LOW INPUT FUNGICIDE PROGRAMMES FOR THE CONTROL OF LATE BLIGHT IN POTATOES

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SUMMARY

Field and farm trials were carried out between 1996 and 2000 to determine the efficacy of the NegFry and Met. Éireann decision support systems (DSS) in controlling late blight of potatoes compared with routine fungicide treatments. The trials were also used to determine the potential of the systems to reduce fungicide inputs.

The NegFry DSS reduced fungicide use by 27% and 49% respectively when compared with a 10-day and 7-day routine spray programmes based on the fungicide Dithane. The greatest reduction in fungicide use was recorded following the Met. Éireann programme where there were average savings of 53% and 67% respectively, but disease control was unacceptable.

The NegFry DSS resulted in no significant reduction in the delay in disease onset or increase in the level of foliage blight at the end of the season or in the area under the disease progress curve (AUDPC) when compared with the 10-day routine programme. This supports the hypothesis that the NegFry DSS results in similar foliage blight control to the Dithane 10-day routine progrogramme. Within the NegFry programmes, the use of Shirlan consistently reduced the level of foliage blight compared with Dithane but in no year was this difference significant.

The Met Éireann DSS consistently reduced the delay in disease onset and consistently increased the level of foliage blight at the end of the season as well as the AUDPC when compared with the 10-day routine programme.

When the 10-day routine treatment with Dithane is compared with the two NegFry treatments it was found that in no year were there significant differences between the marketable yields of the three treatments. In 1999 and 2000 similar results were found when the NegFry treatments were compared with 7-day programmes of either Dithane or Shirlan. This would confirm that the use of the NegFry DSS had no detrimental effect on marketable yield. Within the NegFry programmes there was a consistent benefit from using the fungicide Shirlan, but this benefit was not significant. Similar results were obtained for tuber blight control. This would suggest that the NegFry programmes gave equivalent tuber blight control to the 10-day routine application of Dithane. However, within the two NegFry programmes it was clear that the fungicide Shirlan gave consistently better tuber blight control than Dithane. These differences were significant in 1996 and again in 2000. In years when blight was severe, marketable yields from the Met Éireann programme were significantly lower than those from the 10-day routine programme.

Quality assessments over the period 1998 to 2000 confirmed that the use of the NegFry DSS had no detrimental effect on the dry matter content of the tubers.

Programmes based on the NegFry DSS controlled blight as effectively as routine spray programmes in farm trials in Meath, Kilkenny and Wexford during 1999 and 2000.

INTRODUCTION

Potato late blight, caused by the oomycete fungus *Phytophthora infestans* (Mont.) de Bary is the most destructive disease affecting the potato worldwide. Annual losses in Ireland have been estimated at £8 m per annum (Copeland *et al*., 1993). Disease control requires regular application of fungicides at high rates and short intervals throughout the growing season.

There is increasing consumer demand to improve the health status of our foods and to reduce any pollution effects on our environment. This has resulted in a growing international demand to reduce the use of pesticides in food production. Some countries have already introduced legislation to reduce the use of pesticides in crop production while in others the legislation is still pending. In countries where no such legislation exists, the larger food outlets may insist that their food be produced according to a protocol that includes reduced fungicide inputs. This may involve the scientific justification of each fungicide applied and can only be achieved by the use of a decision support system.

The epidemiology of late blight is very dependent on temperature, relative humidity and rainfall. Due to the large influence of weather on the development and spread of this disease, it is not surprising that forecasting systems have been in use in a number of countries for many years.

One of the first forecasting schemes for potato blight, based on cloudiness, dew, rainfall and temperature was developed in the Netherlands (van Everdingen, 1926). Others were developed in the UK (Beaumont & Staniland, 1933) and the USA (Crosier & Reddick, 1935). Subsequently, Beaumont formulated the Beaumont Period (Beaumont, 1947) which was later superseded by the Smith Period (Smith, 1956). An attempt to refine the system by Sparks (1980) was not successful and the Smith Period continues in use in the UK to the present day.

