Grower Summary

FV/PE 410

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

Annual 2014

Disclaimer

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.

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GROWER SUMMARY

Headline

- Some merit was found in reducing application rates of active ingredients when applied as various tank mixes, allowing broader disease control with a lower risk of pesticide residues at harvest and minimizing the risk of resistance developing in pathogen populations.
- Using products containing mandipropamid (e.g. Revus) provide an opportunity to control the races of *Bremia lactucae* that are resistant to metalaxyl-M, but broad spectrum programmes are needed to provide effective control of a range of potential pathogens in lettuce.
- Products effective against *Sclerotinia sclerotiorum* are also effective against *S. minor*.

Background

Downy mildew (caused by the pathogen *Bremia lactucae)* is responsible for most losses in both outdoor and protected lettuce. Soil-borne diseases, such as *Sclerotinia* and *Rhizoctonia* are also important and contribute to significant losses in some field and glasshouse crops, though interestingly the latter pathogen only appears to be problematic under protection. *Sclerotinia* causes severe head decay, especially near maturity whilst bottom rot (caused by *Rhizoctonia solani*) tends to affect the lower leaves in the crop that, when severe, can render affected plants unmarketable. Grey mould (caused by the pathogen *Botrytis cinerea*) is very often present on the oldest leaves and is usually removed during the normal harvest trimming, but in wet seasons heavy infections can reduce head weight as more leaves need to be removed.

The primary purpose of the project is to identify a range of novel fungicides and bio-control products with activity against the primary pathogens mentioned above but also taking due regard of any ‘incidental’ control of more minor sporadic pathogens including with the current approved products. The main aim is to evaluate a series of spray programmes which provide broad activity against key pathogens on the crop but which also provide a reduced risk of residues at harvest and which ensure minimal risk of resistance development, in the pathogen population.

Summary

The outdoor (ADAS) and protected (STC) trials were completed in autumn 2012, spring and autumn 2013 and spring 2014.

In the autumn 2012 outdoor lettuce trial there were 16 treatment programmes at four application timings and downy mildew was the prevalent disease with *Botrytis* affecting plants secondarily. Other pathogens, where present, were at low to trace levels only. As this trial site was on a commercial farm it was not realistic to artificially introduce the pathogens so we were reliant on natural infection occurring via soil or airborne inoculum. There were significant differences between treatments for the control of downy mildew. Four of the treatment programmes looked particularly promising. Encouragingly, 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. All pesticide residues remained below the limit of detection.

The autumn 2012 protected trial was done in a glasshouse at STC which had been used previously for lettuce disease trials and it was known to have moderate to high levels of fungal pathogens, especially *Sclerotinia* and *Rhizoctonia,* already present in the soil. In this trial there were 12 treatment programmes at four application timings. The treatments included an untreated, an industry standard, four commercial programmes, four experimental programmes, a straight conventional experimental (coded) active and a straight biological experimental (coded) product.

Downy mildew and *Botrytis* infected the crop early and *Sclerotinia* developed at moderate to severe levels, therefore no artificial inoculation, was required as expected. However, somewhat surprisingly, the levels of *Rhizoctonia* recorded during the cropping period were low, given the previous cropping, known problems with *Rhizoctonia* bottom rot and absence of soil sterilisation. Evidently, either the infection conditions for this prevalent pathogen were significantly below optimum or perhaps some antagonist had knocked the *Rhizoctonia* population down.

There were significant differences between treatments when assessed for downy mildew, *Sclerotinia* and the number of dead plants at each assessment date. There were no significant differences between treatments when assessed for *Botrytis* or *Rhizoctonia*. *Sclerotinia* was responsible for most of the plant deaths.

In terms of developing effective fungicide programmes to control such a broad range of target pathogens this trial has again amply demonstrated the challenges faced by growers. For example, the treatments that performed best for control of downy mildew did not perform well against *Sclerotinia* or *Botrytis*. The treatments that performed best for control of *Sclerotinia* were relatively poor for downy mildew or *Botrytis* control and the treatments that were most effective against *Botrytis* were less effective against downy mildew or *Sclerotinia*. Therefore, in order to deliver a broad and effective treatment programme, it is appropriate to develop either tank mixes with different active ingredients (included at reduced rates to keep overall costs and residue levels down) to maintain broad spectrum protection throughout or to tailor the fungicide programme based on prevailing climatic factors and relative to disease risk at specific times of year.

In this protected lettuce study, 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 present in this study, and three of the experimental programmes performed reasonably well against all target diseases also. As disease levels, predominantly *Sclerotinia*, in the glasshouse were so high by the end of the trial most of the plants in each plot had died or were severely diseased, so there were insufficient heads for samples to be taken for residue analyses.

