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Impact of oils tank mixed with late blight fungicides on leaf blight control in three growing seasons

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SUMMARY

Two field trials were established in Ayrshire in each of the three years to compare the foliar blight control achieved by commonly used blight control products with and without the addition of the mineral oil Olie-H @ 3.1% of the spray volume. The first trial was to examine the effects at the rapid canopy expansion phase from rosette stage to full crop canopy. The second was targeted at canopy stable when full crop canopy had been achieved.

Olie H (and an alternative mineral oil, Newman Cropspray 11E, and the vegetable oil, Headland Fortune) consistently improved foliar blight control for the three fungicides Percos, Revus and Invader. In 12 out of the 15 comparisons involving these fungicides, the improvement in foliar blight control was statistically significant. However, the impact of oil added to fungicide on leaf blight was greatly influenced by the fungicide product used in the tank mix. In 2011 Olie-H had deleterious effects when tank mixed with Shirlan or Ranman TP. The formulation of Ranman TP was changed to Ranman Top by the manufacturer during the period of study. Foliar blight control with Olie H added to the mix was not detrimental for the replacement Top formulation. Seasonal variability in foliar blight control with added Olie H was evident in the results for Valbon + ZinZan, Ranman Top and to a lesser extent Infinito.

For 22 out of the 27 paired comparisons, adding oil to the blight fungicide did not significantly affect blight-free yield. For three comparisons the oil plus fungicide had significantly higher blight-free yields. For two comparisons yield was significantly reduced in the oil tank mix compared with the straight fungicide. Four out of these five tank mixes with a significant yield response to added oil had an associated statistically significant difference in foliar blight. The exception was the reduction in blight-free yield with the Valbon + ZinZan and Olie H mix.

Tuber blight incidences in the six trials ranged from very low to low and therefore prevented any conclusion regarding the impact of oil plus fungicide tank mixes on tuber blight control. However, there was no evidence that adding oil to blight fungicides had a substantial detrimental effect on control of this aspect of the disease.

Symptoms of phytotoxicity associated with oil use were only observed with one treatment, i.e. Shirlan + Olie H. A much more frequent and widespread effect was the beading of water droplets on the surface of leaflets treated with oil, resulting in delayed drying of leaf surfaces. Greater leaf blight severity due to this delayed drying is a possibility but this could not be specifically tested in the field trials. The predominantly positive response to added oil suggests that any such enhancement of leaf infection, if it occurred, was relatively small.

KEYWORDS
Foliar blight, *Phytophthora infestans*, mineral oil, vegetable oil

INTRODUCTION

The work described in this paper was part of a larger project "Effectiveness of mineral & vegetable oils in minimising the spread of non-persistent viruses in potato seed crops in GB". The aim of the overall project was to investigate the potential for mineral oils to be used as a control method for potyviruses (non-persistent viruses) in seed crops subject to the GB Certification system of growing crop inspection and control programmes for persistent viruses (Potato Leaf Roll Virus, PLRV) and potato late blight (*Phytophthora infestans*). One objective of the project was to evaluate the risk of oils tank mixed with fungicides to crop safety and fungicide efficacy. The part of the project reported in this paper is the effect of tank mixes of oils and common blight fungicides on levels of foliar and tuber blight, including the identification of any phytotoxic effects.

MATERIALS AND METHODS

Field trials were established at SRUC, Auchincruive Estate, Ayr to compare the blight control achieved by commonly used blight control products with and without the addition of Olie H @ 6.25 l/ha in a tank mix in 200 litres of water per hectare. In 2013 the oils Cropspray 11E and Fortune were also tested (Table 1). One trial was to examine the effects at the rapid canopy expansion phase and another was targeted at canopy stable. The distinction is necessary due to the differing nature of the target plant at these stages. Applications made at rapid canopy need to protect new leaf growth between subsequent applications. At stable canopy the fungicide product is required to protect existing leaf area. Also, applications of oil tank mixed with blight fungicides are generally only approved up to tuber initiation. A positive, neutral or undesirable effect on foliar blight or tuber blight activity associated with the introduction of mineral oil to the tank mix could occur. Fungicide products that are commonly used during these phases of growth were included in the trials with and without the addition of Olie-H to the tank mix (Table 2).

