AHDB
HORTICULTURE

Grower Summary

CP 107c

The application of precision farming technologies to drive sustainable intensification in horticulture cropping systems (PF-Hort)

Final 2018

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 AHDB Horticulture office (hort.info.@ahdb.org.uk), quoting your AHDB Horticulture number, alternatively contact AHDB Horticulture at the address below.

AHDB Horticulture,
AHDB
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel – 0247 669 2051

AHDB Horticulture is a Division of the Agriculture and Horticulture Development Board.

Project title:	The application of precision farming technologies to drive sustainable intensification in horticulture cropping systems (PF-*Hort*)
Project number:	CP 107c
Project leader:	Dr Lizzie Sagoo & Dr Paul Newell Price, RSK ADAS Ltd
Report:	Final Report, July 2018
Previous report:	Annual Report, March 2016 Annual Report, March 2017
Key staff:	Dr Barry Mulholland (ADAS Head of Horticulture) Prof. Bryan Griffiths & Dr Joanna Cloy, SRUC (soil survey work in Scotland) Angela Huckle (ADAS Field vegetable consultant) Dan Munro (ADAS soil scientist) Ben Hockridge (ADAS GIS & Remote sensing consultant) Dr Charlotte White (ADAS Crop physiologist) David Talbot (ADAS HNS Consultant) Dom Edwards, Gail Bennett, Martin Crookes, Daniel Jakes, Michael Morris, Ryan Hinckinbotham and Geoff Bailey (ADAS field teams) Tim Chamen, CTF Europe
Location of project:	Field demonstrations at grower sites around the country
Industry Representative:	Andy Richardson, Allium & Brassica Centre
Date project commenced:	01/04/2015
Date project completed	31/03/2018

GROWER SUMMARY

Headline

- Soil mapping, canopy sensing and yield mapping provide soil and crop variability data which can be used as a decision support aid for soil and crop management plans (eg to quantify and target nutrient applications to crops).
- Controlled traffic farming reduces the field area wheeled by machinery and can lead to improvements in soil structure, efficiency and productivity.

Background

Precision techniques can help to improve the efficiency of operations in horticulture production systems, including cultivation and accurate fertiliser and agrochemical applications. Precision farming involves measuring and responding to variability in soils and crops to optimise returns on inputs. Potential increases in marketable yield of high value crops makes this approach an attractive option for many growers. Anecdotal evidence suggests that whilst uptake of GPS and soil mapping in horticulture is increasing, the development and uptake of other precision farming techniques such as controlled traffic farming (CTF), canopy Nitrogen (N) sensing and yield mapping has largely been focussed in cereals and oilseed rape. Some of these precision farming techniques have direct relevance to horticulture and there is interest from growers in their potential to increase yields and improve profitability.

The aim of this project was to evaluate the current and future potential of precision farming techniques to optimise soil and nutrient management in horticulture, and to encourage greater uptake of commercially available techniques.

Phase one of the project included a field survey of soil structural conditions under horticultural cropping as well as a review of precision farming techniques. In Phase Two the precision farming techniques with the greatest potential for uptake were evaluated through demonstration activities and/or field experiments on six commercial farms.

Summary

Soil structure survey

The soil structure survey was carried out between September 2015 and October 2016 on 75 fields located on 49 holdings. The survey was stratified by crop type and included annual crops and perennial crops. For the annual crops the survey was carried out twice (pre- and post-planting/drilling). For the perennial crops, the survey was carried out prior to establishment at some sites and in the growing crop at others. The structural survey report is available on the CP 107c project page of the AHDB Horticulture website.

Precision farming review and KT Guide

The precision farming review engaged with precision farming companies and machine manufacturers, growers, consultants and researchers to evaluate the potential for precision farming techniques such as CTF, soil mapping, remote sensing of crop canopies, variable rate inputs and yield mapping, to increase crop marketable yield and profitability. The review provides a comprehensive overview of the precision farming techniques available to growers to improve soil and nutrient management and more specifically how these techniques may be applied to horticultural crops. The precision farming review is also available on the CP 107c project page of the AHDB Horticulture website.

The results from the soil structure survey and precision farming review have also been collated into an AHDB GREATSOILS '[Soil management for horticulture' guide].

Field demonstrations

In Phase Two the precision farming techniques with the greatest potential to improve soil and nutrient management in horticulture were evaluated in demonstrations and/or field experiments on six commercial farms.

