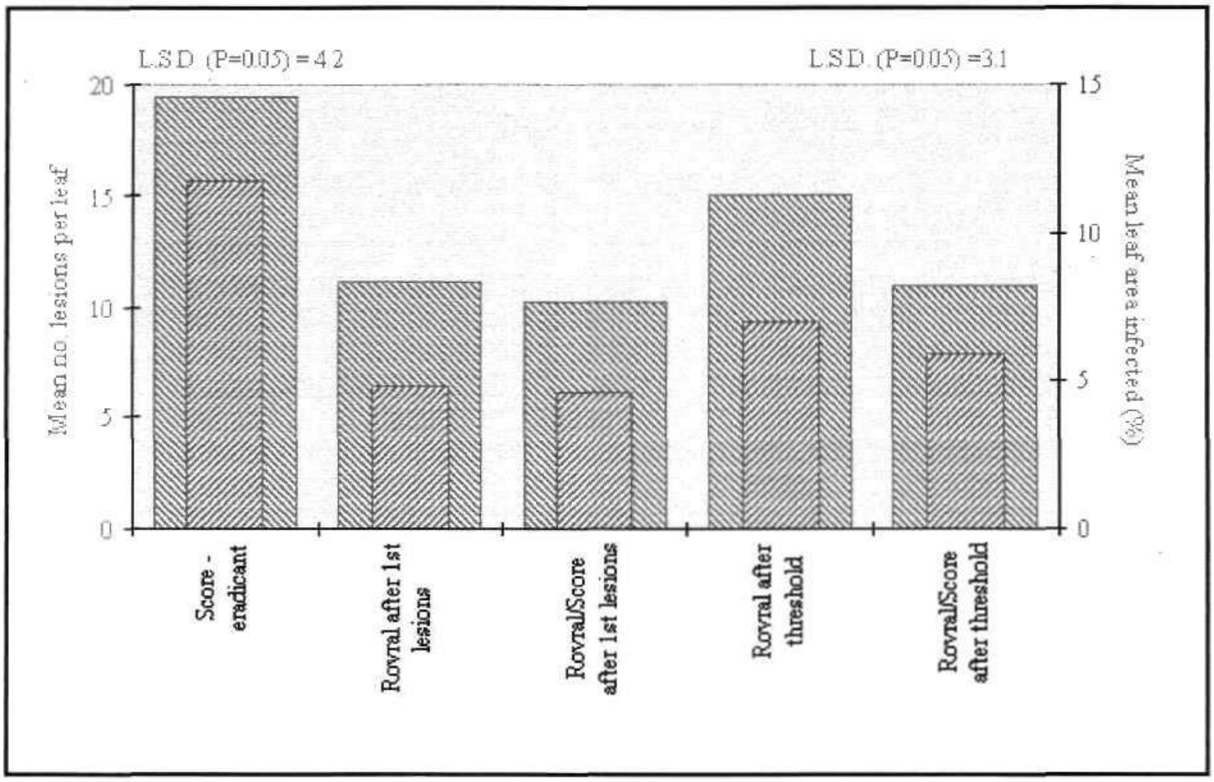
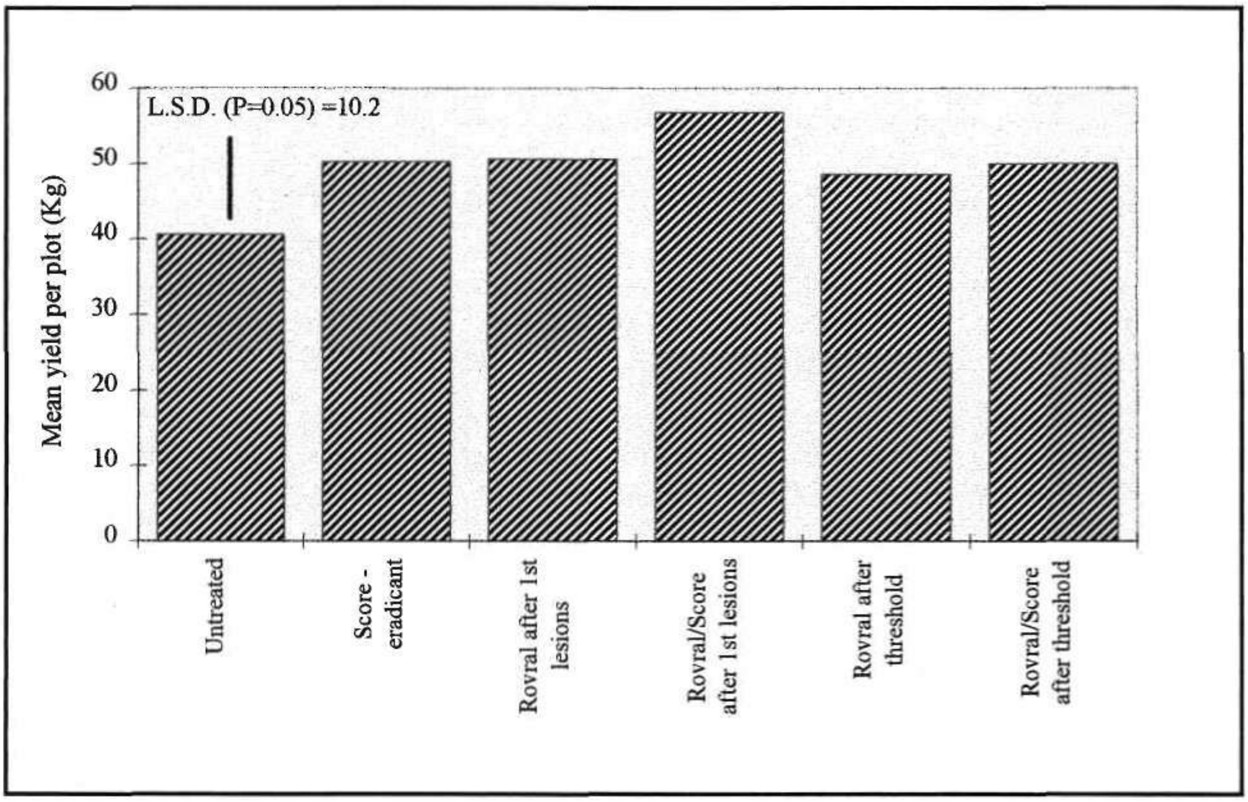



