Project title:	Vining and podded peas: control of potatoes by vision guided spot spraying
Project number:	FV 307b
Project leader:	Jim Scrimshaw, Processors and Growers Research Organisation, Great North Road, Peterborough, PE8 6HJ
Report:	Annual report, June 2014
Previous report:	None
Key staff:	Jim Scrimshaw Nick Tillett Clare Butler Ellis
Location of project:	PGRO Trial ground 2013, Thornhaugh
Industry Representative:	Richard Fitzpatrick, Holbeach Marsh Co-operative, Fleet, Holbeach, Lincs
Date project commenced:	24 April, 2013
Date project completed **(or expected completion date):**	31 March 2015

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The results and conclusions in this report are based on an investigation conducted over a one-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.

James Scrimshaw

Principal Technical Officer

PGRO

Signature .  ..... Date .....16th May 2014.....

Nick Tillett

Director

Tillett and Hague Technology Ltd

Signature .....  ..... Date .....14th July 2014.....

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CONTENTS

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.

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.

Alternative means of control are a priority and this has been highlighted by the Processing Legumes Industry Panel in the Research Strategy Document held by AHDB (HDC).

Recent and current work in leeks, onions and carrots have 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 is designed to evaluate the potential for the use of the guided weeder in vining peas. It is proposed that the study takes place over two years, the first year with small plot replicated trials being closely monitored throughout and if successful, in the second year it is proposed to extend the trial in commercial crops of vining peas.

Currently there is no approval for the use of glyphosate in vining peas and it is proposed that this study includes the collection of crop adjacent to treated potatoes for chemical residue analyses in order to support a case for an EAMU.

Summary

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). There are no other known selective materials to control potatoes in vining peas. 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.

Without any chemical control options, increased acreages of vining peas will have to be hand-weeded to remove potatoes. This will add significant cost to growing vining peas where

potatoes are an issue. In 1992, when a chemical option was available, it was noted that 20% of vining peas were affected by volunteer potatoes: with no chemical means of control we can expect this proportion to increase significantly.

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 of using 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

Without a successful application for an EAMU for the glyphosate product used (Roundup Flex) growers are unable to consider this guided spot application option.

Presuming this is forthcoming, then growers would benefit from considering growing vining peas on wider spacing's. This would leave the crop open for a longer period of time and give a longer 'window' of opportunity for guided spot applications of glyphosate to be made.

SCIENCE SECTION

Introduction

Vining peas annually occupy between 26,000-30000 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. The 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

Vining pea variety-Oasis

Drilled 24th April 2013

Pre-emergence herbicide application: Skirmish (terbuthylazine + isoxaben) 1.0 l/ha - 26th April 2013.

Aphicide application: Aphox (pirimicarb) 280g/ha - 8th July 2013.

Site: PGRO's Thornhaugh Trial ground 2013. OS Grid reference: TF 071018

Soil type: Silty Loam.

Glyphosate applications made 31st May 2014.

Three crop row spacing's of 15 cm, 20 cm and 25 cm were established within a plot 2 m wide 60 m long. There were three plots of each row spacing, 9 plots in total.

'Volunteer' potatoes were randomly hand-planted throughout the test area at depths of 2 – 4 inches.

For each of the three row spacing's one plot was used for equipment set up, the second for the application of a dye and glyphosate was used on the third.

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 in the 20 and 25 cm width plots. 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 the third plot for each row width.

After application there was no rainfall recorded at the site until 12th June.
After treatment targeted potatoes in the glyphosate strips were marked with coloured stakes and monitored.

For the purposes of the residue samples, harvested produce was taken from the plot with the peas planted at 15 cm row spacing's only as this was seen to represent worst case scenario, with the maximum number of plants adjacent to the spot application.

On 19th July plants were taken from at least a 15 cm radius around 12 targeted potatoes, bagged and hand shelled. The minimum sample size required of shelled peas was 100 g but this was not possible within the 15 cm radius criterion there were often few, if any plants, with few or no pods in this area (Figure 1). The radius of the sample area was therefore extended until a sufficient sample had been collected. The 12 samples were frozen, stored and dispatched frozen to the LGC laboratory for residue analysis as arranged by Monsanto UK Ltd 23rd July 2013.

Fig 1:

Results

Primarily the aim of the study in the first year was to investigate the feasibility of using the vision guided equipment in vining peas.

The early emergence of the potatoes with the peas meant the vision-guided weeder could be used effectively. Fig 2.

Fig 2: Early emergence of the potatoes with the peas.