Lab-based screening tests with novel active ingredients, including new SDHI's, for activity against oomycetes such as downy mildew, *Botrytis*, *Rhizoctonia*, *Sclerotinia sclerotiorum* and *S. minor* identified a number of active ingredients capable of inhibiting pathogen growth. Many of the SDHIs provided good to excellent inhibition of *Rhizoctonia* and *Sclerotinia*, but perhaps surprisingly, were less effective against *Botrytis* in this lab based study. Some products inhibited *Botrytis* growth as well as *Rhizoctonia* (iprodione e.g. Rovral) (Figure 1 (a) & (b)), and *Sclerotinia* (prochloraz e.g. Octave) (Figure 1 (c) & (d)). HDC F158 inhibited all three pathogens, but was most effective against *S. minor*. Fungicides containing metalaxyl and dimethomorph provided good inhibition of *Phytophthora*, an oomycete organism used to represent *Bremia* which cannot be cultured *in vitro*. Infinito (fluopicolide + propamocarb hydrochloride) also inhibited oomycete growth well. Alternatives to metalaxyl are needed as resistance to this active in downy mildews is well documented.

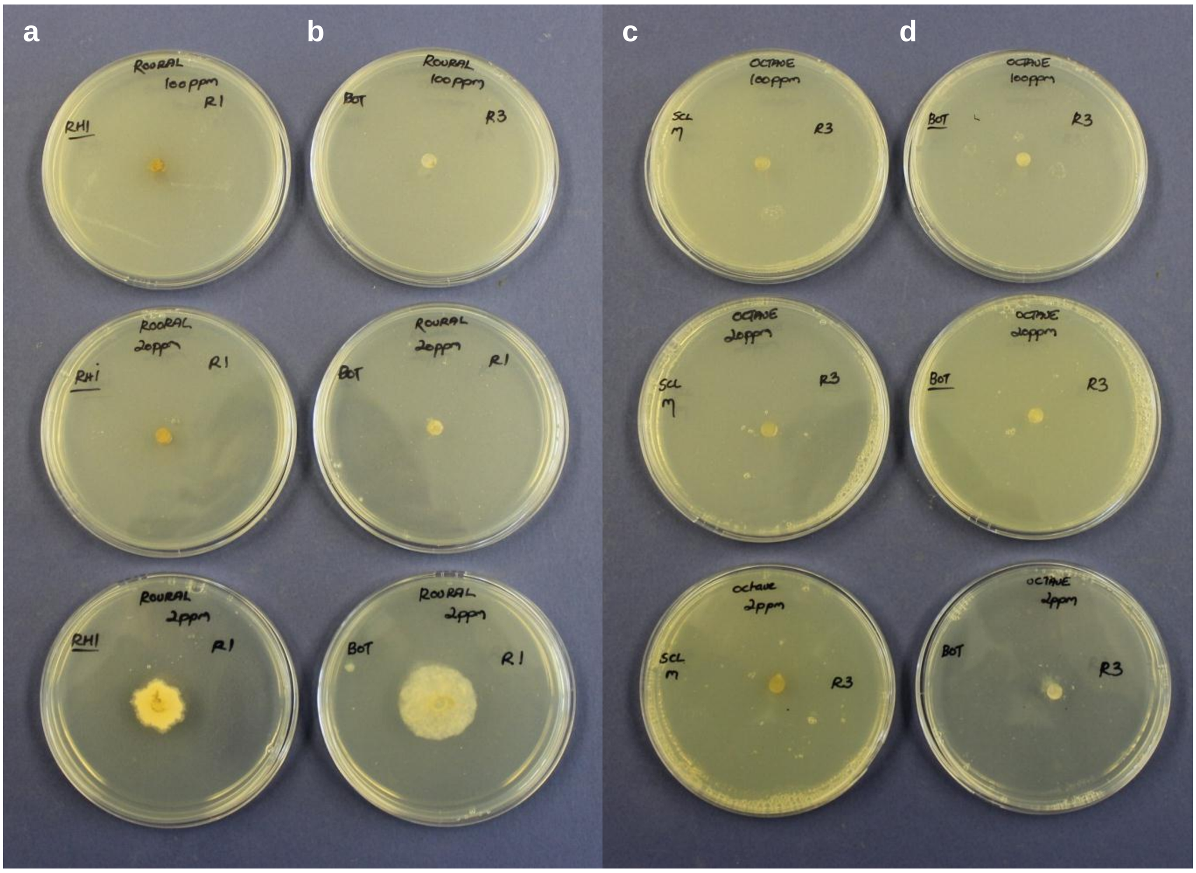

Figure 1. (a) Inhibition of growth of *Rhizoctonia* mycelium on agar plates by iprodione (e.g. Rovral). (b) Inhibition of growth of *Botrytis* mycelium on agar plates by iprodione (e.g. Rovral). (c) Inhibition of growth of *Sclerotinia* mycelium on agar plates by prochloraz (e.g. Octave). (d) Inhibition of growth of *Botrytis* mycelium on agar plates by prochloraz (e.g. Octave). The highest concentration of product (100ppm) is at the top of the photograph, followed by 20ppm in the centre and the lowest concentration (2ppm) is at the bottom.

A commercial crop of iceberg lettuce cv. Robinson was used for the spring 2013 outdoor trial. Pathogen infection was by natural occurrence, and the likelihood of infection was increased by using a field with a history of *Sclerotinia* and crop covers during the early part of the season because of the cold spring. There were 16 treatments combining tank mixes and single product applications. Four post-planting treatment applications were made. There was a high incidence, and moderate severity of *Botrytis* in the trial, and low levels of *Sclerotinia*. No downy mildew or ringspot were recorded in this 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. *Sclerotinia* disease levels were low and no treatment differences were significant. 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. No pesticide residues were detected in any of the samples and all remained below the limit of detection.

In the spring 2013 protected lettuce trial there were 12 treatment programmes including an untreated control (Figure 2). Four post-planting application timings were planned, but only three could be made as the crop matured quickly. The treatments included an untreated, an industry standard, two commercial programmes, four experimental commercial programmes and four experimental (non-commercial) programmes. Many of the programmes included Amistar early in the programme, primarily to control *Rhizoctonia* so that they could be compared to the use of Basilex pre-planting used as an industry standard treatment. The programmes in this trial were designed to see how late fungicide applications could be made before harvest without incurring residue exceedances. Currently the majority of the fungicide applications are made in the first three to four weeks after planting, potentially