- ***Options for soil mapping – F.B. Parrish & Son Ltd.***

Soil variability is one of the key factors determining differences in crop yield potential within and between fields. Soil mapping can be used to delineate the boundaries between soil types and to define or characterise the soil types themselves (e.g. pH or soil nutrient indices). F.B. Parrish & Son Ltd. hosted a demonstration focussing on soil mapping in their Avenue Field (10 ha) at Chicksands in Bedfordshire. The aim of this field demonstration was to demonstrate options for soil mapping, including soil sensing techniques (i.e. soil electrical conductivity/electro-magnetic induction scans and soil brightness) and soil nutrient mapping, and compare the effect of soil sampling intensity and a grid-based compared to zone-based approach to soil sampling on the soil nutrient maps produced.

A soil EC survey was conducted and satellite soil brightness imagery sourced for the field. Topsoil samples (0-15 cm) were taken in November 2016 using a number of different

sampling approaches. These soil samples showed significant within field variability in soil pH and nutrients.

The soil analysis results were used to create soil pH and soil extractable P, K and Mg maps to demonstrate grid and zone based sampling strategies and the impact of sampling intensity. Once created, soil pH and nutrient maps can be converted into maps for variable rate fertiliser or lime application. This type of soil nutrient mapping is of most value in variable fields where it identifies lower soil index areas, which would otherwise have been under-fertilised or under-limed. Where soil pH or nutrient levels vary above target soil indices, such variation should not be expected to affect crop yields, however variable rate fertiliser application may still offer cost savings through not over-applying nutrients to higher Index areas.

- ***Controlled traffic farming – Barfoot Farms Ltd.***

CTF aims to improve soil structure by reducing the proportion of each field area that is compacted by wheeled machinery. These improvements can lead to fewer and less energy-intensive cultivations, reduced fuel use, improved seedbeds, better drainage, more machinery work days, improved water/nutrient use efficiency and increased yields in some years. These benefits can be accrued within a few years of adopting CTF systems.

Barfoot Farms Ltd. have converted the majority of their machinery to a CTF system as part of a new soil management strategy that also includes the adoption of reduced tillage systems and the use of cover crops to improve soil structure. The CTF field demonstration at Barfoots contained three elements:

i) Capturing detailed technical information on machinery to compare the extent of tracking under the previous conventional and recently adopted CTF systems;
ii) A short term field study to investigate within-field soil quality and crop variability under the recently adopted CTF system;
iii) A field study to investigate the long term effects of the recently adopted CTF system on soil quality.

The tracking study was based on a rotation of sweetcorn, pumpkins, tenderstem broccoli and beans with the addition of cover crops at Barfoots' Little Abshot Farm. Detailed technical information was collated for all the machinery before and after CTF adoption, including track gauges (i.e. distance between wheels on an axle) and implement working widths. The gathered data was used to provide a graphical representation of tracking in the four-year rotation prior to and after CTF implementation. CTF adoption resulted in a potential 63% reduction (37% versus 100%) in tracked area.

The farm is in the early stages of transition towards a CTF system, incorporating the use of cover crops. The demonstration therefore provided the opportunity to capture the soil and crop management challenges encountered in the first few years of the transition. Detailed soil measurements taken within the 2017 sweetcorn crop in two fields (one field in the second year of CTF and a second field in the 5th year of CTF) showed that the base of the topsoil was firm to compact in both fields, indicating that it can take more than 5-10 years for soils to recover from a conventional system of random traffic with deep cultivation to a reduced tillage CTF system.

- ***Soil management strategies – Wyevale Transplants (Forestry) Ltd.***

Wyevale Transplants (part of Wyevale Nurseries) specialises in raising tree and hedging transplants in Herefordshire. Soils are sandy, many of the fields are sloping and plants are harvested in the autumn-winter period when soils are moist or wet, leaving soils bare over winter. In the past, soil erosion and runoff has had a significant impact on local watercourses and properties. One of the principal challenges for the business is therefore to improve resilience through increasing soil organic matter and reducing soil erosion risk. Demonstration activities focused on assessing soil condition and investigating the potential for various soil management strategies including the use of controlled traffic principles.

Detailed soil assessments carried out in three fields showed that the upper topsoil was generally well structured, with a firmer layer at 10-25 cm depth and a moderately-developed tillage pan. Despite recent subsoiling operations, the upper subsoil at around 30-45 cm depth was the firmest layer (probably associated with in-furrow ploughing), with soil compaction generally extending to below the effective working depth of most agricultural subsoilers.

Wyevale Transplants have introduced a range of measures to slow down and capture surface-runoff, including wide grass margins, sediment ponds and filter barriers. Additional measures have included the introduction of 18-month grass leys into the rotation and the application of green compost every two years; and the nursery is considering a reduced tillage trial in which cultivations will be carried out without subsoiling.

