Grower Summary

FV 368

Desk Study: A technical review of available and emerging technologies for harvesting of Brassicas and whole head lettuce

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Headline

Produce sensing and robotics will be the keys to developing more capable vegetable harvesters.

Background and expected deliverables

The Brassica and leafy salad industries rely heavily on the use of manual labour for most harvesting tasks. In addition, labour costs are increasing and labour is becoming more scarce. Although sophisticated mobile pack houses have been developed for in-field harvesting they mostly rely on selective manual picking of the crop. Automatic picking systems are commercially available for top lifting of some crops e.g. cabbages and whole head lettuce. However, these machines are non-selective, once-over devices with generally higher product damage and wastage levels than manual systems. Selective harvesting of cauliflower has been demonstrated in principle but the technique has yet to be commercialised.

The Brassica and lettuce growers have identified harvesting as a priority target for improvement since the introduction of more automated systems has the potential to alleviate some of their labour problems, reduce costs and potentially improve consistency. This report will include a review of the state of vegetable harvesting automation, recommendations on currently available machinery that could be used or adapted for UK growers use, indications of the gaps in technology that are currently preventing progress and suggestions on where research and development should be concentrated in order to close or reduce those gaps.

Summary of the project

UK vegetable growers have been losing out due to competition from abroad and a dwindling home market for cabbage, cauliflower and lettuce. Labour costs are rising and harvesting labour represents a large proportion of the production costs. If harvesting machinery could be made to be more efficient and less reliant on manual labour the costs of production would be reduced. The report begins with a review of the types of machinery that are currently being used to harvest cabbage, lettuce, broccoli and cauliflowers. At present this means tractor mounted or self propelled harvesting rigs and one-pass, semi-automatic harvesters. Unfortunately, commercial, selective vegetable harvesters do not exist. The review therefore goes on to examine relevant harvesting research that could enhance the performance of current equipment or lead the way to new, fully-automated machines.

The only way, at present, of selectively harvesting vegetables is by hand. In the commercially available harvesters section some images of the types of harvesting rigs that have been developed to maximise the efficiency of hand picking are shown. In addition to the picker-cutters, most of these machines have people on board preparing and packing the produce. The efficiency of these types of rig could be improved if these preparation and packing tasks were automated. Emulating the human's ability to do all these tasks is impossible using traditional agricultural engineering techniques. However, blending mechanical engineering, modern electronics and computing permits the design of highly capable produce handling and packing devices. An almost fully automatic lettuce trimming and packing factory, built in Spain, is evidence of what can be done. More information can be found about this facility in the robotic harvesting section of this review.

One-pass harvesters for cabbage and lettuce have been around for some time. Typical examples of these types of harvester are discussed in the review. Details are given, in particular, of the design philosophy and research that led to the Univerco cabbage puller. This machine pioneered the technique of lifting the cabbage, including its roots, rather than

cutting it off at ground level. The designers of these types of machine claim they cause less damage and permit a more accurate cut, so that produce quality is maximised. Like the picking rigs most of the one-pass harvesters have personnel on-board for trimming and packing etc. The case for automating these tasks is just as applicable to these types of harvester as it is to the picking rigs.

Figure 1. Univerco prototype harvester at work

A commercial, one-pass broccoli harvester is now available from Dobmac Agricultural machinery in Australia. Images and a description of this machine are given in the review. Detail design and development of another Australian broccoli harvester (Matilda Fresh) are also presented. Work with this machine resulted in a further Australian project which aimed to improve the uniformity and number of harvestable quality broccoli heads that would be available to a one-pass harvester. Selective harvesting of broccoli is a step closer. The methodology behind some machine vision research that successfully determined the maturity state from an analysis of broccoli images is explained.

Figure 2. The Dobmac Agricultural Machinery broccoli harvester

One of the main problems preventing the development of selective vegetable harvesters is the non availability of suitable produce maturity sensors. Detecting the maturity of cauliflower curds is particularly difficult because they are usually obscured by leaves. The successful development of a selective cauliflower harvester would, potentially, provide sensing and handling solutions that would be applicable to all the other target crops. A significant part of the selective harvesting section therefore reviews the findings from a UK research project aimed at developing a selective cauliflower harvester (Caulicut). They found that x-rays were very good at detecting curd maturity (size) but the required device would be too heavy and expensive to be practical on a real harvester. They also looked at microwave sensing methods. Although promising, the technique was only able to be refined to the point where

40% of curds were successfully detected. The Caulicut project also investigated cutting, elevation and trimming (though not on the same rigs). This work is assessed in conjunction with a later patent application.

The final section of the main report assesses the potential for robotics and how adopting this type of technology could result in more capable harvesters. Such machines would be “sensor rich” with individual modules for each harvesting task. The modules would be able to communicate with each other, and a central controller, sharing information to ensure each product was picked, processed and appropriately packed.

Main conclusions

One-pass harvesters and picking rigs rely on humans to inspect, prepare and pack the produce for it to be suitable for the fresh market. Advances in electronics, sensing and computing now make the automation of these tasks entirely possible.

A promising, new, one-pass broccoli harvester has been produced by Dobmac Agricultural Machinery in Australia. Once the first cut has been taken out by hand this machine can harvest the rest in a single pass.

One-pass cabbage harvesters that pull the plant from the soil, then cut the stem separately, give the best chance of producing cabbages suitable for the fresh market

Improved agronomic management using selected varieties and optimised growing locations improved the number of one-pass harvestable broccoli heads by up to 90% in an Australian project. Similar initiatives, relevant to our conditions and varieties, could be undertaken here.

There are no automatic, selective vegetable harvesters currently in production. The key factor currently limiting the development of selective harvesters is the lack of a reliable, affordable, produce maturity sensor. A project to investigate produce sensing and combining inputs from multiple sensors e.g. tactile, visual, microwave is recommended.

X-ray technology can successfully distinguish the size of 90 % of obscured cauliflower curds to within +/- 10 mm. Until the weight, cost and size of x-ray systems comes down the use of one of these detection devices, per row, remains impractical. Microwave sensors could potentially be used to detect maturity but the best results available, 2002, indicate that only 40% of curds were successfully detected.

Automatic detection of broccoli maturity state from images of the heads has been successfully demonstrated. This could potentially lead the way to the development of a selective broccoli harvester.

Robots are now widely used in the food industry for handling variable, delicate products. The cost of robots has fallen and their capabilities have grown to the point where high-speed robotic harvesting of vegetables would be possible. A feasibility study to determine the performance levels required and types of robot that could be used on field harvesters is recommended.

Most of the science and technology needed to develop more capable automatic harvesters already exists. Whether these machines will actually be developed and whether the UK will be involved, will depend on how much commitment the UK growers and manufacturers are prepared to make and what priority is given to the topic.

Financial benefits

The introduction of more automated harvesting systems would reduce labour, reduce waste and could improve quality levels through more consistent handling. The level of financial benefit would depend on the number of operators saved, the value of the crop and wastage reductions that could be achieved. This would vary between crops and would be dependent on the type of harvester and the degree of automation. The benefits could therefore be substantial, however, quantifying such benefits is beyond the scope of this technical review.

Action points for growers

- Engage with the manufacturers of your existing equipment with an aim of persuading them to improve their machines.

- Consider forming consortiums to aid the manufacturer to finance developments that would benefit all parties.