exposing the crop to pathogen risk later which could make heads unmarketable. Growers are cautious of applying fungicides close to harvest because they do not wish to exceed maximum residue limits (MRLs). These programmes were designed to space out the number of applications to give better control of fungal pathogens from planting to harvest and, by using half rates and tank mixes thus trying to minimise residues at harvest. Unfortunately, due to a spell of hot weather, the crop matured faster than expected and the final treatment applications could not be applied. The crop had to be harvested before the minimum recommended harvest intervals had been reached for many of the products. This enabled data to be gathered on whether reducing application rates also reduced residues at harvest.

The variety used was a butterhead lettuce of cultivar Tahamata (Rijk Zwaan). To increase the chances of infection by the target pathogens, the trial was done in a glasshouse which had been used in the past for lettuce disease trials and it was known to have high levels of fungal pathogens, especially *Rhizoctonia* and *Sclerotinia*, already present in the soil. In view of the unexpected low incidence of *Rhizoctonia* in the previous trial, *Rhizoctonia* was artificially introduced by inoculating the soil pre-planting. *Bremia lactucae* was artificially inoculated by applying a spore suspension to six plants per plot on two occasions during the trial. However, neither inoculation with *Bremia lactucae* established in the crop. *Botrytis cinerea* occurred naturally, without artificial infection.

Some treatment programmes included pre-planting applications 24 days prior to planting. The first foliar applications were carried out 2-3 days post-planting, with other applications made at 14 day intervals.

Figure 2. Spring 2013 protected trial at STC showing plots in the foreground that suffered from severe *Sclerotinia* and *Rhizoctonia* infections.

No *Bremia lactucae* was observed in the trial. There were high levels of *Botrytis* and moderate levels of *Rhizoctonia* and *Sclerotinia*. The presence of *Botrytis* was not consistent from one assessment to the next, and although there were significant differences between treatments in the first and last assessments, these differences were not repeated in both assessments and we suspect this might relate to the difficulty in differentiating between damage caused by the various pathogens on the same plant. Botrytis incidence in the untreated control was low, but may have been masked by the high levels of *Rhizoctonia* and *Sclerotinia* present. There were significant differences between the levels of *Rhizoctonia* and *Sclerotinia* at all assessments and these differences remained fairly consistent from one assessment to the next. There were low levels of bacterial rot to the lower leaves recorded at harvest.

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 anyway (the lowest limit of detection). Considering the crop was cut before the minimum harvest interval, the policy of using half rates in tank mixes has meant that products could potentially provide an alternative approach to maintaining disease control without necessarily increasing the risk of unacceptable residues at harvest. Naturally it would be necessary to have further discussion with CRD in this regard to ensure any applications made are within the legal framework. If not it may be possible to change this with appropriate data.

