AHDB HORTICULTURE

Grower Summary

FV PE 410

Lettuce: Further development of 'Best Practice' for disease control in protected and outdoor crops

Final 2016

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The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

If you would like a copy of the full report, please email the AHDB Horticulture office (hort.info.@ahdb.org.uk), quoting your AHDB Horticulture number, alternatively contact AHDB Horticulture at the address below.

AHDB Horticulture,
AHDB
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel – 0247 669 2051

AHDB Horticulture is a Division of the Agriculture and Horticulture Development Board.

Project title:	Lettuce: Further development of 'Best Practice' for disease control in protected and outdoor crops
Project number:	FV/PE 410
Project leader:	Dr G M McPherson, STC
Report:	Final Report, January 2016
Previous report:	Annual Report, July 2015
Key staff:	Mr J Townsend, STC Mr A Ormerod, STC Dr E Wedgwood, ADAS Ms A Huckle, ADAS Mr T Boor, ADAS
Location of project:	Stockbridge Technology Centre Research Foundation, Cawood, North Yorkshire. ADAS, Boxworth, Cambridge
Industry Representative:	David Norman, Independent Consultant Colin Bloomfield, Independent Consultant Geoffrey Smith, Mapleton Growers
Date project commenced:	01 August 2012
Date project completed (or expected completion date):	31 January 2016

GROWER SUMMARY

Headlines

Outdoor lettuce

- Both Fubol Gold and Revus were consistently effective against downy mildew at the final spray timings in different spray programmes.
- Some biopesticide products were demonstrated to be as effective as conventional fungicides at certain timings within a fungicide programme.
- Products with activity against powdery mildew were as effective at half rate compared to full rate (in a low disease situation).
- Whilst none of the novel fungicide programmes evaluated were significantly better than the current commercial programmes, the addition of novel mode of action products would help with resistance management and protect existing active substances for the long-term.

Protected Lettuce

- A reduction in the application rate of active ingredients using tank mixes, allowed broader disease control without compromising overall efficacy. This helped reduce the risk of pesticide residues at harvest and minimises the risk of resistance development in pathogen populations.
- The inclusion of alternative Oomycete fungicides e.g. mandipropamid (Revus) helped control metalaxyl resistant strains of *Bremia lactucae.*
- Whilst downy mildew is a key target, broad spectrum fungicide programmes are needed to provide effective control of other lettuce pathogens.
- Products effective against *Sclerotinia sclerotiorum* also proved to be effective against *Sclerotinia minor*.

Background

Downy mildew (*Bremia lactucae)* is responsible for most losses in outdoor and protected lettuce. Soil-borne pathogens, such as *Sclerotinia, Botrytis* and *Rhizoctonia* are also important and contribute to significant losses in some crops. *Sclerotinia* causes severe head decay, especially near maturity whilst bottom rot (*Rhizoctonia solani*) tends to affect the lower leaves (predominantly in protected crops) that can render affected plants unmarketable. Grey mould (*Botrytis cinerea*) is often present on the older damaged leaves (including those infected by *Bremia*) and is usually removed during trimming, though in wet seasons severe infections can reduce head weight significantly.

The primary purpose of this project was to identify and evaluate novel fungicides and biopesticides with good activity against the primary lettuce pathogens and to see if there was 'incidental' activity against the more minor pathogens that occur sporadically. Work also aimed to determine if control could be maintained with reduced application rates to minimise the risk of residues at harvest whilst ensuring minimal risk of resistance development.