On the day of application, 31st May 2013 peas were at growth stage 103-105 and potatoes were effectively identified by the vision-guided weeder and targeted on all row widths used (15 cm, 20 cm and 25 cm). Fig 3, Fig 4 and Fig 5.

Fig 3: Identified and targeted potato showing dye deposits

Fig 4: Treated potato 7DAT glyphosate

Fig 5: Potato 18th June 19 DAT. Chlorotic peas directly adjacent.

Quantifying the applied spray liquid

The quantity of spray liquid recovered from potato and pea plants are shown in Figure 6 and the distribution of quantity over the 25 samples per row spacing are given in Figures 7 and 8. Table 1 summarises the relative deposit on pea and potato plants, and shows that a greater volume of spray liquid was recovered from the wider-spaced row compared with the 20 cm row, which was the result of a greater quantity of plant material within the sampling area.

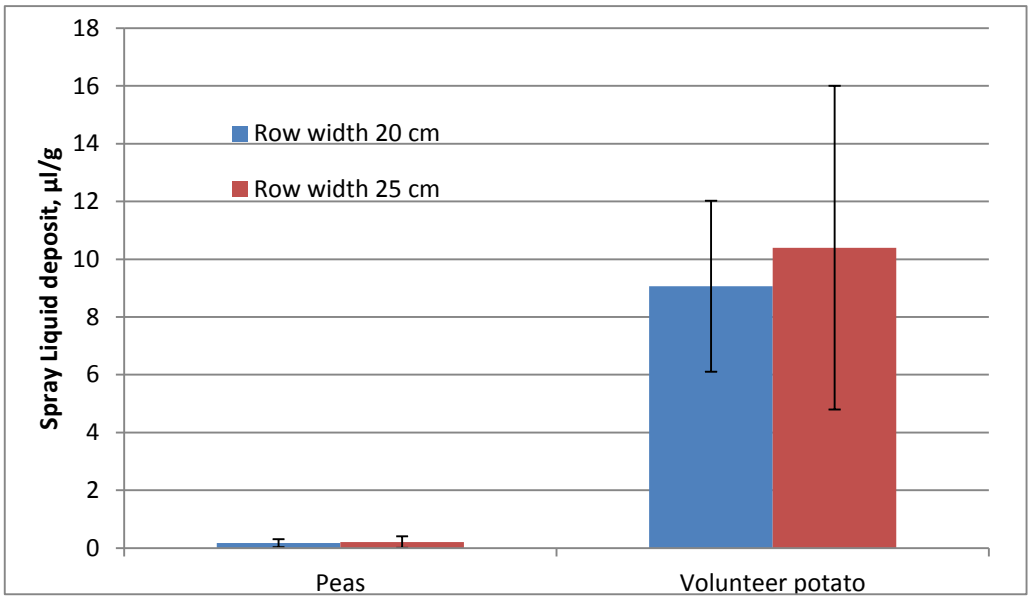

Fig 6: Spray liquid recovered per gram of plant biomass.

