Grower Summary

FV 307a (HL 01102)

Reducing herbicide use in row crops with targeted application methods treating detected weeds in small patches or spots

Final year

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.

Further information

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

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HDC is a division of the Agriculture and Horticulture Development Board.

The following are members of the Consortium for LINK project HL 01102:

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Project Number:	FV 307a
Project Title:	Reducing herbicide use in row crops with targeted application methods treating detected weeds in small patches or spots
Project Leader:	Professor Paul Miller
Report:	Final Report
Publication Date:	July 2013
Start Date:	01 April 2010
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Project Cost (total project cost):	£70,000

Headline

- A new automated system has been developed to detect and control individual and patches of weeds with low levels of crop damage at commercially acceptable rates

Background

EU legislation (e.g. the revision of 91/414 EEC, the EU Thematic Strategy on the Sustainable Use of Pesticides and the Water Framework Directive) has been and is continuing to reduce herbicide availability - the limited range of herbicides remaining does not adequately cover the weed spectrum encountered in horticultural crops and for some weed species there is, or soon will be, very reduced or no approvals for using selective herbicides. There are very few new herbicides in the pipeline, even for cereals. This is a particular problem for horticultural crops because high quality is required and growers cannot risk leaving weeds if it could result in crop rejection, loss of product quality and of income.

Mechanical weed control is now more widely practised, but there are a number of circumstances when these methods are unsatisfactory – in wet weather, and for control of perennial weeds and species with a strong tap root. Chopping up roots of some target weeds such as creeping thistle may exacerbate the problem. Repeated cultivations may also have adverse effects on the environment both in terms of energy use and greenhouse gas emmissions. Flame and steam weeding are damaging to invertebrates and consume large amounts of energy. Hand labour has now become expensive and scarce.

Targeted application of herbicides to weeds that are difficult to control mechanically is an attractive option potentially providing good control with minimum chemical quantities and thus a low cost and environmental impact. Systems for guiding precision banded applications including band spraying are commercially established although only limited work has quantified the spray distribution in narrow bands (see Lund and Jensen, 2002) and the sharpness of the cut-off at the edge of the band.

Previous work has been successful in developing an image analysis based weed detection system linked to a spot spray control mechanism. This system was initially developed around the specific problem of treating volunteer potatoes within onion, carrot and parsnip crops. Discrimination of live plant material from background was on the basis of colour and a number of criteria were used to determine if plant material was crop or weed. As implemented during field trials conducted in 2009, these criteria included; distance from crop row (located using a band-pass filter), feature size (volunteer potatoes tend to be larger) and feature shape (overall aspect ratio rather than leaf profile).

The experimental rig developed in the previous LINK project used a new fluidic nozzle design to generate very large droplets (>1000 μm in diameter) that were applied to detected weed targets to give levels of control in field trials of typically 90 to 95% of volunteer potato plants within the selected size range at the time of treatment.

While the spot treatment of detected weeds in row crops offers to deliver large savings in herbicide use and maintain good levels of control, there are implications for product approvals where existing approvals or EAMU's are not relevant. For this, and reasons associated with offering greater flexibility and weed control options in a wider range of conditions, there is a need to examine the use of the approach with:

- All major formulation types;
- A wider range of weed species;
- A wider range of crops.

The major deliverable from this project has therefore been the basis for the design and operation of a commercially viable unit for detecting individual large weeds that can be treated by spot application or patches of smaller weeds that can be patch sprayed particularly in onion, leek and sugar beet crops. The techniques developed will have application to other crops, particularly carrots and parsnips, and a key component of the work has been to develop a system that will operate with a wide range of herbicide formulations.

Summary of the project and main conclusions

This LINK project has built on the results from a previous LINK project (Miller et al., 2010) that specifically addressed the issue of controlling volunteer potatoes in crops of onion, carrot and parsnip and demonstrated the feasibility of detecting and applying a targeted herbicide dose to such targets.

The current project aims to extend the approach developed in the earlier work so as to:

- Enable a wider range of formulation types to be used;
- Address a wider range of target weed species in a wider range of crops particularly onions and leeks;
- Have the ability to treat patches of weeds as well as using spot applications directed at single weeds.

An existing field rig was modified for use in field trials that were conducted as part of this project.

A new nozzle cartridge system was designed in the first year of this project and successfully developed and used in field trials during the second season of the project work. The cartridge unit enables one of two nozzle tip designs to be fitted, namely:

(a) a version of the "Alternator" nozzle design creating very large droplets appropriate for treating large weeds with spot applications;
(b) an "Even-spray" tip generating a medium/fine quality spray appropriate for treating small weeds (e.g. grass weeds at an early stage of growth) when detected as patches in row crops.