Summary

Initial Fungicide & Biopesticide Screening

Laboratory screening tests with novel active ingredients, including new SDHI fungicides, for activity against downy mildew, *Botrytis*, *Rhizoctonia*, *Sclerotinia* spp. identified a number of novel active substances capable of inhibiting pathogen growth. Many of the SDHIs provided good to excellent inhibition of *Rhizoctonia* and *Sclerotinia* though, perhaps surprisingly, were less effective against *Botrytis* in vitro. Some well-established products inhibited *Botrytis* growth as well as *Rhizoctonia* (iprodione e.g. Rovral), and *Sclerotinia* (prochloraz e.g. Octave). HDC F158 inhibited all three pathogens, but was most effective against *Sclerotinia*. Fungicides containing metalaxyl and dimethomorph provided good inhibition of the Oomycete *Phytophthora* (used as a *Bremia* surrogate). Infinito (fluopicolide + propamocarb hydrochloride) also provided a good inhibition of Oomycetes. The information gleaned from the laboratory screen helped to design a range of experimental fungicide programmes in replicated field & glasshouse trials.

Field & Glasshouse trials

A range of outdoor (ADAS) and protected (STC) lettuce trials were completed; the details of which are outlined in Table 1 below:-

Table 1 Trial schedule for outdoor & protected lettuce crops

Trial Type	**Site**	**Crop period**	**Year**	**Main disease present**	**Reported**
Field Crops (ADAS)	Grower site, Norfolk	Aug - Oct	2012	Downy mildew	July 2013
	Grower site, Staffs	April - June	2013	*Botrytis*	July 2013
	Grower site, Lincs	Aug - Oct	2013	Downy mildew	July 2014
	Grower site, Kent	Aug - Oct	2014	Downy Mildew	January 2016
	Grower site, Lincs	July – Oct	2015	*Botrytis*	January 2016
Glasshouse Crops (STC)	STC, Yorkshire	Oct - Dec	2012	Downy mildew, *Sclerotinia*	July 2013
	STC, Yorkshire	May - June	2013	*Botrytis*	July 2013
	Grower site, Yorks	Mar - May	2014	*Sclerotinia minor*	July 2014
	STC, Yorkshire	Aug – Sept	2014	*Rhizoctonia*	January 2016
	STC, Yorkshire	Sept – Nov	2015	*Botrytis*	January 2016

Outdoor trials

Five replicated trials were conducted during 2012-2015. All the trials were conducted on commercial farms so they relied on natural pathogen invasion rather than artificial introduction.

Disease levels in crops varied between sites and seasons, as might be expected, but the predominant disease was downy mildew with *Sclerotinia* and grey mould occurring in some cases. Other pathogens, where present, were generally at low to trace levels only.

In *autumn 2012* downy mildew was the prevalent disease with *Botrytis* affecting plants secondarily. There were significant differences between treatments for the control of downy mildew and four of the treatment programmes looked particularly promising. Unsurprisingly perhaps, the most effective programmes for downy mildew control were based on products already approved for use on lettuce and included Fubol Gold (mancozeb + metalaxyl M), Revus (mandipropamid), Previcur Energy (fosetyl-aluminium + propamocarb hydrochloride) and Paraat (dimethomorph). There were no significant differences between treatment programmes for control of *Botrytis* or in terms of marketable yield.

In *spring 2013* a site with a history of *Sclerotinia* was used, including crop covers, to increase disease risk. There was a high incidence and moderate severity of *Botrytis* but only low levels of *Sclerotinia.* No downy mildew or ringspot developed in the trial. There was significantly more *Botrytis* in treatments that received Signum at the first application. Whilst the exact reason for this is unclear, it may relate to a slight phytotoxic response thus predisposing the treated plants to colonisation by this opportunist pathogen. As *Sclerotinia* levels remained low there were no significant treatment effects. Treatment 10, which contained products for downy mildew control at each application and HDC F151 in a tank mix at the second application, had a significantly lower incidence of *Botrytis* and a lower *Botrytis* severity than all the other treatments.