In the Republic of Ireland, Bourke developed a set of rules for forecasting late blight which were first used in 1952 and are known as the ‘Irish Rules’ (Bourke, 1953). These rules were based on experimental laboratory work carried out by

Crosier in the USA (Bourke, 1955). The rules were used for the development of a late blight warning service that is run by Met. Éireann (the Irish Meteorological Service).

Recent developments in information technology have made it possible to log weather data continuously for individual sites and to use this information in computer-based decision support systems (DSS) to predict the date of disease outbreak and to determine the most suitable intervals between sprays. The objective is to achieve optimum disease control with minimum fungicide use. Over the last few years, one such DSS, namely NegFry, has been compared with both the Irish Rules and with routine spray programmes at Oak Park Research Centre, Carlow, Ireland.

The first part of NegFry is based on the negative prognosis (Ullrich and Schrödter, 1966) which calculates the epidemic free period for *Phytophthora infestans* and then recommends the first spray at the end of this period. The second part of the model is based on a method developed by Fry *et al*. (1983) and calculates subsequent spraying intervals based on blight units. The blight units are calculated using the length of any humid spell, the air temperature during the humid spell and the susceptibility of the cultivar to late blight. The NegFry model requires as inputs for the calculations, air temperature, relative humidity, rainfall, cultivar susceptibility and crop emergence date.

The Met Éireann blight warning service follows the Irish Rules and uses data supplied by their automatic weather stations to calculate the severity of each blight spell. It combines this with synoptic weather charts to predict spells of blight weather and so give a spray warning (Keane, 1986). The spray warnings are issued over national television and radio as required during the growing season.

Further developments of these systems will include the use of weather forecasts, to predict blight weather before it occurs and so give an early warning of blight weather. Model builders are also working on Internet-based programs that will allow farmers to log-on directly and get spray timings for individual crops in specific locations.

The objective of this project was to establish if fungicide application according to a decision support system could be used to reduce fungicide inputs in a potato late blight control programme without loss of disease control.

METHODS

Treatments

Routine fungicide application at 7- and 10-day intervals were compared with fungicide applications as dictated by the Met. Éireann blight warnings and the NegFry decision support system. Two different protectant fungicides were used at recommended rates, Shirlan (fluazinam, 0.4 l/ha or 0.3 l/ha) and Dithane (mancozeb, 2.25 kg/ha) in conjunction with the NegFry decision support system.

Weather data recording

An in-crop weather station (Hardi Metpole) was used to record humidity, temperature, rainfall, radiation, wind speed, soil temperature and soil moisture. The data was recorded every 10 minutes and the average of 3 readings was transmitted by radio signal to a receiver and transferred to a computer where it was stored for final analysis using the NegFry decision support software.

Field experiments

Trials were conducted at Oak Park Research Centre, Carlow, Ireland, using certified seed of the maincrop potato cultivar `Rooster` which has a rating of 4 for foliage blight resistance and 6 for tuber blight resistance. The preceding crop was winter barley and the soil was a free draining medium loam with a low clay and organic matter content and a pH of 6.6 (+/- 0.2). The trials were planted into preformed drills using a Randsom two-row automatic planter. The drill width was 81.28 cm and the distance between tuber centres was 31.75 cm. Paraquat (600 g. a.i./ha) and simazine (600 g. a.i./ha) was applied as pre emergence herbicides.

The design was a randomised complete block (RCB) with 4 replications per treatment. Each plot was made up of 6 drills 7.69 m long. The total plot size was 37.5 m^2, from which 25 m^2 were harvested across the centre 4 drills. A 3 m divider strip was left between each plot to facilitate mechanical harvesting. An unsprayed inoculater plot was planted at each end of the trial. A mancozeb treated non-experimental buffer-plot was planted between the unsprayed plot and the experimental area. Artificial inoculum of *P. infestans* (5,000 sporangia/ml) was applied to the under-surface of 5 leaflets/plant in the inoculater strips at either end of the trial area if no disease was apparent within 10 days after disease onset was predicted by the NegFry DSS.