Treatment 3 (Commercial) – (Contans / Amistar / Fubol Gold / Paraat), treatment 6 (experimental commercial tank mixes) - (Amistar + Fubol Gold/ Signum + Switch/ Paraat + Rovral), and treatment 7 (experimental commercial tank mixes) - (Amistar + Fubol Gold/ Signum + Paraat) resulted in significantly fewer dead plants at the end of the trial than the industry standard. There were differences in the disease severity between these treatments and the standard, but these were not significant. The mean head weight for these treatments was slightly below that recorded for the standard programme, but not significantly so. The number of marketable heads was significantly greater in these treatments than in the standard (Figure 3). All three programmes had three products in common: Amistar, Fubol Gold and Paraat. Interestingly in agar plate tests azoxystrobin, the active ingredient of Amistar, did not provide good inhibition of *Rhizoctonia* and *Sclerotinia*, but it is known that some products provide additional activity *in vivo* e.g. the 'turning on' of host defence systems or leaf greening and these effects are not measurable during *in vitro* studies. Contans, which provided good inhibition of *Sclerotinia* in *in vitro* tests, may have helped control *Sclerotinia* in Treatment 3 and Signum, which provided good inhibition of *Rhizoctonia* and *Sclerotinia* in *in vitro* tests, may have helped to control these diseases in treatments 6 and 7, but it was not applied until later in the treatment programmes, as was Rovral in treatment 6, which does not explain why very low levels of these pathogens were recorded in earlier assessments. Treatment 7 only received two treatment applications in total, and yet was one of the best performing treatments. It seems possible that there may be an interaction between Amistar and Fubol Gold, when made as an early application, which is controlling these pathogens more effectively. These results suggest that by using these products in the effective tank mixes at the correct timings, it may not be necessary to use Basilex as a pre-planting treatment. As no *Bremia* infected the trial it is not possible to evaluate the performance of Fubol Gold, although in the field trial it performed well at controlling the pathogen in treatment programmes that also included Amistar. Such mixtures or alternating programmes will continue to be important to reduce the risk of resistance in the *Bremia* population. Paraat was also used in the field trial programmes and provided quite good control of *Bremia*, although not as good as Fubol Gold.

Figure 3. Spring 2013 protected trial: standard treatment (left) compared to treatment 7 (right). Photos taken at harvest and heads turned over to show condition of lower leaves.

None of the experimental programmes evaluated performed as well as the standard or any of the commercial programmes. Whilst this is disappointing, it does suggest that it may be possible to control these important pathogens using existing approved products available to growers without the necessarily waiting for new products to be registered and approved.

The autumn 2013 outdoor lettuce trial was a stern test of fungicide efficacy on downy mildew with over 70% leaf area affected by the disease in the untreated control at the harvest assessment. This trial included 16 treatment programmes applied at four application timings and downy mildew was the prevalent disease with *Botrytis* affecting plants secondarily. The most effective programme overall was Revus applied at all four application timings in combination with HDC F145 (22.5% leaf area affected), however this would not be possible to complete in commercial situations as Revus is only approved for 3 applications. Amistar + Karamate / Previcur Energy / Infinito / Revus in a programme were nearly as effective (22.8% leaf area affected) and represent a wider range of actives which is beneficial for resistance management and also contain broad spectrum products (Amistar + Karamate) to help control Botrytis and soft rots which are high risk after transplanting.

There were no significant differences between treatment programmes for control of *Botrytis*. However there was a trend for Switch, Karamate and Amistar at the T1 and T2 timings to improve control. Significant differences between some treatment programmes for marketable trimmed head weight and average weight per head were recorded after harvest. All test pesticide residues remained below the limit of detection.

The protected trial, carried out in spring 2014, focused on *Sclerotinia minor* and included several straight fungicide treatments, both approved and experimental, as well as programmes based on approved products and experimental products. Contans was applied as a pre-planting treatment on its own and also before all of the treatment programmes. Four post-planting treatment applications were made for each of the straight product applications, but the number of post planting applications varied for the programmes.

In the first assessment, after two treatment applications, there were no visual signs of *S. minor*, although there were some heads affected by virus symptoms, the predominant one being Lettuce Big Vein Disease. Both viruses associated with this disease (*Mirafiori lettuce big-vein virus* or MiLBVV and *Lettuce big-vein associated virus* or LBVaV) are transmitted by the fungus-like organism *Olpidium brassicae*, so incidence of big vein symptoms was recorded in the first and final assessments. However, there were no significant differences between treatments for incidence of this disease.