Figure 20. Yield after treatment with various fungicide regimes, cv Coliban - Lenswood 1996



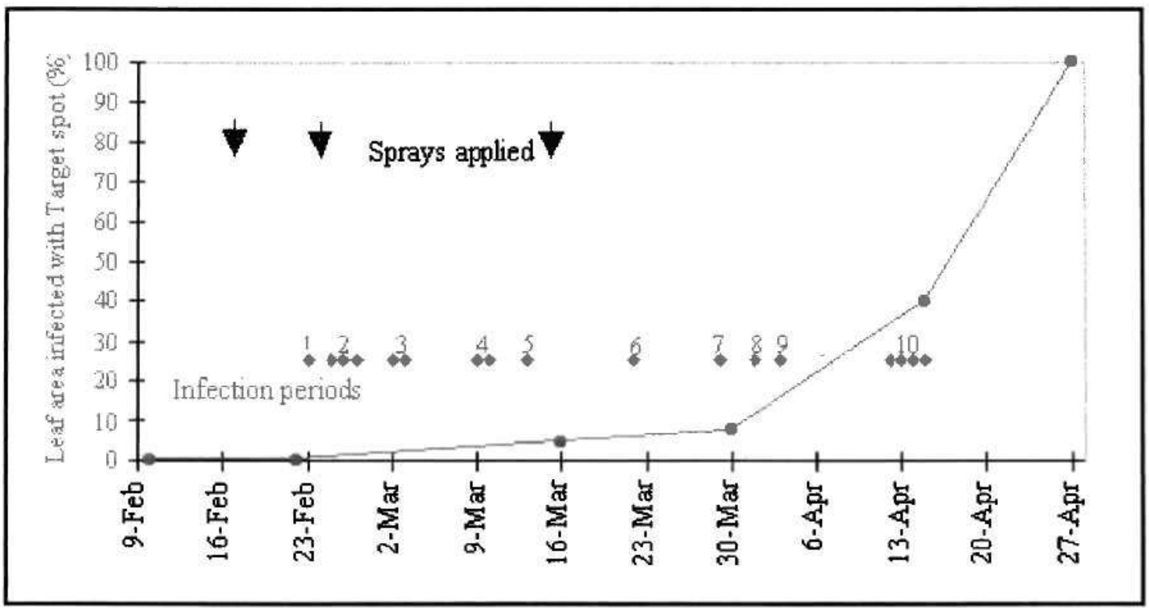
## Monitoring

### *Infection periods and disease progression*

Potato plantings on commercial properties near trial sites were regularly monitored to assess the level of disease. The amount of Target spot was assessed using the disease keys in appendix 1 on a full leaf from the middle third of each of 10 plants from 10 areas chosen at random within the planting. A disease progression curve was correlated against rainfall and temperature data collected from nearby weather monitoring equipment.

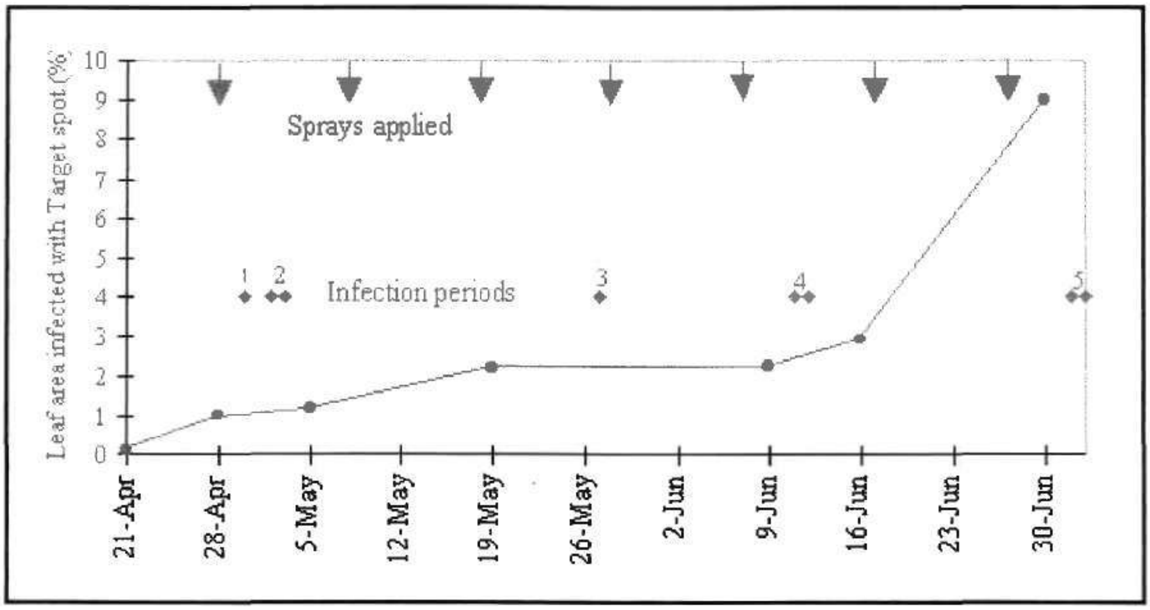
In the potato crop adjacent to the Lenswood trial, 1993/94, there were 10 infection periods from the start of flowering to harvest. This showed that where infection periods occur regularly, it is more appropriate to use a protectant fungicide regime, as the use of an eradicant schedule of Score would have resulted in more applications than recommended by the manufacturer.

Figure 21. Disease progression curve and infection periods, Lenswood 1994



In contrast, the planting at Virginia adjacent to the 1995 trial where 5 infection periods occurred after flowering, would have been suitable for an eradicant program. At this site the infection periods were sufficiently apart in time to be considered as 3 groups which would have required only 3 well timed sprays over the season.

Fig 22. Disease progression curve and infection periods, Virginia 1995.



*Pdays and incubation periods*

To assist in determining which Pday was best to initiate a spray program, commercial plantings and trial sites were monitored regularly from emergence and the P days calculated when the first symptoms were observed. These varied considerably, the lowest being 177 and the highest 425 (Table 11). The weather data was then used to determine the most likely date of the infection period causing the lesions, defining the infection period as 12 hours at 10°C to 8 hours at 15°C. The incubation time was then calculated, and was usually around 8 days, however in the colder weather this extended up to 16 days (Table 11). On some occasions there were more than one possible infection period, and in these cases all possibilities have been listed.

