Project title:	Vining and podded peas: control of potatoes by vision guided spot spraying
Project number:	FV 307b
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Location of project:	Boston
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The results and conclusions in this report are based on an investigation conducted over a two-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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GROWER SUMMARY

Headline

Timely vision-guided spot applications of glyphosate to volunteer potatoes in vining peas can avoid labour-intensive and costly removal by hand (£60/ha) to ensure a contaminant-free product.

Summary

With the loss of various chemical products over the years the control of volunteer potatoes is of great concern to those who are involved in vining pea production. Excessive levels of potato plant parts or the berries they sometimes produce are not tolerated by processors and can cause loads to be rejected by the factory. Presently available chemical control may cease to be an option in the relatively near future. With limited chemical control and a reliance on labour intensive and expensive hand pulling of potatoes from vining peas, the crop may well become uneconomic for some to continue growing.

Use of the guided weeder to spot apply glyphosate showed some promise. Effective targeting of potatoes was seen in crops grown with a row spacing from 25 to 15cm (in year 1). As row width reduces, the window of opportunity to use the equipment successfully is reduced. Work in the commercial crop (12.5cm row spacing) in year two has highlighted the fact that emergence of the potatoes with, or ahead of the emerging peas is vital for effective targeting of potatoes and subsequent control. Unfortunately season to season this may not happen and potato emergence can continue after canopy closure when detection by the machine becomes impossible.

The spot application of glyphosate remains a welcome option and the study has successfully illustrated the potential of the equipment and generated data to help achieve EAMU approvals for the use of two glyphosate products in vining peas using this technology. The equipment needs to be effective and permitted in as many on-farm crops as possible so that the cost of purchase can be spread making the technique more economic.

Background

Vining peas occupy between 26-30 thousand hectares in the UK and have crop value of £41M. Crop production is a mechanised and carefully planned operation so that the processing factory receives a continuous supply of vined peas which, for freezing, often takes place within 150 minutes of vining. Each crop load received at the factory is sampled for quality which includes an assessment of extraneous vegetable matter (EVM). Many varieties of potatoes produce berries and these can contaminate the vined peas during harvesting. Potato berries are toxic and their presence in a delivered sample of peas to the factory results in rejection of the whole load.

A survey carried out in 1992, showed that 20.2% of vining peas were affected by volunteer potatoes. This was an increase on data produced in a similar survey in 1974 and although a more recent survey has not been undertaken, there is no evidence of a reduction in potato incidence in vining peas at the present time.

Processors must exercise due diligence to avoid contaminants in produce. Potato berries and all parts of the plant contain toxic glycoalkaloids and are therefore one of the most serious vegetable contaminants. Potato berries are similar in shape size and colour and density to vined peas and they may pass through all the processes in the factory up to final inspection. Removal of low levels of contaminants is sometimes possible with 1 or 2 passes through an electric eye colour sorter and frozen peas can be re-sorted at an additional cost. However this is not possible for peas for canning. Such removal processes add additional processing costs and the loss of good peas is inevitable. If the contamination is too high, the produce is rejected.

Control of volunteer potatoes in the field is difficult to carry out in practice. Herbicides applied after drilling and pre-emergence have the potential to suppress the growth of the volunteers (imazamox + pendimethalin) but the effect can be reduced where the potatoes emerge from depth. Post-emergence broad leaf herbicides are ineffective in either suppressing potato growth or suppressing flower and berry developments. Currently an EAMU is in place for the application of flumioxazin which gives some control of potato foliage and subsequent flowers but application is very dependent on weather conditions after application and the active ingredient is scheduled for withdrawal. There is often little opportunity for cultural control before peas are planted and the final chance of reducing possible contamination is by hand weeding at a cost of £60/ha.

Recent and current work in leeks, onions and carrots demonstrated the potential for a vision-guided sprayer which delivers a small amount of glyphosate precisely to the targeted volunteer potatoes. The ideal time for such an application is when the potato plants can be identified within or between the crop rows. Vining peas are often grown at row widths which will often be too narrow to provide a sufficiently long window prior to canopy closure at which point detection becomes impractical. However if such a system is effective then a widening of these row widths would not be impracticable for large scale pea growing.

This project was designed to evaluate the potential for the use of the guided weeder in vining peas. It was proposed and agreed, in the final year to extend the trial in commercial crops of vining peas.

Since July 2014 there have been two EAMU's for glyphosate use in vining peas.

Conclusions

At the moment there is an effective selective chemical material which can be used to control volunteer potatoes in vining peas post crop emergence. The approval of the effective materials used in the past was withdrawn some years ago and this is the likely fate of the current option (flumioxazin). Work in onions, carrots and leeks has demonstrated the usefulness of the vision-guided sprayer which delivers a low dose of glyphosate precisely to target. The potential benefits of applying this method to vining peas may help alleviate the difficulties involved in control volunteer potatoes.