Spraying was carried out with an ATV drawn Hardi sprayer mounted on a Logic chassis with an independent power source. Machinery access was by rotovated spray paths to prevent crop damage. Spraying commenced when the plants were

beginning to meet along the drill or as determined by a decision support system. The spray volume was equivalent to 250 l/ha and the spray pressure was 3 bars using Hardi flat spray nozzle number 370694/4110-20 delivering 1.59 l/min at 7.6 km/h (4.72 mph). During the growing season, disease levels were assessed at weekly intervals up to desiccation using the B.M.S. foliage blight assessment key (Cox & Large, 1960).

The experiments were desiccated with full rate diquat in September and harvesting took place in November using a Randsom two-row elevator digger. The produce was picked into jute sacks and stored at a temperature above 10^0C for at least two weeks to allow tuber blight symptoms to develop. The tubers were then graded into the following grades:- < 45 mm, 45-65 mm, 65-85 mm, > 85 mm, blighted tubers and other diseases. After grading the produce was weighed and the yield expressed in tonnes/ha. A 2 kg sample was taken from the 65-85 mm grade in each plot and assessed for dry matter content.

Farm validation

In 1999 and 2000, validation tests were conducted on the cultivar Rooster at farm level. Routine fungicide application was compared with a Shirlan programme applied as per the NegFry decision support system. In 1999 and 2000 the trials were located in Meath and Wexford with an additional trial site in south Kilkenny in 2000. Each treatment area was a minimum of one hectare and was unreplicated.

A Hardi-Metpole was located in each crop and the weather data was transmitted to an on farm receiver and automatically transferred to a computer. Each morning the data was transferred to Oak Park via E-mail for analysis. A decision on spraying was relayed to the farmer via E-mail and telephone. The objective of this work was to assess performance and problems with a DSS at farm level.

RESULTS

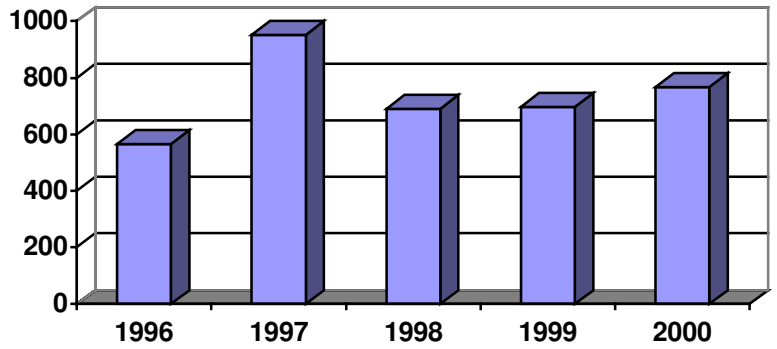
Variation in disease severity between years

The accumulated risk value as measured by the NegFry decision support system is a good measure of the conditions suitable for the spread of foliage blight during the course of each season. It also provides a consistent and scientific comparison between years. High values indicate a year where conditions were most suitable for the spread of foliage blight.

The accumulated risk values for the years 1996 to 2000 are given in Fig. 1. The highest accumulated risk value was recorded for 1997 with the second highest

recorded for the year 2000. Both of these years were above average in terms of conditions suitable for disease spread while the remaining years were normal. This information is consistent with the levels of foliage blight at the end of each season (Table 3).

Fig. 1: Variation in the accumulated risk value 1996-2000 (Blight units from June 1 to September 30)



Number of fungicide applications

Routine fungicide application started in mid-June and continued at 7- or 10-day intervals up to the date of desiccation. The number of routine fungicide applications was dictated mainly by the date of desiccation. The number of fungicide applications for the decision support systems was determined by either the NegFry or the Met. Éireann programmes. The number of fungicide applications for each programme in each of the five years is given in Table 1.

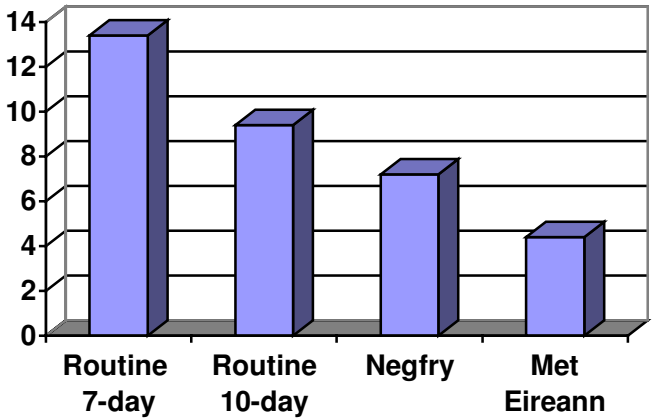
Table 1: The number of fungicide applications following different application programmes 1996-2000.