Table 11. Pdays and incubation periods of first lesions in various potato crops.

| Location | Variety | Emergence date | Date of first lesion | Pdays | Incubation period (days) |
|---|---|---|---|---|---|
| Lenswood | Winlock | 26.12.93 | 10.2.94 | 326 | 9 |
| Currency Creek | Atlantic | 22.1.94 | 11.2.94 | 177 | 8 |
| Angle Vale | Atlantic | 10.2.94 | 10.3.94 | 241 | - |
| Angle Vale | Whiti | 19.5.94 | 13.7.94 | 337 | 16 |
| Angle Vale | Brodic | 29.6.94 | 18.8.94 | 215 | 16, 19 |
| Angle Vale | Whiti | 19.7.94 | 29.9.94 | 343 | 14, 16 |
| Angle Vale | Atlantic | 19.9.94 | 10.11.94 | 349 | 8 |
| Angle Vale | Atlantic | 2.10.94 | 28.11.94 | 389 | 8 |
| Angle Vale | Atlantic | 12.11.94 | 6.1.95 | 376 | 9 |
| Currency Creek | Atlantic | 12.2.95 | 14.3.95 | 261 | 8, 12 |
| Virginia | Sequoia | 2.4.95 | 28.4.95 | 196 | 9, 12 |
| Purnong | Coliban | 12.8.95 | 23.10.95 | 439 | 8 |
| Lenswood | Coliban | 27.12.95 | 29.1.96 | 204 | 7, 10 |
| Currency Creek | Atlantic | 27.1.96 | 22.3.96 | 425 | 7, 10, 13 |

Uninfected leaves immediately above an infected leaf on several plants within the unsprayed areas in trial sites were also monitored to determine the incubation period of the new lesions. The incubation period was between 8 and 10 days to infect from leaf to leaf.

## ACKNOWLEDGMENTS

We thank the Horticultural Research and Development Corporation and the Australian Potato Industry for supporting this work. Undertaking this project would not have been possible without the help and collaboration of the various potato growers who allowed us to conduct experiments on their properties. We also appreciated the help of the staff at the Lenswood Research Centre.

## RECOMMENDATIONS

### Extension/Adoption

This work has shown that weather data and disease monitoring coupled with appropriate computer software are useful tools to predict the initiation and timing of fungicide applications for the control of Target spot.

Although automated electronic weather stations were used in these studies, including some connected to remote telemetry, our experiments demonstrated that those stations still required regular maintenance. The development of simple and user friendly weather stations would be more appropriate for rapid adoption of this technology.

The results of this work have been presented at several grower meetings in South Australia and Victoria.

### Direction for future research

These results showed that Score is one of the most effective fungicides for the control of Target Spot. The use of this material on a curative (post infection) schedule can reduce the number of fungicide applications by 4 or 5 per season. However the manufacturers do not recommend Score to be used in this manner due to the possible development of resistant strains. Resistance to these type of fungicides has been found overseas and in order to monitor changes in sensitivity, Australian isolates of *A. solani* should be tested to develop base line levels of sensitivity. This will enable any suspect resistant strains of *A. solani* to be tested and compared with known sensitive isolates.

If the post infection activity of Score is to be utilised, the conditions suitable for infection need to be accurately measured. Cheap and robust electronic weather stations that measure temperature and leaf wetness are being developed and these need to be critically evaluated in Australian conditions.

Although Late blight (*Phytophthora infestans)* did not develop in these experiments - further work evaluating spray warning and predictive systems for this disease need to be developed in conjunction with Target spot. In light of the present situation in the USA and Europe where an $A_2$ strain of *P. infestans* which is more aggressive than other strains and is also resistant to Ridomil has caused widespread destruction of potato crops. In Australia work needs to be done to identify the mating types of the local strains of *P. infestans*, and to continue evaluation of disease warning systems for this pathogen. If there are significant climatic changes due to the glasshouse effect then many potato growing areas may become warmer and wetter and in these situations Late blight may become a significant problem.

Further work needs to be done in developing and evaluating new fungicides for use on potatoes. Apart from Score, few of the registered fungicides are outstanding in the control of Target spot. Fungicides with new chemistry need to be evaluated on potatoes and their effect on other diseases of potatoes determined. Other aspects that need investigation are new spray application techniques that improve spray coverage as well as applying spray volumes lower than those presently used in the industry.