In *autumn 2013* downy mildew was particularly severe with over 70% leaf area affected by the disease in the untreated control at the harvest assessment. *Botrytis* was also present colonising plants secondarily. The most effective programme overall was Revus applied at all four application timings in combination with HDC F145 though unfortunately this is not a viable commercial programme. Amistar + Karamate / Previcur Energy / Infinito / Revus in a programme was almost as effective and provides a wider range of actives, beneficial for resistance management. This programme also included broad spectrum products (Amistar + Karamate) to help control *Botrytis* and other incidental pathogens. There were no significant differences between treatment programmes for control of *Botrytis*. There was though a trend for Switch, Karamate and Amistar at the T1 and T2 timings to improve control. Some treatment programmes significantly improved marketable head weight and average weight/head.

In *autumn 2014* useful information was gained on product efficacy and spray programmes for the control of downy mildew in a low disease situation. Downy mildew was the main disease in the trial. *Botrytis* and *Sclerotinia* were present and identifiable on the lower leaves; though no significant treatment effects were noted. The spray programme based on the previous trial results [Amistar (azoxystrobin), Karamate (mancozeb), Signum (boscalid + pyraclostrobin), Invader (dimethomorph + mancozeb), Infinito (fluopicolide + propamocarb hydrochloride), Fubol Gold (mancozeb + metalaxyl-M) and Revus (mandipropamid)] was one of the most effective treatments. The novel product F147 gave the overall best control of downy mildew. The use of biofungicides was also evaluated and, in this low disease situation, F145 gave equivalent control to the conventional fungicide Revus when applied as the fifth spray in a programme. Where another biofungicide (F188) was used there were 25% more heads affected demonstrating that whilst such products may have potential further understanding of their timing and placement is needed to inform their practical use in commercial programmes.

In *autumn 2015* the primary aim of the trial was to target downy mildew, but this pathogen failed to develop. Instead, due to the dry conditions, powdery mildew occurred and useful information on this target was collected. A total of eight products were investigated, each applied at full and half rate to compare their relative efficacy. The main disease present at harvest was *Botrytis*, with over 90% of plants affected in some treatments. As most treatments selected for this trial targeted downy mildew, they failed to provide significant control of *Botrytis* with no consistent treatment trends observed. With respect to powdery mildew, there were significant treatment effects with Amistar (azoxystrobin), Fenomenal (fenamidone + fosetyl-aluminium), F145 (experimental biological) and F145 + Revus (mandipropamid). The performance of F145 on powdery mildew on lettuce was promising within this project and this supports data collected in the SCEPTRE project (CP 077) on other crops.

In most of the outdoor trials pesticide residues remained below the limit of detection though, in the autumn 2015 trial residues were found two weeks after the final application timing for certain actives, with the majority of residues being from the dithiocarbamate products. None of the levels were above MRLs and most were detected at <5% MRL values, however this result does highlight the importance of the positioning of certain products in the spray programme.

Protected Trials

Five replicated trials were conducted during 2012-2015. The majority of the trials were conducted at STC though one trial specifically targeting *Sclerotinia minor* was conducted on a commercial nursery. Where trials were conducted at STC efforts were made to use the same glasshouse to build up soil inoculum levels and to manipulate pathogen occurrence through artificial inoculation. Disease levels in crops varied between seasons, as might be expected, but the predominant disease was downy mildew with *Rhizoctonia*, *Sclerotinia* and *Botrytis* occurring in some cases. Other diseases, where present, were generally at low to trace levels only.

The *autumn 2012* downy mildew and *Botrytis* infected the crop early and *Sclerotinia* developed at moderate to severe levels and artificial inoculation was not required. The level of *Rhizoctonia* in the trial was surprisingly low and ultimately *Sclerotinia* was responsible for most of the plant losses. There were significant differences between treatments for downy mildew, *Sclerotinia* and the number of dead plants in the trial. The standard commercial programme (Amistar/Fubol Gold/Teldor/Revus) provided the best control of downy mildew, but it performed poorly against *Botrytis* and below average against *Sclerotinia*. One of the commercial programmes (Fubol Gold/Signum/Switch/Serenade) provided the best overall control of the three pathogens that predominated. Encouragingly, three of the experimental programmes also performed well against these target pathogens. In terms of developing effective fungicide programmes to control such a broad range of target pathogens this first trial clearly demonstrated the challenges faced by growers.