The decision to develop the cartridge approach with two nozzle tips was taken after measurements with different nozzle designs in the first year of this project showed that it was not possible to achieve the range of spray characteristics needed for both spot and patch application from a single nozzle design. Further measurements of the droplet size distributions from both the "Alternator" and "Even-spray tips were made in the second year of the project and confirmed that the "Even-spray" tip would create a fine spray at pressures above 3.5 bar. Some problems with leakage between components of the cartridge assembly were identified during the work in the second season of the project and addressed by re-molding some parts in a different, more compliant, plastic material.

A review of the options for controlling spray movement from nozzle to target concluded that, for spot application, the use of large droplets delivered with a controlled trajectory was the best option. For application to patches where a medium/fine spray quality is needed, less control may be needed when selective herbicides are applied and trajectory control is probably still the most appropriate. Studies in this second year of the work investigated the potential for crop contamination by splash and concluded that for most formulation types the addition of components to modify the physical properties of the spray liquid (e.g. viscosity) was not justified.

A new solenoid valve developed during the first year of the work in conjunction with the valve manufacturer proved to be significantly more reliable when used with emulsion based formulations than the version used previously and which was specified for water soluble formulations such as glyphosate.

Weed detection algorithms have been developed throughout the life of the project based on increased field experience. Work in the first year of the project developed an algorithm for weed patch detection in vegetable crops based on determining a green area index for the inter-row region. Options for discriminating weeds based on sensing height were also examined. Work in the second year specifically involved the development and construction of a stereo camera system particularly for the detection of weed beet by height discrimination. Preliminary analysis of image pairs collected in field conditions have gave promising results, but the stereo analysis algorithms will require further refinement if the technique is to progress to a practical sensing technique. Assessments of the performance of the weed patch detection algorithm were conducted in a crop of rape established with a wide (500 mm) row spacing in year two of the project and in a sugar beet crop in year three.

Field experiments conducted during the project:

a) Confirmed that high levels of control (>90%) of large weeds such as volunteer potatoes in onion and leeks could be achieved by spot application of selective and non-selective herbicides. Non-selective formulations gave a more rapid and complete weed kill with acceptable levels of crop damage.

b) Showed that spray deposits on target weeds treated by spot application were at least an order of magnitude greater than on crop plants in the vicinity of treated weeds from assessments made in the onion crop in the 2011 season and in leeks in the 2012 season.

c) Confirmed that the experimental rig, in its final configuration, was able to operate in a wide range of crop conditions with different herbicide formulations and mixtures relevant to the treatment of a range of weed species as spots or small patches.

d) Showed that herbicide residues in leek crop plants in the immediate vicinity of weeds targeted in spot treatment applications were below the level of detection at the time of harvest confirming provisional results from a previous project in onions, carrot and parsnip crops.

e) Investigated the treatment of weed beet by simulating spot application to the base of a detected plant deflected forwards by a rubbing bar. Results from this work showed that variable levels of control were likely with no correlation between the response to the application and weed size and the amount of leaf at lower levels on the weed.

A key factor influencing the commercial uptake of the system relates to the regulatory position concerning herbicide use. Discussions held with The Chemicals Regulation Directorate as part of project work and followed up by staff from The Horticultural

Development Company have resulted in an EAMU relating to spot application in a range of vegetable crops being issued.

Financial Benefits

A cost benefit analysis has been made based on experimental data, knowledge of engineering costs and general farm economic information derived from Nix (2011)) and partner growers. It is assumed that the precision spraying technology developed in this project would be implemented as an additional capability to a vision guided band sprayer. This is important economically as it allows the machine to be utilised for a larger proportion of the season than would be the case if its only function was the control large broadleaf weeds. Three different scenarios are compared for each of the three crops covered in this project. The proposed new strategy using a combination of spot, band and overall spraying compares favourably (18% saving) with the current weed control strategy in leeks and indicates a 40% saving over the projected situation in 2015. The situation in onions is similar to that of leeks except that the current herbicide situation is slightly better in onions and so there generally no need for inter-row cultivation which is a relatively expensive operation. The new strategy represents a 1% saving over the current situation and a 40 % saving over the projected situation in 2015.

Action Points

The project has developed and validated the technology necessary for the production and operation of a commercial prototype system for the detection and treatment of large weeds by spot application and patches of weeds using patch spraying approaches. It is expected that the commercial partners involved with the project will now develop commercial prototype machines for evaluation by growers in response to demand for such systems.