Table 1. *Details of oils*

Product	Dose (% of spray volume)	Ingredient	Dose (litres per ha)
Olie-H [1]	3.1%	96% mineral oil (petroleum oil)	6.25
Cropspray 11 E [2]	2.5%	99% paraffinic oil	5.0
Fortune[2]	0.5%	75.0 % Oilseed derived fatty acid esters + n-butyl	1.0

[1] Not yet approved in the UK

[2] May be applied up to tuber initiation

Table 2. *Details of fungicides.*

Fungicide	Active ingredient(s)	Formulation	Rate (kg or L/ha)
Percos	ametoctradin + dimethomorph	SC	0.8
Revus	mandipropamid	SC	0.6
Invader	dimethomorph + mancozeb	WG	2.4
Ranman Top	cyazofamid	SC	0.5
Infinito	fluopicolide + propamocarb	SC	1.6
Valbon (+ ZinZan)	benthiavalicarb + mancozeb	WG	1.6 (+ 0.075% v/v)
Ranman TP	cyazofamid	KL	0.2 + 0.15
Shirlan	fluazinam	SC	0.3
Quell Flo	mancozeb	SC	3.3

All trials were planted with the cv. King Edward, chosen for its susceptibility to potato blight; foliar blight resistance rating 3 and tuber blight resistance rating 4. Trials were inoculated with genotype 13_A2 (the stable canopy trials in 2012 and 2013 were naturally infected by this genotype). Small areas at both ends of all plots that were not treated with fungicide were inoculated to provide even disease pressure within each trial. The experimental design was a randomised complete block with four replicate blocks. Plots were 3.4 m (4 rows) x 7.5 m. Each trial was treated with test fungicide treatments at the appropriate growth stage. At other growth stages common blanket sprays were applied (Table 3). In the rapid canopy trials the one initial blanket spray was at the rosette stage of growth. All test treatments were applied in 200 l/ha of water at 3.5 bar using Lurmark F03-110 nozzles to provides a Medium – Fine spray quality. The sprayer was tractor-mounted.

Weekly assessments of foliar blight were made to document disease progress over time. The severity (percentage of leaf area destroyed by blight) was recorded. In addition visual observations were made of phytotoxicity symptoms and moisture retention within the canopy. Yield and tuber blight were recorded for the treatments. Tuber blight was assessed pre- and post-storage (rapid canopy 2011 and 2012; stable canopy 2011) or post-storage only (rapid canopy 2013; stable canopy 2012 and 2013). Tuber blight was assessed by external inspection

of two random samples of 50 tubers from each plot. The samples were taken at harvest and the assessment carried out after the tubers had been thoroughly washed.
Data from the blight control trials were subjected to analysis of variance using Genstat 15th Edition. AUDPC values were calculated after angular transformation of the foliar blight severity data for each plot.

Table 3. *Fungicide programme structure for the rapid canopy and stable canopy trials (named fungicides are blanket sprays)*

Rapid canopy 2011	**Rapid canopy 2012**	**Rapid canopy 2013**
Shirlan x 1	Curzate M x 1	Curzate M x 1
Test fungicides x 4	Test fungicides x 3	Test fungicides x 4
Shirlan x 4	Quell Flo x 5	Quell Flo x 5
Stable canopy 2011	**Stable canopy 2012**	**Stable canopy 2013**
Shirlan x 1	Curzate M x 1	Curzate M x 1
Consento x 3	Revus + C50 x 3	Consento x 3
Test fungicides x 6	Consento x 1	Test fungicides x 7
	Test fungicides x 7	

RESULTS

The AUDPC values for the 27 paired comparisons of fungicide alone versus fungicide plus oil were used to summarise the 3 years' results. Fungicide plus oil treatments were categorised as having either significantly greater efficacy, significantly worse efficacy or similar efficacy compared with fungicide alone. The same categorisation procedure was used to summarise the impact of oil mixed with fungicide on blight-free yield.