Treatment	1996	1997	1998	1999	2000	Mean
Dithane DF @ 10 days	9	9	10	10	10	9.6
Dithane DF @ 7 days	13[1]	13[1]	14[1]	14	14	13.6
Shirlan 0.4 l @ 10 days	9	9	10	10	10	9.6
Shirlan 0.3 l @ 7 days	13[1]	13[1]	14[1]	14	14	13.6
Dithane DF Met. Warnings	3	5	4	5	5	4.4
Dithane DF NegFry	4	7	8	8	8	7.2
Shirlan 0.4 l NegFry	4	7	8	8	8	7.2

[1]estimated values based on 7-day intervals

Over the five-year period of the experiment the 10-day routine programme received an average of 9.6 fungicide applications while the 7-day programme received an average of 13.6 applications per season. Over the same period the NegFry programme recommended an average of 7.0 fungicide applications while the Met. Éireann programme recommended an average of 4.4 applications. When compared with the 10-day routine programme, the NegFry decision support system reduced the use of fungicide by 27.1% but when compared with the 7-day routine programme the saving was 48.5%. The greatest reduction in fungicide use was recorded following the Met. Éireann programme where there was an average saving of 54.2 and 67.6% respectively. The two decision support systems represent a considerable saving in fungicide use (Fig. 2) but this would need to be combined with an acceptable level of disease control.

Fig. 2: Effect of spray programme on the mean number of fungicide applications 1996-2000



Effect on foliage blight

The effect of different fungicide programmes on the incidence of foliage blight can be compared by using the delay in disease onset, the level of foliage blight at the end of the season or by using the area under the disease progress curve (AUDPC) which measures the rate of disease development during the course of the whole epidemic.

The delay in disease onset for the different treatments is given in Table 2. All fungicide treatments significantly delayed the date of disease onset compared with the untreated control. The least delay in disease onset was consistently recorded

following the Met. Éireann treatment and this was significantly lower than the routine Dithane treatment at 10-day intervals in 1997 and 1998. When the NegFry programmes were compared with the 10-day routine programme it was found that there was no significant reduction in the delay in disease onset. In general the best results were achieved with Shirlan and this was significantly better than the Dithane 10-day control treatment in 1996.

Table 2: Effect of different fungicide programmes on the delay in disease onset in days as compared with the untreated control.

	1996	**1997**	**1998**	**1999**	**2000**
Dithane DF @ 10 days	12.75	24.50	59.75	14.00	21.50
Dithane DF @ 7 days	-	-	-	24.75	30.50
Shirlan 0.4 l @ 10 days	-	-	44.25	23.00	28.50
Shirlan 0.3 l @ 7 days	-	-	50.50	25.00	30.25
Dithane DF Met. Warnings	15.50	3.50	26.25	14.00	18.00
Dithane DF NegFry	17.00	15.75	44.75	17.50	21.50
Shirlan 0.4 l NegFry	25.50	12.25	59.75	17.75	30.25
LSD (5%)	9.77	15.34	19.06	16.18	10.60
LSD (5%) Excl. untreated control and Met Warnings	12.77	18.98	21.69	16.80	8.48

The % foliage blight for the different treatments at the end of the growing season is given in Table 3. In each of the 5 years, all fungicide treatments significantly reduced the incidence of foliage blight at the end of the season compared with the untreated control. In all years the Dithane 10-day routine programme resulted in better disease control compared with the Dithane applied as per the Met. Éireann warnings. These differences were significant for 1997, 1999 and 2000 and confirms that the Met. Éireann programme resulted in inadequate foliage protection, except in 1996 when disease pressure was least severe.

When comparing the programmes applied as per the NegFry decision support system with the Dithane 10-routine programme it can be seen that in no year was there a significant difference between the programmes. This confirms that over the 5 years of the experiment the NegFry programme gave similar foliage blight control to the Dithane 10-day routine programme. Within the NegFry programmes, the use of Shirlan consistently reduced the level of foliage blight compared with Dithane but in no year was this difference significant.