With the availability of a glyphosate control option, a reduced acreage of vining peas will have to be hand-weeded to remove potatoes. This may introduce significant cost saving to growing vining peas where potatoes are an issue. Removing potatoes by hand is an option but is expensive (£60/ha), time-consuming and the level of success achieved is dependent to some degree on the individuals 'walking' the field. Having to pay this added cost increasingly regularly will make many growers seriously consider whether producing vining peas is economical.

The ability to use targeted glyphosate applications via the vision-guided spot weeder look as though they would give growers a useful option in some situations and help protect UK vining pea production.

Financial Benefits

Worst case scenario:

In a relatively short space of time, the inability to control volunteer potatoes would cause widespread crop rejection due to increased contamination issues. This could lead to a collapse of the £41 000 000 UK vining pea industry. The availability of a feasible chemical option could avoid this.

At best scenario:

Vining peas are an expensive crop to grow with seed costing up to £1000/tonne. This combined with pesticide inputs and the costs associated with the logistics of the harvesting operation could mean the increased need and cost of removing potatoes regularly by hand (£60/ha) may well make production unfeasible for many. It is predicted by industry this could reduce the UK acreage by perhaps 30% (7-10000 hectares).

Action Points

With successful applications and approvals for both Roundup Energy (20141672) and Roundup Flex (20141671) via EAMU's, growers are now able to consider the option of a guided spot application.

Growers could see a benefit from growing vining peas on wider spacing. This would leave the crop open for a longer period of time and give a longer 'window' of opportunity for guided spot applications using these products.

SCIENCE SECTION

Introduction

Vining peas annually occupy between 26,000-30,000 hectares in the UK and have a crop value of £41M. Crop production is a mechanised and a carefully planned operation so that the processing factory receives a continuous supply of vined peas. Each crop load received at the factory is sampled for quality which includes an assessment of extraneous vegetable matter (EVM). Many varieties of potatoes produce toxic berries which can contaminate the vined peas during harvesting. Too many berries present in a delivered sample of peas to the factory results in rejection of the whole load. The ability to control volunteer potatoes economically and effectively is crucial to maintain a viable, long-term vining pea industry in the UK. This work was designed to test the feasibility of using a vision-guided weed-control system to accurately target potatoes in the crop and deliver an effective dose of glyphosate.

Materials and methods

Hippee vining peas were drilled on 19th May 2014 as per commercial practice on row spacing of 12.5cm.

General crop husbandry was carried out following good agricultural practice.

Site: Holbeach Hurn, Worths Farm.

OS grid reference: TF 393 293

Soil type: Silt clay.
Glyphosate applications made 6th June 2014.

Crop growth stage: 101-102 (1 to 2 leaf pairs)
As the natural population of volunteer potatoes at the site began to emerge a plot of 120m x 6m was marked out. Within this a representative population of volunteer potatoes was developing. The targeted glyphosate applications were made in this area. Equipment was set up and dye applications were made elsewhere in the same commercial crop.

For the work in 2014 the 6m version of the guided weeder was used as opposed to the 2m configuration that was used for the plot work in 2013.

The vision-guided weeder was adjusted to spray 100 % of the detected area of each potato plant when travelling at a speed of 4 km/hr.

Following the application of the dye solution (Green S at 2 g/L in tap water) 25 potato plants were identified at random. Pea plants within a 15 cm radius of each potato plant were cut at ground level and bagged. The selected potato plants were also cut at ground level and bagged separately. Samples of the tank mix were also taken as a reference for deposits recovered from the plant material. Plant samples were taken back to the laboratory, weighed, then, washed in a known volume of liquid, and the quantity of tank mix deposited onto each pant sample was determined using spectrophotometry to a defined protocol. The data was then analysed to determine the amount of dye on the target potato compared to any contamination of the immediately adjacent crop.

Finally an application approximating to 4.0 l/ha Roundup Flex (glyphosate) in 200 l/ha water was made to potatoes in another plot. After potatoes were marked with coloured stakes and photographs used to monitor the effects on both the potato volunteers and crop.

Although conditions were dry there had been rainfall the previous day and was recorded at the local weather station the following day.

Results

The work in 2013 (Year 1) had shown that it was feasible to use the vision guided equipment to control volunteer potatoes in vining peas as long as potato emergence was early.

This was illustrated again in 2014 work. Fig 1.

Fig 1. Early potato emergence means good size difference for effective targeting.

The 12.5 cm row width for the 2014 commercial crop was narrower than the previous row widths tested (2013) and consequently more challenging for the vision guided equipment.

During application of the dye it was noticed that on occasion a proportion of the dye would be deposited both on the target and on the ground adjacent. Fig 2.

Fig 2. Dye both on the ground and on the potato.