A tracking study indicated that there may be some potential to reduce the extent of compaction using controlled traffic, but establishing permanent trackways is challenging with machinery harvesting on sloping land in wet conditions over winter. The first quick win to reduce compaction would be to upgrade tyres to one of the latest designs to reduce tracking and ground contact pressure.

- ***Canopy sensing for variable rate N applications – Savoy cabbage (2016) and Brussels sprouts (2017)***

Canopy sensing measures reflectance from the crop surface. This information is presented as a vegetation index, which can relate to crop biomass and crop N uptake. Information on crop canopy variation across a field can be used to vary the N rate. This technology may have the potential to improve nitrogen use efficiency in horticultural crops. Two project demonstrations therefore focused on variable rate N management for brassica vegetables: one on Savoy cabbages in 2016 at Glassford Hammond Farming LLP and a second on Brussels sprouts in 2017 at W Clappison Ltd's Park Farm, Risby. The overall aim of these field experiments was to demonstrate the potential for canopy sensing for variable rate N management on brassica vegetables.

The demonstrations included N response experiments and tramline comparisons of uniform and variable rate N application to address the following questions:

(i) Does the optimum N rate for the crop vary across the field?
(ii) Can we relate canopy sensing information to crop biomass and N uptake during the growing season?
(iii) Can we demonstrate a benefit from variable rate N application?

Statistical analysis of N response data from the replicate N response experiments showed that for both the Savoy cabbage and Brussels sprouts N response was similar between the experiments and there was no evidence to indicate a difference in optimum N rates.

There was a good relationship between crop reflectance measurements (NDVI) and above ground biomass and N uptake early in the season. The results indicate that canopy sensing can be used to provide a good proxy measure of variation in brassica vegetable crop biomass and N uptake and may be used as the basis to vary N applications, but may not be as effective in identifying biomass/N uptake differences later in the season as the crop develops a larger number of overlapping leaves.

Comparison of marketable head weights and total marketable yields from the uniform and variable rate N tramline comparisons on the Savoy cabbage did not provide any evidence that varying the N rate increased total marketable yield or produced a more consistent sized crop. However, the variable rate N tramline comparisons in the Brussels sprouts showed slighter higher yields and a greater proportion of large sprouts from the variable rate compared to uniform N treatment. However, the yield difference (1.4 t/ha) was considered small and it was not possible to assess whether the difference in yield between the two tramlines was statistically significant.

- ***Focus on variability – G's Growers Ltd. Cambridgeshire (lettuce)***

Consistency of crop size and quality are key issues for growers. The aim of this field demonstration was to use a case study field to show growers the various precision farming tools available to them to measure variation in their soils and crops. Information on soil variability was collected via a soil EC survey, soil brightness maps, soil sampling and analysis, soil structural assessments and soil moisture probes. Information on crop variability was collected using crop canopy sensing. Areas of thinner and thicker crop were identified for targeted soil and crop sampling.

The case study field showed significant variation in lettuce head weight. Soil sampling and analysis showed that soil organic matter content varied from 7 to 45% in the fenland soils. The pattern of variation in soil organic matter matched the pattern of variation in crop reflectance data. It is likely that the variation in lettuce head weight was driven by factors related to variation in soil organic matter and this may be a combination of differences in soil moisture availability and nutrient availability. Targeted soil and crop sampling identified a number of trends for lower soil and tissue nutrient concentrations in areas of thinner crop, however it was difficult to confidently identify any specific nutrients as likely causes of yield variation.

Focusing on crop variability can help growers identify and address yield-limiting factors. If the causes of yield limitation can be identified and eliminated, crop productivity in the low-yielding areas can potentially be increased resulting in rapid benefits for all crops grown in the rotation. However, this case study also showed that it can be difficult to disentangle the various soil and other yield-limiting factors to understand which are most important in driving crop variability.

Financial Benefits

This project has provided information on the state of horticultural soils and guidance on precision farming and other techniques to identify, avoid and alleviate soil compaction, thereby increasing opportunities to carry out field operations; reduce cultivation and other input costs; increase crop yields and farm profitability, while minimising environmental impact.

The project has assessed the potential for precision farming techniques to better target soil management and nutrient inputs to horticulture crops. The potential benefit of variable rate inputs is greatest in fields that are inherently variable, where it can result in a more accurate use of inputs, optimising nutrient availability across the field and delivering a greater proportion of marketable product.

Action Points

- Soil compaction can be a key yield-limiting factor. Growers can manage the impact of soil compaction by identifying and alleviating it where it has occurred and where possible, by avoiding it in the first place.
- Precision farming tools such as soil mapping, canopy sensing and yield mapping can provide growers with valuable information about the variability of their soils and crops. Where growers have identified variability in their soil or crop, they should first seek to

identify the causal factors before adopting appropriate techniques to provide an effective return on investment.