Table 3: Effect of different fungicide programmes on the % foliage blight at the final assessment date 1996-2000

Treatments	1996	1997	1998	1999	2000
Unsprayed	96.25	100	68.75	93.75	100
Dithane DF @ 10 days	14.00	43.75	0	1.53	1.78
Dithane DF @ 7 days	-	-	-	0.30	0.55
Shirlan 0.4 l @ 10 days	-	-	0.025	0.05	1.55
Shirlan 0.3 l @ 7 days	-	-	0	0.05	0.55
Dithane DF Met. Warnings	15.00	93.75	14.25	27.50	56.25
Dithane DF NegFry	3.00	62.50	0.025	2.55	8.00
Shirlan 0.4 l NegFry	0.78	62.50	0	0.30	0.33
LSD (5%)	12.23	18.86	23.83	17.83	13.77
LSD (5%) Excl. untreated control	14.20	22.04	14.63	18.46	14.85
LSD (5%) Excl. untreated control and Met Warnings	14.14	27.83	0.050	2.26	6.74

The area under the disease progress curve measures the development of disease over the whole season and is a more accurate assessment of differences between treatments over the course of the epidemic. All fungicide treatments significantly reduced the area under the disease progress curve compared with the untreated control (Table 4).

In all years the Dithane 10-day routine control resulted in better disease control compared with the Dithane applied as per the Met. Éireann warnings. These differences were significant in all years except 1996, which was the year with the lowest accumulated risk value. This again confirms that the application of fungicides as per the Met. Éireann warnings did not give adequate control of late blight during the course of this experiment.

When the programmes applied as per the NegFry decision support system are compared with the Dithane 10-day routine programme it can be seen that there was no significant difference between the programmes except in 2000. In that year the Dithane applied as per NegFry resulted in significantly higher levels of foliage blight. Within the NegFry programmes, the use of Shirlan consistently reduced the level of foliage blight compared with Dithane and in 2000 this difference was significant. This confirms that in most years of the experiment the NegFry /Shirlan programme gave similar or better foliage blight control when compared to the Dithane 10-day routine programme. In the two years where a Dithane 7-day programme was used it reduced the area under the disease progress curve, and this difference was significant in 1999. However, in neither year was it significantly

different from the two NegFry treatments.

Table 4: Effect of different fungicide programmes on the area under the disease progress curve (AUDPC) 1996-2000

Treatments	1996	1997	1998	1999	2000
Unsprayed	1782	2981	1522	1114	3,100
Dithane DF @ 10 days	215	364	0	18.5	18
Dithane DF @ 7 days	-	-	-	1.6	10
Shirlan 0.4 l @ 10 days	-	-	0.6	0.7	15
Shirlan 0.3 l @ 7 days	-	-	0.52	2.5	12
Dithane DF Met. Warnings	198	1505	18.72	171.7	896
Dithane DF NegFry	33	778	1.48	13.1	84
Shirlan 0.4 l NegFry	11	596	0.00	5.1	11
LSD (5%)	401	503	949	15	228
LSD (5%) Excl. untreated control	242	496	13.97	16	220
LSD (5%) Excl. untreated control and Met Warnings	281	484	1.71	16.8	33

Effect on yield

The total and marketable yields are given in Tables 5 and 6. The yield varied considerably between years with the highest yields recorded in 1996 and the lowest in 1999. In general yields tended to be highest in the years that were most suitable for disease spread. All fungicide treatments resulted in significantly higher total and marketable yields compared with the untreated control in all years except 1998 when only some of the differences were significant. In both 1997 and 2000, the two most severe blight years, the marketable yield from the Met. Éireann programme was significantly lower than the 10-day Dithane routine programme. This reflects the poor foliage blight control achieved by this programme.

When the 10-day routine treatment with Dithane is compared with the two NegFry treatments it can be seen that in no year was there a significant difference between the marketable yield of the three treatments. In 1999 and 2000 a similar result was found when the NegFry treatments were compared with 7-day programmes of either Dithane or Shirlan. This would confirm that the use of the NegFry DSS had no detrimental effect on marketable yield. Within the NegFry programmes there was a consistent benefit from using Shirlan, but this benefit was not significant.