In *spring 2013* downy mildew didn't develop in the trial crop though there were high levels of *Botrytis* and moderate levels of *Rhizoctonia* and *Sclerotinia*. In assessments it proved difficult to determine the primary cause of plant loss in some cases and, as such, the results require cautious interpretation. Amistar was included early in some programmes (primarily to control *Rhizoctonia)* for a comparative evaluation with Basilex pre-planting. There were significant differences between treatments for *Rhizoctonia* and *Sclerotinia* control at all assessments and these differences remained fairly consistent. Programmes that had Amistar, Fubol Gold and Paraat in common had significantly fewer dead plants at the end of the trial and a significantly greater number of marketable heads than the industry standard. These results suggest that by using these products in tank mixes at the correct timings, it should be possible to exclude the use of Basilex as a pre-planting treatment. Some low levels of pesticide residues were recorded at the end of the trial, but these were below the MRLs with the exception of HDC F152, which has an MRL in lettuce of 0.01 mg/kg (the limit of detection).

In *spring 2014* a commercial nursery with soil-borne *Sclerotinia minor* was used to evaluate a range of novel fungicides and biocontrol products and to determine whether products active against *S. sclerotiorum* were also effective against *S. Minor*. The trial included several straight fungicide treatments, both approved and experimental, as well as programmes based on both commercially available and experimental products. Contans (*Coniothyrium minitans*) was applied as a pre-planting treatment on its own and also before all of the treatment programmes. The QoI fungicides Amistar and Signum as straight applications provided most effective control of *S. minor*. However, when the same products were applied as part of a programme disease control was compromised. Further work is required to develop effective fungicide programmes where *Sclerotinia minor* occurs. Contans reduced *S. minor* slightly, but this was not significantly different from the untreated. A number of the experimental products also controlled *S. minor* well, though were less effective than Amistar or Signum.

In *autumn 2014* a lettuce crop at STC established well though disease symptoms were not noted until three weeks after planting. The main pathogen was *Rhizoctonia* which developed to severe levels and was responsible for extensive plant death. *Sclerotinia* infection was also moderate-high though whilst infection didn't arise until later (on the necrotic leaf margin tissues) the combination of these two aggressive pathogens killed many of the trial plants by the end of the study. Downy mildew ranged from 10% to 50% plants infected depending on treatment but the overall infection severity was low. *Botrytis* levels were very low, though may have been masked by the high levels of *Rhizoctonia* and *Sclerotinia*. Phytotoxicity occurred with T11 (HDC F159) but plants soon recovered and it wasn't considered sufficiently damaging to halt work with the product.

Control of both *Rhizoctonia* and downy mildew was good in the first two assessments with programmes containing a combination of Contans, Amistar, Fubol Gold, Paraat and an SDHI product e.g. boscalid (in Signum) and significant differences were apparent. However, by the later stages of the trial both *Rhizoctonia* and *Sclerotinia* levels were exceptionally high and many of the trial plants died due to disease. As such, there were no significant differences between treatments for any of the diseases assessed at crop maturity.

The most effective control of *Rhizoctonia* was achieved with spray programmes that included Amistar or an SDHI fungicide. This reflects the results seen in the spring 2013 trial.

Autumn 2015

The Autumn 2015 trial focused on downy mildew though, ironically, the disease was sporadic this season. A *Bremia* inoculated split plot trial used two (Cobham Green & Brian) to increase the risk from the disease. Yet, even after repeated inoculation, unfavourable weather prevented development of the disease until late in the trial period. In order to salvage some data the crop was retained for approximately 2 weeks beyond maturity.