Over the 3 years, 14 out of the 27 tank mixes of oil plus fungicide tested resulted in significantly improved control of foliar blight. For 11 tank mixes the oil had no significant effect on foliar blight control by the fungicide partner. Only two combinations of oil plus fungicide significantly impaired blight control. These two tank mixes were Ranman TP (the Twinpack formulation that was withdrawn from the market during this study) + Olie H in the rapid canopy trial in 2011; and the Shirlan + Olie H tank mix in the stable canopy trial in the same year. The testing of these two tank mixes was therefore discontinued after the first year.

Some core combinations of oil plus fungicide were tested three times to check the repeatability of results in different growing seasons, i.e. Olie H with Infinito, Invader, Percos, Revus or Valbon + ZinZan. The effect of Olie H on the efficacy of individual fungicides was most consistent for Percos but also consistent for Invader and Revus (Table 4). In 2013, the final year of field experiments, tank mixes of an additional mineral oil, Cropspray 11 E, or a vegetable oil, Headland Fortune (Headland Diamond) with Invader, Percos and Revus were tested. The impact of these two additional oils on blight fungicide efficacy was consistent with that obtained with Olie H. When the three oils were compared tank mixed with Revus or Percos all three tank mixes were generally significantly more effective than straight fungicide. When Cropspray 11E and Fortune were compared tank mixed with Invader, Fortune significantly improved control of foliar blight compared with Invader alone whereas Cropspray 11E gave equivalent control to the

fungicide alone. However, because different oils were only compared in 2013 and only in the rapid canopy trial, conclusions regarding the relative efficacies of the different oils must be considered to be preliminary.

A similar summary of blight-free yield results over the 3 years demonstrated that for 22 out of the 27 paired comparisons, adding oil to the blight fungicide did not significantly affect blight-free yield (data not presented). Yield was only significantly reduced for two oil tank mixes compared with the straight fungicide. The first was Olie H plus Ranman TP in the rapid canopy trial in 2011. This reduction was related to the very poor control of foliar blight for the tank mix compared with Ranman TP alone. The second, Valbon + ZinZan + Olie H in the 2013 rapid canopy trial, was not associated with significantly poorer control of foliar blight. For three comparisons the oil tank mix had significantly higher blight-free yields. In all three cases the elevated yields were related to significantly better control of foliar blight. The three were Percos + Olie H and Revus + Olie H (both in rapid canopy 2012) and Revus + Fortune (rapid canopy 2013).

The incidences of tuber blight in the six trials were low (data not presented); so low in 2013 that the data were not analysed. In the four earlier trials the incidences of tuber blight did not differ significantly for 11 of the 14 paired comparisons. In the rapid canopy trial in 2012 the addition of Olie H to Ranman Top resulted in significantly less tuber blight. A similar result was obtained for Valbon + ZinZan + Olie H in the stable canopy trial in 2011. However, in the same trial tank mixing Olie H with Invader produced significantly more tuber blight. These limited results prevent a conclusion being reached regarding the impact of mixing oils with blight fungicides on tuber blight control. The impact of Olie H on tuber blight control by Ranman Top, Valbon + ZinZan and Invader can't be explained by the effect of the added oil treatment on foliar blight control by the respective treatments.

Symptoms of phytotoxic damage were only observed in the 2011 stable canopy trial for one treatment: Shirlan plus Olie H. However, a frequently seen effect attributable to mineral oil treatment was the beading of water droplets on the surface of leaflets.