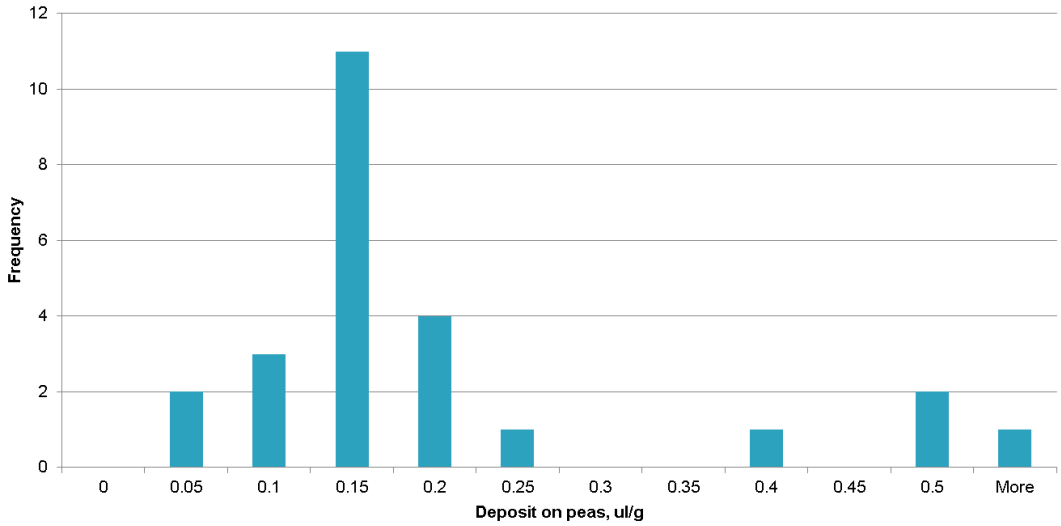

Fig 7: Distribution of spray liquid on pea plants

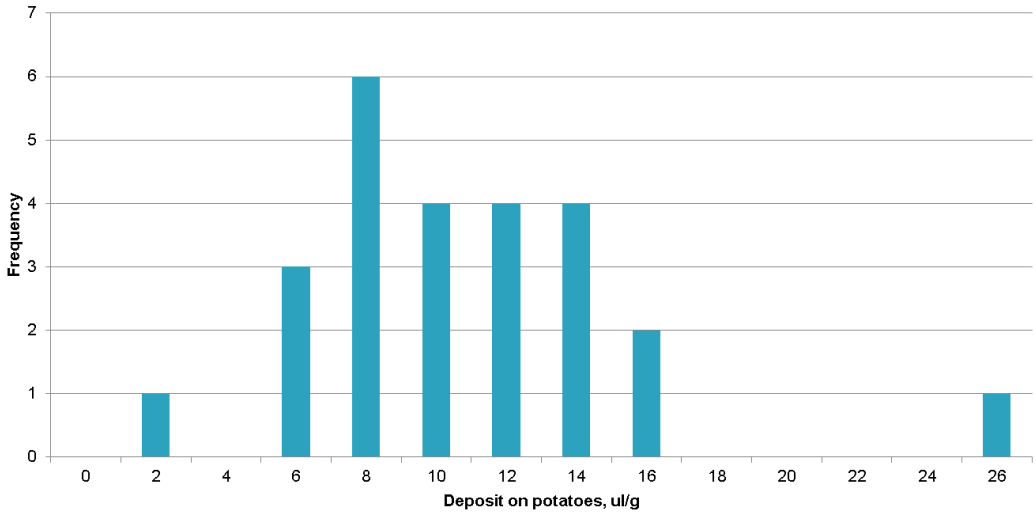

Fig 8: Distribution of dose on potatoes.

Table 1: Deposit on peas as a percentage of that on potatoes, and total quantity of spray liquid recovered

Row width, cm	Deposit on peas as a % of deposit on potatoes	Mean spray liquid recovered (µl) per sample area
20	1.88	100
25	2.02	141

Discussion

In year one we have demonstrated that the guided spot weeder can successfully be used in vining peas as it has been in previous HDC projects FV 307 and FV 307a with onions and leeks respectively. Appropriate adjustments to the hard/software configuration can be made so that different row widths can be accommodated in vining peas and potatoes successfully targeted with glyphosate and killed. (see figure 5)

Peas within a 15 cm radius of a targeted potato plant, received on average approximately 2% of spray liquid deposits compared with the potatoes. Row width (20 or 25 cm) appeared to make little difference. This demonstrates a good degree of accuracy from the equipment.

Samples for residue analysis collected from those peas planted on 15 cm row spacings were considered to be the 'worst case scenario' and chemical analysis revealed that from all twelve samples submitted, glyphosate was virtually undetectable (less than 0.05mg/kg of glyphosate). Peas directly adjacent to treated potatoes which received a very small amount of glyphosate turned chlorotic (see figure 5). As a general rule vining peas exposed to small amounts of glyphosate will at best, not prosper and have a high probability of being killed. There will be no harvestable produce from these plants; hence little or no residue is detected.

This work and the LGC Laboratories analysis were used to support an unsuccessful EAMU application. See Appendix 1.

Conclusions

We have shown that the guided weeder can be effective under specific circumstances, should there be a time in the future when there are no selective chemical options. However it was noted that should potatoes emerge later when the peas are more developed and fill a greater proportion of the inter row space, 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 spacing's of 15 cm or less. It is expected that commercial work planned for year 2 of this project will demonstrate this.

The machine is accurate in terms of applying a sufficient quantity of pesticide to the potato plants with minimal contamination of the surrounding crop. The very small amount of

glyphosate that finds its way on to the crop causes plant death so there is little chance of residues being an issue as is shown by the LGC analysis.

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 an economical purchase for use in vining peas alone for just tackling volunteer potatoes. For those involved with growing other high value row crops as well, such as carrots, onions and leeks the spot sprayer may be a more attractive investment.