No downy mildew was recorded on the commercial variety, Brian, demonstrating the importance of resistance genes incorporated into modern varieties. There was low to medium incidence of downy mildew on Cobham Green in the untreated plots and all of the treatment programmes provided effective control of the disease with very low incidence in some treatments, including where half rates had been applied. This potentially represents significant cost savings and should help reduce the risk of both residues and resistance risk. The incidence of *Botrytis* in cv. Cobham Green was medium-high, primarily affecting the outer leaves, but there were no significant differences between treatments. Incidence of *Botrytis* in the variety Brian was low-medium, only affecting lower leaves of the crop; again there were no significant differences between treatments. *Rhizoctonia* and *Sclerotinia* also occurred in both varieties, but at insignificant levels. It is interesting to note that whilst there were no significant differences in disease incidence or severity between treatments in the cv. Brian, there were significant differences in mean head weights at harvest. This could potentially relate to improvements in leaf greening or perhaps relates to the suppression of incidental soft-rot pathogens on the basal leaves in the crop.

Financial Benefits (Outdoor & Protected Crops)

- This project has demonstrated that reduced fungicide rates can potentially be used effectively in low disease (especially downy mildew) situations and at early spray timings for disease control and this not only helps in reducing spraying costs but can potentially also minimise residues at harvest and reduce resistance development to protect active substances for future use.
- Lower residue risk products, including biopesticides, can potentially be integrated into spray programmes in low disease situations but, in high disease risk situations it is important to maintain an effective preventative fungicide programme using manufacturer recommended dose rates. It is too early to determine if this would result in cost-savings to the grower but there could be other indirect benefits in this approach that could add value to the produce.

Action Points (Outdoor & Protected Crops)

- Make full use of cultivar resistance, where available, to reduce reliance on conventional fungicide application, especially for disease like downy mildew and avoid increasing selection pressure through use of monocultures where possible.
- Monitor crops regularly and consider disease risk carefully relative to prevailing climate locally and according to the weather forecast. Remember that for downy mildew

especially, it is important to apply products preventatively in advance of symptom expression for effective control.

- If weather conditions are conducive to disease i.e. cool & wet and there is known disease, especially downy mildew, in the area use products at the manufacturers recommended rates, choosing products particularly active against downy mildew. If other pathogens are suspected, include alternative products in the spray programme to broaden the spectrum of activity.
- If the weather is not conducive to disease consider reducing rates of application and using tank mixes to broaden the spectrum of activity of the spray programme.
- Be aware of the different mode of action groups for fungicides and avoid over-use of those regarded as moderate-high risk of resistance development. Either alternate or tank mix products from different mode of action groups to minimise any risk. For detailed information of fungicide groups and resistance risk see http://www.frac.info/docs/default-source/publications/frac-code-list/frac-code-list-2016.pdf?sfvrsn=2
- There are significant restrictions on the timing of application of some products e.g. dithiocarbamates so it is imperative these are used effectively early in crop development to minimise any risk of pesticide residues at harvest.
- Where there is a risk of other diseases consider using products with broad-spectrum activity (noting that most downy mildew products are specific to Oomycete organisms) and won't provide effective control of pathogens like *Botrytis, Sclerotinia & Rhizoctonia.*
- Whilst there is still much to learn about the use and effectiveness of biopesticides, some biological or low residue risk products can potentially be integrated into programmes to reduce residue risk and these are worth considering especially when disease pressure is not particularly high.
- In a low downy mildew disease year consider extending the spray interval between applications to reduce the overall number of sprays that may need to be applied to the crop. Conversely, during high disease pressure periods consider reducing the spray interval to maintain effective protection against key pathogens like downy mildew.
- In high disease pressure situations it would be inappropriate to use reduced dose rates or biological products; certainly without significant further research to better understand their range of protectant and/or curative activity.
- Finally, prior to use of any pesticides always ensure you have a copy of the relevant approval documents and that you have read and understood the requirements and

restrictions relating to their use. This is essential to provide adequate protection of spray operators, the crop, consumers and the environment more broadly.