As the pea crop was at a very early stage of development the dye which was off target didn't land on as many surrounding pea plants as might have been expected.

The results in table 1 - 3 show that reducing the row width down to 12.5 cm compared to the 20 and 25cm row widths used in 2013, increases the amount of spray intercepted by the pea crop. Peas are not tolerant of glyphosate applications and whether they receive a large or small dose inevitably means plant loss. However at this early stage of pea development a loss of a small number of plants is unlikely to significantly affect yield.

The results show a clear increase of spray interception by the volunteer potatoes using wider widths of 20 and 25cm as were used in 2013 compared to the 12.5cm row widths used in 2014. The wider rows allowing a greater inter row 'free' space within which potatoes could be targeted in isolation.

Fig 3. Glyphosate treated potato 27th June 2014.

Fig 4. Reaction to sub lethal dose of glyphosate.

Where potatoes had been successfully targeted (Fig 3) then there was an effective kill. It was on occasion evident that some potatoes had not received an adequate dose to kill but normal development and berry formation (Fig 4) was prevented.

Within the core test area there were no potatoes which had not received an amount of glyphosate. Those on the boundary of the 6m boom width occasionally escaped control but may well have been just outside the field of view of the equipment in this direction but targeted on the return trip through the crop.

Table 1. Comparison of the mean dye recovered against biomass on peas and volunteer potato (2014).

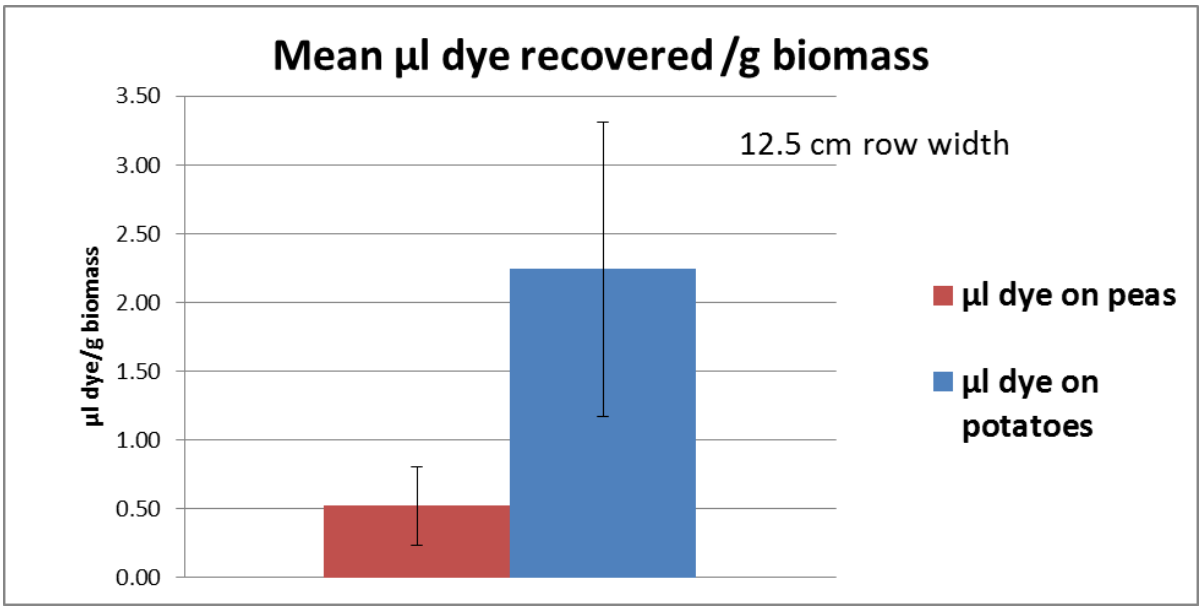

Table 2. Comparison of the amount of spray solution deposited at 12.5, 20 and 25cm row widths to peas and volunteer potato.