Amistar and Signum provided best control of *S. minor* (Figure 4). Further work would still be required on how to incorporate these into an effective programme as the programme containing these two products controlled *S. minor* significantly better than the untreated, but not as well as Amistar or Signum alone.

One pre-planting application of Contans reduced the incidence of the disease, but this was not significantly different from the untreated. The experimental products controlled *S. minor* well, better than the programmes, but not as well as Amistar or Signum.

As the majority of the treatments in this trial were repeat applications of the same product, to evaluate each product's individual efficacy, which is not standard practice, the MRLs would have been exceeded, so no residue data were recorded.

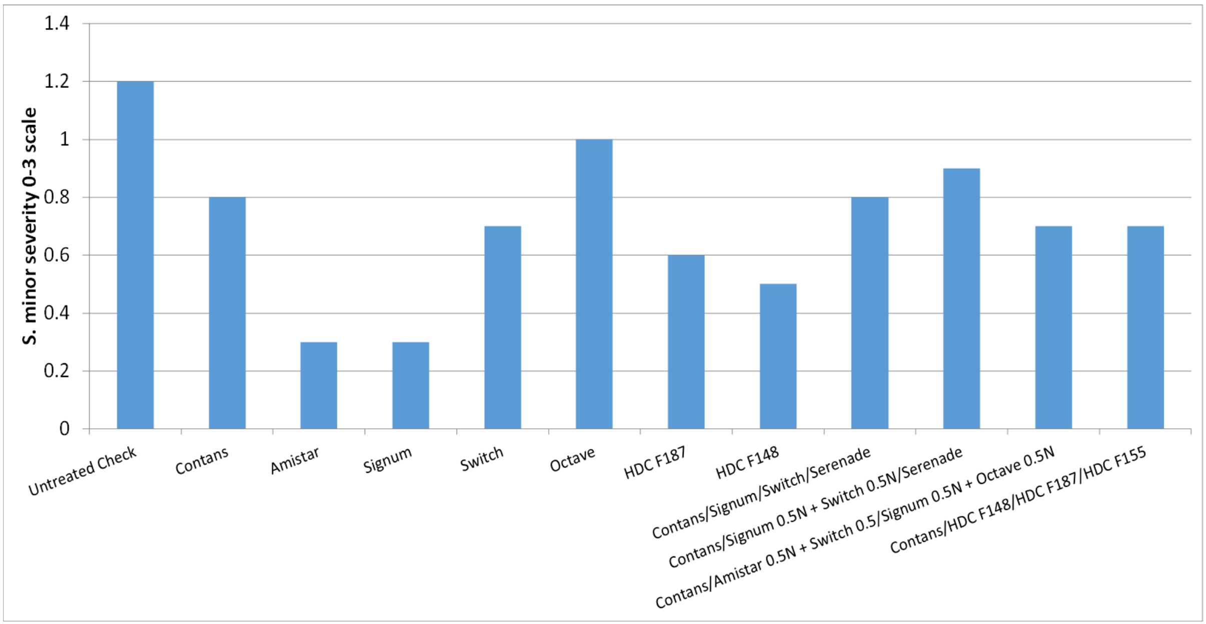

Figure 4. Severity of *Sclerotinia minor* at harvest in a trial in a commercial lettuce crop on grower holdings

Financial Benefits

Some useful initial benefits of the project work are the indication that a reduced number of treatment applications could be made per crop by improving timings of application. The use of effective tank mixes of products at reduced rates means that disease control can be maintained and products could potentially be applied closer to harvest. This could result in cost reductions for products and application time and a concomitant reduced risk of resistance development. As fungicides could also be applied closer to harvest, crop losses could also be reduced therefore increasing the economic yield. Further work would be required to ensure such uses stay within the regulatory framework.

Action Points

- Use specifically designed spray programmes, using already approved products, taking into account:
    - the likely risk of specific pathogens at the time of year
    - the type/cultivar of lettuce grown and the particular resistance/susceptibility rating
    - the cropping history of the site
- There is potential to use reduced application rates of products either in tank mixes or as alternating spray programmes to target two or more pathogens simultaneously. Prior to doing this it will be important to check the regulatory situation especially in

relation to applications closer to harvest as several products have specific restrictions relating to latest time of application.

- There are good products available for the control of downy mildew in outdoor lettuce and products containing mandipropamid (e.g. Revus) could be effective against strains resistant to Metalaxyl-M.
- For those growers with *Sclerotinia minor* problems, products effective against *S. sclerotiorum* can be used to control the organism without resorting to soil sterilization measures.