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

Appendices

Appendix 1

Commercial in Confidence

Setting standards in analytical science

Certificate of Analysis

Report number: FA20/13/999

CUSTOMER: **Monsanto UK Ltd**
1st Floor Building 2030
Cambourne Business Park, Cambridge
CB23 6DW

SAMPLE INFORMATION: HDC PROJECT 307 B

Customer Number	Sample Type	Analysis	LGC Number	Result mg/kg
1	Frozen peas	GLYPHOSATE	P13000655	<0.05
2	Frozen peas	GLYPHOSATE	P13000656	<0.05
3	Frozen peas	GLYPHOSATE	P13000657	<0.05
4	Frozen peas	GLYPHOSATE	P13000658	<0.05
5	Frozen peas	GLYPHOSATE	P13000659	<0.05
6	Frozen peas	GLYPHOSATE	P13000660	<0.05
7	Frozen peas	GLYPHOSATE	P13000661	<0.05
8	Frozen peas	GLYPHOSATE	P13000662	<0.05
9	Frozen peas	GLYPHOSATE	P13000663	<0.05
10	Frozen peas	GLYPHOSATE	P13000664	<0.05
11	Frozen peas	GLYPHOSATE	P13000665	<0.05
12	Frozen peas	GLYPHOSATE	P13000666	<0.05

REPORT DATE: 05 August 2013

Report prepared by:

Emmanuelle Braidman
Food and Consumer Safety Team, LGC
Date: 05 August 2013

Report authorised by:

Nicola Coles
Food and Consumer Safety Team, LGC
Date: 05 August 2013

Fig 9: Vision guided spot sprayer preparing to travel down one of the 2 m beds.

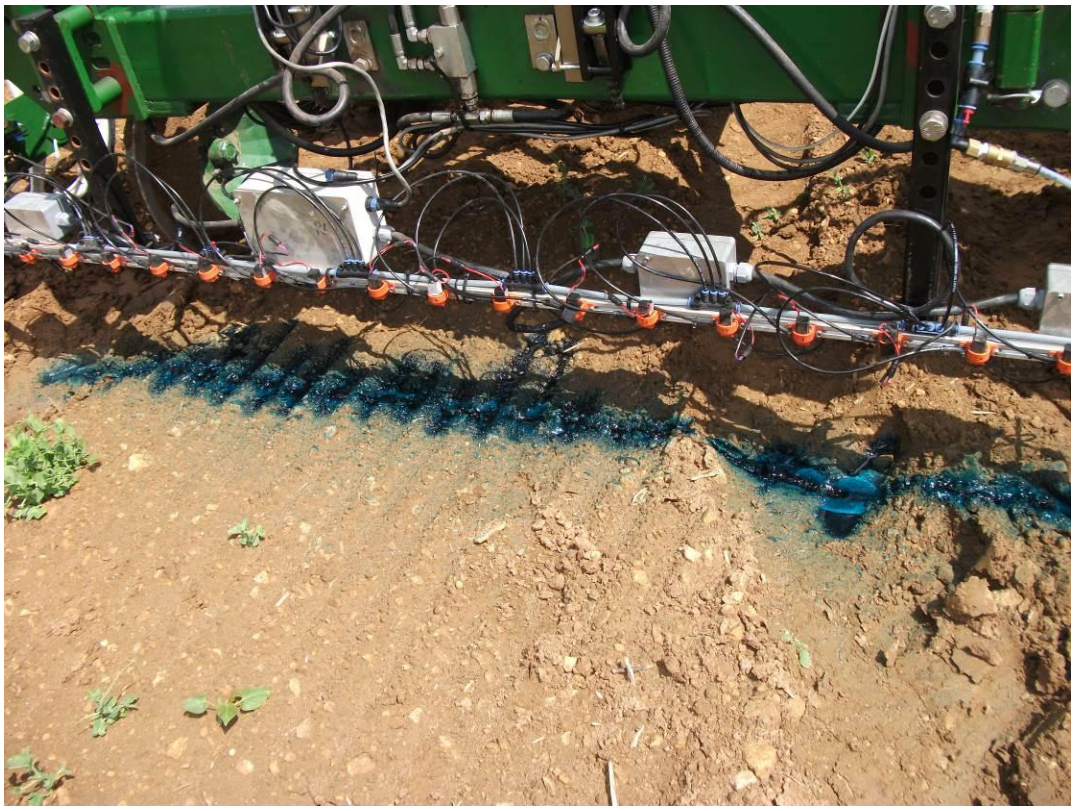

Fig 10: Setting up for the dye application.