In summary, future research should involve the following:-

1. Evaluation of new fungicides.
2. Determination of base line levels of sensitivity to new fungicides.
3. Evaluation of weather stations.
4. Evaluation of predictive models.
5. Evaluation of new spray application technology.
6. Determination of spray deposits - distribution and tenacity.

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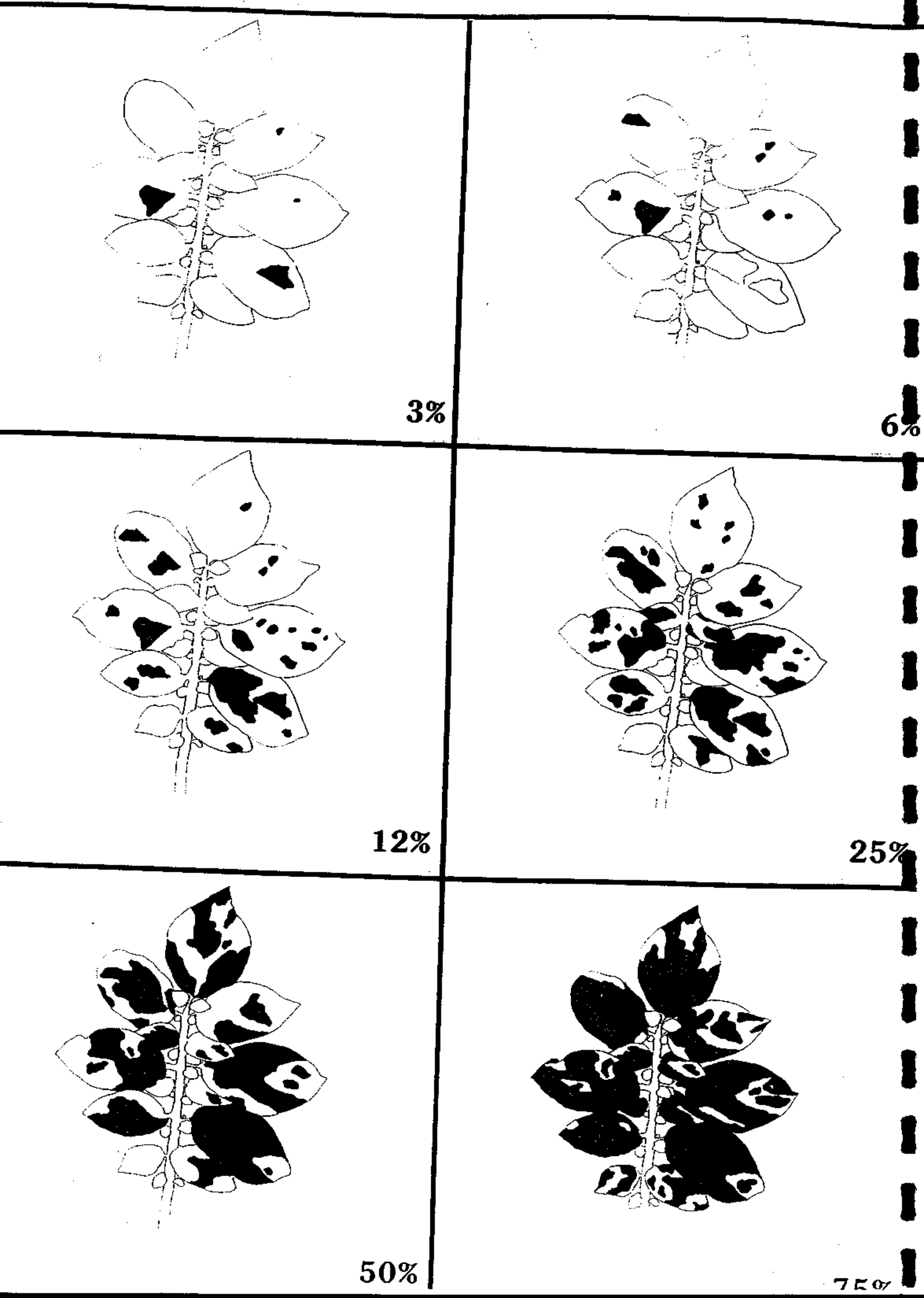
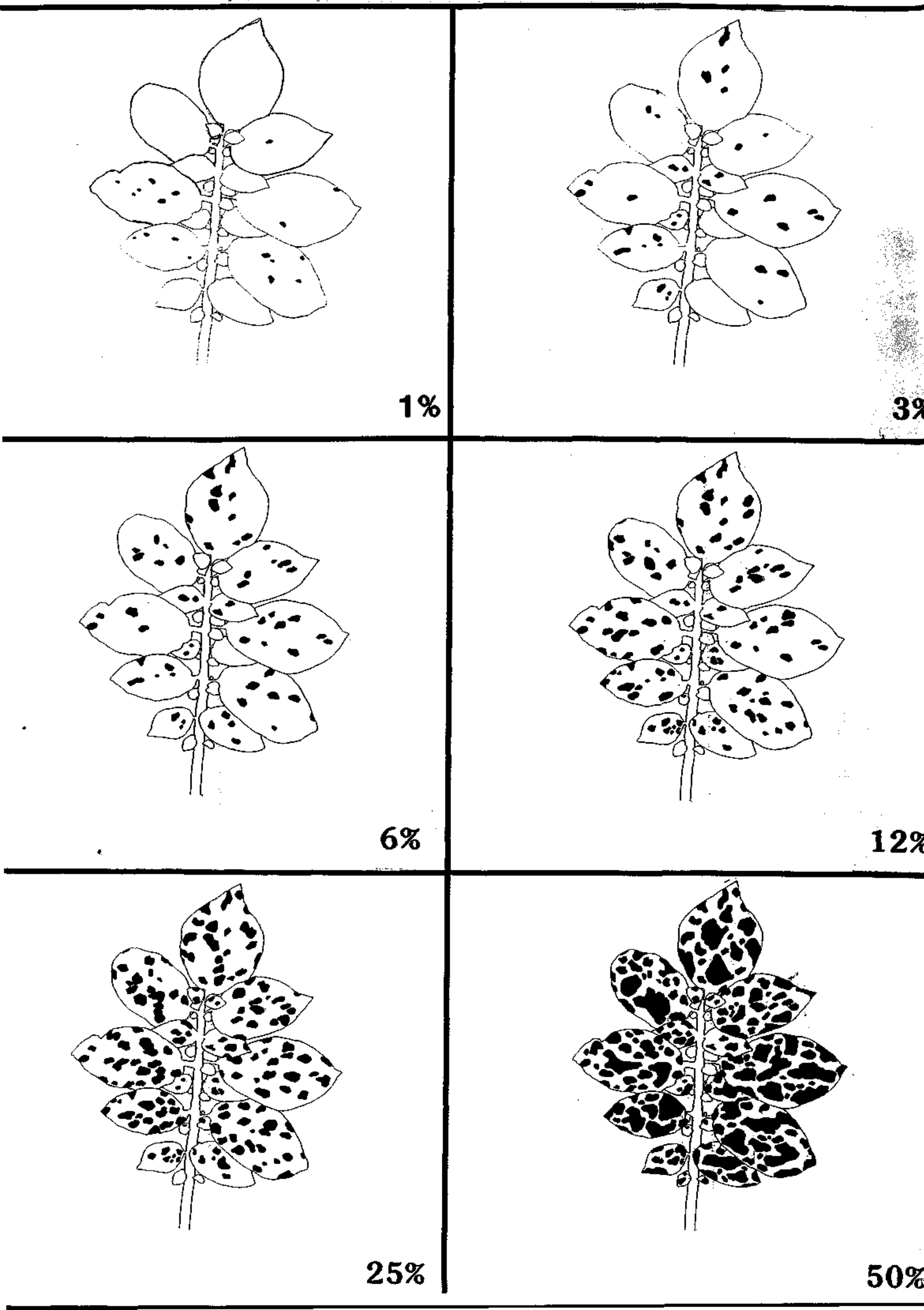
# TARGET-SPOT ASSESSMENT



# TARGET-SPOT ASSESSMENT



**Appendix 2.**

Effect of wetting period and temperature on infection of potato by *A solani*. (Rotem, 1994)