Table 5: Effect of different fungicide programmes on total yield (t/ha) 1996-2000

Treatments	1996	1997	1998	1999	2000
Unsprayed	45.86	33.91	32.38	15.66	35.26
Dithane DF @ 10 days	54.93	52.56	40.46	22.82	52.92
Dithane DF @ 7 days	-	-	-	20.14	60.00
Shirlan 0.4 l @ 10 days	-	-	40.44	20.72	55.12
Shirlan 0.3 l @ 7 days	-	-	43.06	20.88	52.84
Dithane DF Met. Warnings	58.58	44.27	44.98	19.49	45.48
Dithane DF NegFry	56.43	46.08	34.33	20.26	57.20
Shirlan 0.4 l NegFry	56.29	49.42	44.27	21.24	54.10
LSD (5%)	5.81	6.42	9.71	4.01	6.34
LSD (5%) Excl. untreated control	6.10	5.43	8.94	3.80	6.96

Table 6: Effect of different fungicide programmes on marketable yield (t/ha) 1996-2000

Treatments	1996	1997	1998	1999	2000
Unsprayed	39.16	29.70	24.53	13.96	28.84
Dithane DF @ 10 days	47.78	47.91	34.24	20.83	48.68
Dithane DF @ 7 days	-	-	-	18.09	56.48
Shirlan 0.4 l @ 10 days	-	-	34.64	18.64	51.12
Shirlan 0.3 l @ 7 days	-	-	35.59	19.11	52.84
Dithane DF Met. Warnings	51.86	39.54	38.39	17.49	40.24
Dithane DF NegFry	49.02	41.94	27.13	18.44	53.32
Shirlan 0.4 l NegFry	49.64	44.77	37.95	19.46	50.68
LSD (5%)	5.91	6.31	11.80	3.74	6.51
LSD (5%) Excl. untreated control	6.15	5.55	11.19	3.55	6.96

Effect on tuber blight

Despite the existence of good conditions for tuber infection in some years, the overall level of disease during the course of this experiment was low. The relatively high level of tuber resistance in the variety Rooster would contribute to this result. The incidence of tuber blight following the different fungicide programmes is given in Table 7. In no year was there a significant difference between the NegFry programmes and the 10-day Dithane routine control. This would confirm that the NegFry programmes gave equivalent tuber blight control

to the 10-day routine application of Dithane. However, when you compare the two NegFry programmes it is clear that the Shirlan programme gave consistently better control than the Dithane programme. These differences were significant in 1996 and again in 2000.

Table 7: Effect of different fungicide programmes on yield of blighted tubers (t/ha) 1996-2000

Treatments	1996	1997	1998	1999	2000
Unsprayed	0.01	0.19	0.10	0.20	0.04
Dithane DF @ 10 days	0.05	0.29	0.04	0.07	0.04
Dithane DF @ 7 days	-	-	-	0.10	0.00
Shirlan 0.4 l @ 10 days	-	-	0.00	0.01	0.12
Shirlan 0.3 l @ 7 days	-	-	0.04	0.05	0.00
Dithane DF Met. Warnings	0.02	0.34	0.01	0.25	0.08
Dithane DF NegFry	0.18	0.36	0.02	0.06	0.16
Shirlan 0.4 l NegFry	0.00	0.22	0.02	0.03	0.00
LSD (5%)	0.12	0.29	0.07	0.12	0.14
LSD (5%) Excl. untreated control	0.15	0.34	0.05	0.11	0.14

Effect on Dry Matter

The effect of the different fungicide programmes on the dry matter content of the tubers is given in Table 8. In 1998 and again 2000 the untreated control showed significantly lower quality than the remaining sprayed treatments. Within the sprayed treatments the differences were small and not significantly different from Dithane routine 10-day control treatment. This would confirm that use of the NegFry DSS had no detrimental effect on the dry matter content of the tubers.