Table 4. *Percentage improvement in foliar blight control contributed by tank mixing oil with fungicide*

Fungicide	Oil	% improvement[1]		
		2011	**2012**	**2013**
Percos	Olie H	**47.2**[2]	**44.6**	**36.4**
	Cropspray 11 E			**23.7**
	Fortune			**26.5**
Revus	Olie H	18.9	**47.9**	**47.9**
	Cropspray 11 E			**31.1**
	Fortune			**49.5**
Invader	Olie H	**42.4**	**29.0**	45.7
	Cropspray 11 E			12.2
	Fortune			**25.3**
Ranman TP	**Olie H**	**-188.1**		
Ranman Top	Olie H		**49.9**	-3.2
Infinito	Olie H	12.9	11.0	-42.1
Valbon + ZinZan	Olie H	6.1	**29.8**	-6.6

[1] Calculated from the relative AUDPC values for paired treatments of fungicide alone and fungicide plus oil. A negative value indicates poorer control by the tank mix of oil and fungicide.

[2] Values in bold are statistically significant ($P<0.05$)

Fungicides that were tested with one oil once only are excluded from the above table

DISCUSSION

Seasonal factors can influence the impact of using oil with blight fungicides. For example, in each of the three stable canopy trials Infinito was assessed with and without Olie H. Although the result obtained in each year was similar, i.e. oil did not significantly change the AUDPC, the percentage improvement, or decline, in foliar blight control was markedly different in 2013 compared with the two previous years. It can be hypothesised that spray timing relative to infection period will have a confounding effect.

The impact of oil on foliar blight control was influenced greatly by the fungicide product used in the tank mix. In 2011 Olie-H had deleterious effects when tank mixed with Shirlan or Ranman TP. The work with Shirlan was not continued in 2012 and the formulation of Ranman TP was changed by the manufacturer to Ranman Top. In contrast, the oils consistently improved blight control for the three fungicides Percos, Revus and Invader; in 12 out of the 15 comparisons including these fungicides the improvement was statistically significant. Much greater variability in control was evident in the results for Valbon + ZinZan, Ranman Top and to a certain extent Infinito.

The reason for the variability with some fungicides can't be determined from the dataset generated by this study. Additional experiments conducted under controlled environments are required to provide the explanation. In theory there should be greater variation in response to added oil from fungicide products with two active ingredients compared with one. This is because the two a.i.s are likely to have different characteristics and also the oil may differentially enhance the contribution of the two active ingredients. However, there is no evidence that this is the case. Although inconsistent control of foliar blight occurred for oil mixed with Infinito (fluopicolide + propamocarb) and Valbon (benthiavalicarb + mancozeb) + ZinZan, it was also evident for Ranman Top (cyazofamid). Foliar blight control was considerably more consistent for oil plus Invader (dimethomorph + mancozeb), Percos (ametoctradin + dimethomorph) and Revus (mandipropamid).

Very different results for foliar blight control were obtained for Olie H with Ranman TP in 2011 and Ranman Top in 2012. Differences between the blight epidemics in 2011 and 2012 will account for some of this difference but it is likely that much of the discrepancy was due to formulation differences between the two fungicide products. Both products provided 80 g of the fungicide cyazofamid per hectare.

Given the observed importance of the formulation of fungicide products to oil impact, it is important to acknowledge the limitations of the data set generated by this study. This study compared fungicide alone with fungicide plus oil. It can't be assumed that the results observed in these experiments will necessarily be replicated if oils are tank mixed with mixtures of blight fungicide plus for example aphicides. The formulation of, and adjuvant in, an aphicide are likely to differ from those of the blight fungicide. Previous work conducted by Scottish Agronomy Ltd found that tank mixing mineral oil with Biscaya (a neonicotinoid insecticide) should not be carried out due to incompatibility in formulation and the occurrence of phytotoxic symptoms.

The oils Cropspray 11E and Headland Fortune were only tested in one trial in one year with three fungicides. The results were similar to those achieved with Olie H, the oil tested most extensively. However, it should be noted that Cropspray 11E and Headland Fortune were tested in tank mix with the three fungicides that responded most consistently to mixture with Olie H.

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