Interactions between WP, temperature, and inoculum dose were demonstrated in an experiment with potato early blight, replicated from an identical experiment conducted previously with potato late blight (Rotem et al, 1971). The test plants were inoculated with various doses of *A. solani* spores and were wetted for 6, 12, 24, and 48 h at various temperatures measured and controlled with thermocouples clipped to their leaves. Under the least favorable conditions for infection, with the shortest WP (6 h)

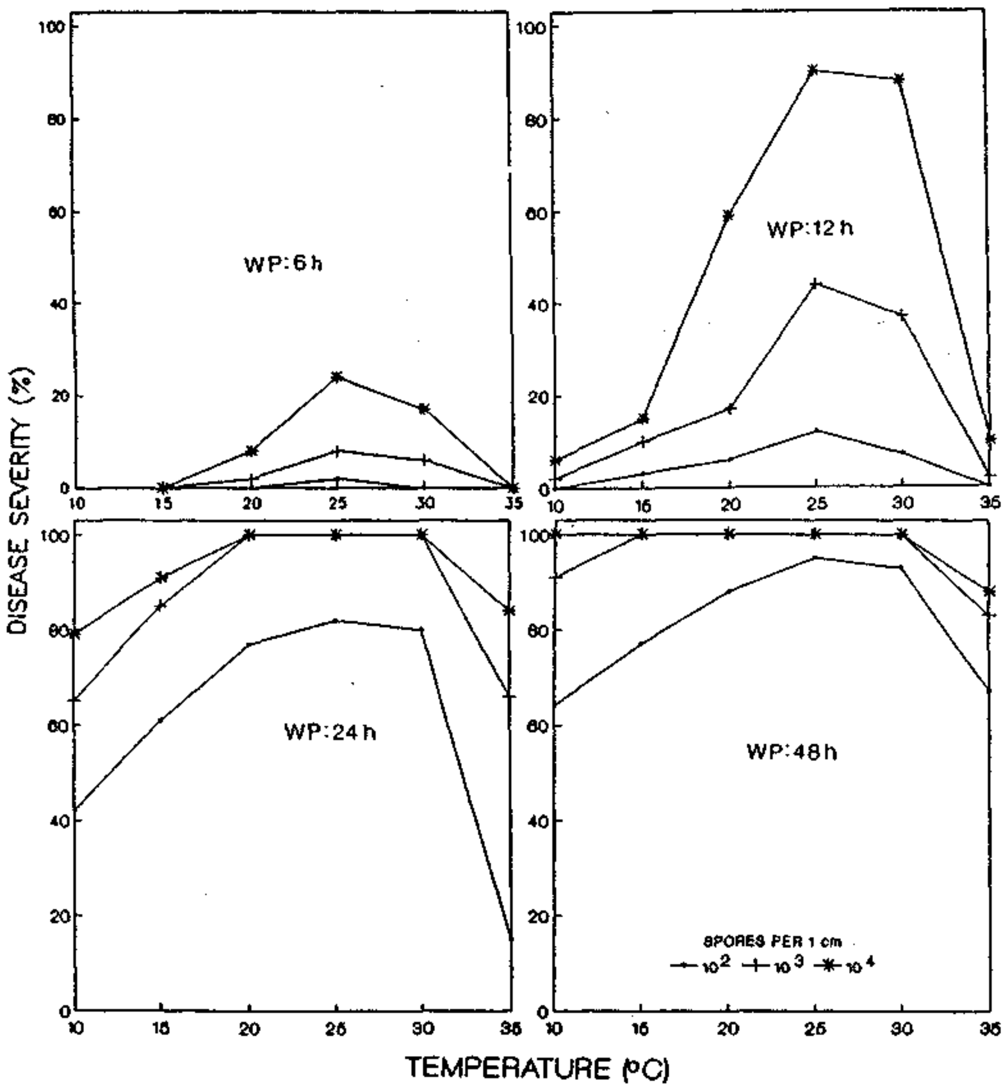



**Figure 5.2.** Effects of wetting period (WP), inoculum dose (number of spores per 1 cm$^2$), and temperature on infection of potato by *Alternaria solani*. Interactions between the wetting period, inoculum dose, and temperature determine the level of infection and show that minimum, optimum, and maximum conditions do not have fixed values. A favorable level of one factor compensates for a less favorable level of another factor and widens the range of successful infections.