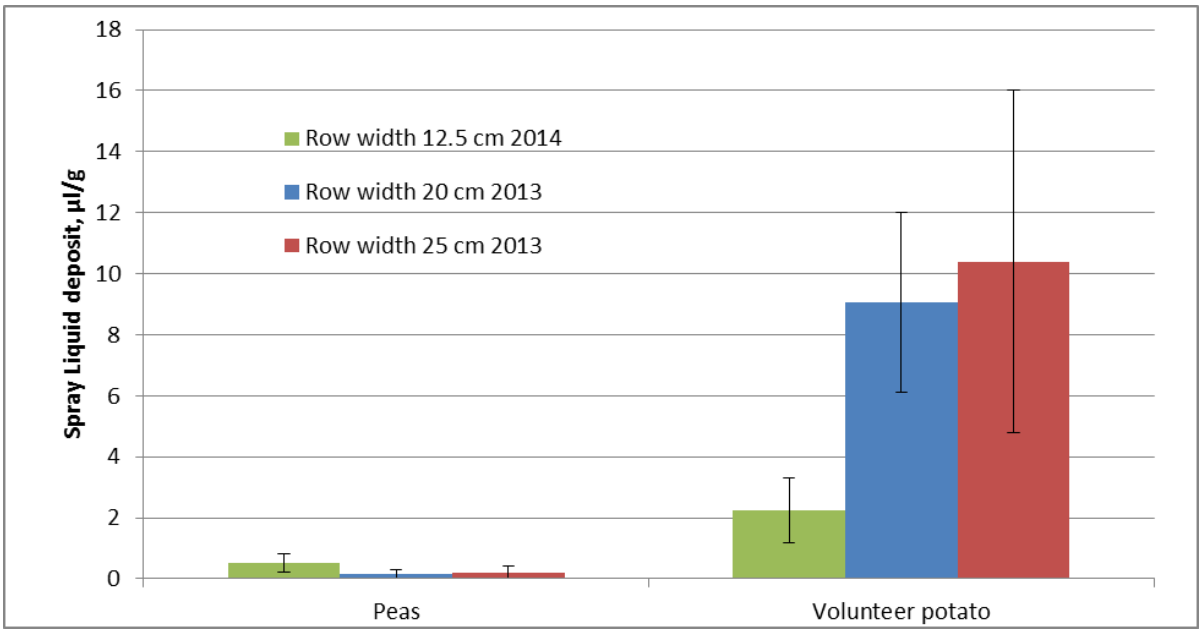

Table 3. Percentage of dye recovered from peas per plot in 12.5, 20 and 25cm row widths.

% of dye recovered from peas (per plot)	Row width, (cm)	
18.84	12.5	(2014)
1.84	20	(2013)
1.98	25	(2013)

Discussion

In the second and final year of this project it has been demonstrated that the guided spot weeder can successfully be used in a commercial vining pea crop where row widths are 12.5cm. Adjustments to the hard/software configuration had to be made so that the smaller commercial row width could be accommodated and potatoes successfully targeted with glyphosate.

The narrower row width for the 2014 commercial crop further challenged the spot sprayer. It is suggested that this narrower row width is the main reason for the increase of spray intercepted by the crop.

Observations showed a good portion of the dye hitting the ground adjacent to the target plant. The sparse development of the crop meant that the dye that missed didn't land on as many surrounding pea plants as might have been expected.

Less dye was recovered per gram of potato plant than 2013 but enough glyphosate was received by the potatoes to cause plant death or arrest normal development.

Conclusions

Should there be a time in the future when there are no selective chemical options available to control volunteer potatoes in vining peas we have shown that the guided weeder can be effective when crop row widths are as narrow as 12.5cm, as in the commercial crop as well as the more accommodating 15cm, 20cm and 25cm widths used in 2013. However it was noted again that the timing of the potato emergence was crucial for effective control. Should potato emergence be later when the peas are more developed, particularly on the narrow commercial row spacing, it could be envisaged the guided weeder would be less effective. For this reason peas grown on a wider row spacing such as 20 cm or 25 cm would offer a greater window of opportunity but at the moment commercially crops are usually grown on narrower spacing of 15 cm or less.

The machine continues to accurately apply a sufficient quantity of pesticide to the potato plant to either kill or heavily suppress development and in turn prevent it producing toxic berries. As well as the berries, plant parts are also an unwanted contaminant in the vining pea crop however these are less likely to make their way through the viner at harvest and processing factory, into the final product.

As later-drilled peas are generally planted when soil conditions are warmer, these crops perhaps lend themselves more to using this equipment as both the peas and potatoes tend to emerge quickly under these conditions.

A guide price for a commercial version of the guided spot sprayer is thought to be around £40 000 (Tillett and Hague Technology). At this price it would not be economical to purchase for tackling volunteer potatoes in vining peas alone. Consequently the loss of the selective options could well mean a significant reduction in UK production as grower groups withdraw from the industry. For those involved with growing other high value row crops as well, such as carrots, onions and leeks the guided spot sprayer may be a more attractive investment.

For information a letter of support has been sent to CRD (HSE) supporting flumioxazin.

Knowledge and Technology Transfer

Prior to commencement of the project (15th January 2013) Jim Scrimshaw and Nick Tillett gave a presentation describing both the aims of the work and guided weeder to the Vegetable Agronomists Association. This is a group which collectively represents around 90% of the vining pea area grown in the UK.

The guided weeder was on display and the trial demonstrated at PGRO's Vining Pea Open Day 11th June 2013.

The provisional results of the deposit measurements were shown to the CUPGRA conference in December 2013.

The project was discussed with attending visitors at the PGRO Vining Pea Open Day at STC 1st July 2014.

Appendices

Vision Guided equipment in the field in its 6m configuration for 2014.

Close up of machine and nozzle arrangement.