Farm validation

During 1999 excellent foliage blight control was recorded for the NegFry decision support system in Meath throughout the whole of the growing season. In Wexford, blight was recorded in the NegFry programme shortly after the first spray but not in the routine spray programme. This could be explained by the proximity of an inoculum source to the area sprayed by the NegFry decision support system.

During 2000 no blight was recorded in either the routine or NegFry treatments at the Meath site. In both the Wexford and Kilkenny sites foliage blight was first recorded on June 28th. In Wexford it was recorded in the routine programme only

while in Kilkenny it was at a low level in both treatments. Later in the season the disease could not be recorded in any treatment.

Table 8: Effect of different fungicide programmes on the % dry matter of the tubers 1998-2000

Treatments	1998	1999	2000
Unsprayed	23.05	21.70	19.08
Dithane DF @ 10 days	24.18	21.50	22.28
Dithane DF @ 7 days		21.30	22.48
Shirlan 0.4 l @ 10 days	24.67	22.00	22.70
Shirlan 0.3 l @ 7 days	25.26	22.00	22.65
Dithane DF Met. Warnings	24.54	22.10	21.65
Dithane DF NegFry	24.18	21.40	21.75
Shirlan 0.4 l NegFry	24.70	22.10	22.93
LSD (5%)	1.04	1.14	0.87
LSD (5%) Excl. untreated control	1.06	1.16	0.88

DISCUSSION

During the five years of this experiment the NegFry decision support system reduced fungicide use by 27% and 49% respectively when compared with routine fungicide application at 10-day and 7-day intervals. These are very considerable savings in fungicide use and may be improved by better decision support systems and more up-to-date epidemiological knowledge. The savings with the Met. Éireann blight warning programme was even greater but the level of foliage and tuber blight control was unacceptable.

The foliage and tuber blight control achieved with the NegFry DSS showed no significant difference from the routine Dithane treatments. This would confirm that there was no loss in disease control following the use of this decision support system. Within the NegFry treatments the use of Shirlan resulted in a consistent but not significant, improvement in the level foliage and tuber blight control compared with Dithane. This is consistent with earlier trials at Oak Park which confirmed that Shirlan gave better blight control than Dithane (Dowley & O'Sullivan, 1995). With significantly reduced fungicide use it would be important to use the most effective fungicide and this would be particularly important in relation to tuber blight control.

Earlier experiments at Oak Park confirmed the superior performance of phenylamide fungicides for late blight control (Dowley & O'Sullivan, 1994). During the period of these trials the systemic fungicide Ridomil was also used

according to the NegFry decision support system. However, results with this fungicide were not encouraging. Earlier work at Oak Park confirmed that the best results with the systemic fungicides are obtained when they were applied early in the season (Dowley, 1994). As the main effect of NegFry was to delay the application of the first spray, this could explain why systemic fungicides were not effective when used with this decision support system.

The variety Rooster, which has good tuber blight resistance, performed very well in these trials, but other varieties with very low levels of tuber blight resistance may not be as effective.

The good foliage and tuber blight control achieved by the NegFry DSS was accompanied by good yields and good quality. This confirms that the DSS has no deleterious effect on yield or dry matter content.

The cost of fungicide application in potatoes is relatively inexpensive and therefore growers will need another incentive to introduce a DSS system into their production programmes. This could come in the form of a statutory order to reduce fungicide input or more likely as a requirement to justify fungicide use by the large food retailers. Whatever the driving force, decision support systems will play a significant part in future potato production.

Potato production in Ireland tends to be carried out on rented land which may be located far from the growers base. This would give rise to problems of information transfer from in-crop weather stations. It may also require a number of weather stations to cover different fields for the same grower. This problem would be eliminated if we had a national or regional weather station grid which would be centrally controlled and could be assessed through the Internet.

CONCLUSIONS

- The NegFry DSS resulted in a 27 and 49% saving in fungicide use when compared with the 10- and 7-day routine Dithane treatments.
- No significant loss in disease control was recorded following the use of the NegFry DSS.
- The fungicide Shirlan gave consistently better results than Dithane in the NegFry DSS.
- The NegFry DSS had no deleterious effect on yield or quality
- The NegFry DSS performed well at farm level in 1999 and 2000
- The Met. Éireann blight warning system resulted in inferior blight control and lower yields

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