Grower Summary

CP 107c

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

Annual 2017

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:	Annual Report, March 2017
Previous report:	Annual Report, March 2016
Key staff:	Dr Barry Mulholland (ADAS Head of Horticulture - project director), Angela Huckle (ADAS Field vegetable consultant), Dan Munro (ADAS soil scientist), Dom Edwards, Gail Bennett, Martin Crookes, Daniel Jakes & Michael Morris (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 (or expected completion date):	31/03/2018

GROWER SUMMARY

Headlines

- Soil mapping, canopy sensing and yield mapping provide information on soil and crop variability that can help better target nutrient inputs and soil management.
- Controlled traffic farming (CTF) reduces the field area wheeled by machinery and can lead to improvements in soil structure, efficiency and productivity.
- Targeted nutrient management, soil mapping, crop sensing and CTF are being demonstrated on commercial farms in 2016 and 2017 and the benefits and limitations communicated to growers through on-site interactive workshops.

Background

Improved soil management and targeted nutrient inputs are key agronomic management strategies to improve the productivity, profitability and sustainability of intensive horticulture production systems. Precision technology can help to improve the efficiency of farm operations, including cultivation and accurate fertiliser and agrochemical applications; implemented correctly these techniques can improve the efficiency and profitability of production. Precision farming involves measuring and responding to variability in soils and crops to optimise returns on inputs (i.e. fertiliser applications, soil cultivations etc.). Potential increases in marketable yield of high value crops makes precision farming 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 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 now interest from growers in their potential to increase yields and improve profitability and sustainability.

The aim of this project is 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 any commercially available techniques with potential to increase yields and profitability within horticulture.

Phase one of the project (first 14 months; objectives 1-3) included a field survey of soil structural conditions under horticulture crop production and a review of precision farming techniques for improved soil and nutrient management. In Phase Two (years 2 & 3) the precision farming techniques with the greatest potential for uptake are being 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 and comprised 75 fields located on 49 holdings. The survey was stratified by crop type and included Brassica, carrots, onions, leeks, leafy salads and vining peas (annual crops) and asparagus, blackcurrants, raspberries, apples, narcissus and cut flowers (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 other sites. The results from the soil survey have been written up as a separate AHDB Research Review Report.

Precision farming review and KE Guide

The precision farming review engaged with industry, including the precision farming companies and machine manufacturers, growers, consultants and researchers to evaluate the potential for precision farming techniques such as controlled traffic farming, soil mapping, remote sensing of crop canopies, variable rate inputs and yield mapping, to increase crop marketable yield and profitability.

The combination of the literature review and the interviews with precision farming companies, machine manufactures and growers has provided a comprehensive overview of what precision farming techniques are 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 has been written up as a separate AHDB Research Review Report.

The results from the soil structure survey and precision farming review are currently being collated into a KE *Guide to improved soil and nutrient management in horticulture*.

Field demonstrations (year 2)

In Phase Two (years 2 & 3) the precision farming techniques with the greatest potential to improve soil and nutrient management in horticulture are being demonstrated and evaluated on six commercial farms. There were three field demonstrations in year two (2016/17) which focussed on canopy sensing for variable rate nitrogen (N) applications, controlled traffic farming and options for soil mapping.

1. Canopy sensing for variable rate N applications – Glassford Hammond Farming

Canopy sensing measures reflectance from the crop surface. This information is presented in the form of 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. The field demonstration at Glassford Hammond Farming aimed to demonstrate the potential for canopy sensing for variable rate N applications to a Savoy cabbage crop. The demonstration included N response experiments and tramline comparisons of uniform and variable rate N application to address the following questions:

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

Nitrogen response experiments were replicated in three different areas of the field to see if there was any evidence of within field variation in optimum N rate – variable rate N management will only be of benefit where there is variability in crop N requirement.

In addition, we compared the farm standard uniform N application rate to variable N application in tramline comparisons. The farm standard N application rate was 240 kg N/ha and was applied in three splits: 80 kg N/ha on 4th July at planting, 100 kg N/ha on 4th August and 60 kg N/ha on 24th August. For the variable rate N treatment we varied the second N application from 60-140 kg N/ha (i.e. +/- 40 kg N/ha from the 100 kg N/ha farm standard) based on crop canopy measurements using a drone/unmanned aerial vehicle (UAV).

Crop canopy measurements from the N response plots showed a strong relationship between NDVI and total biomass, and between NDVI and crop N uptake. The N response plots also showed a significant yield response to N fertiliser; fresh weight marketable yield increased from 10 t/ha (mean marketable head weight of 603 g) on the zero N treatment to a maximum of 44 t/ha (mean marketable head weight of 1174 g) at the highest N rate of 360 kg N/ha.

The large yield response to N fertiliser and the strong relationship between crop canopy measurements (NDVI) and above ground crop biomass and N uptake indicate that canopy sensing can be used as a basis to vary N applications and where N availability varies across the field we could potentially see improvements in crop uniformity and/or an overall yield increase. However, statistical analysis of N response data from the three experiments showed that, in this case, N response was similar across the length of the field.

Comparison of marketable head weights and total marketable yields from the uniform and variable rate N tramline comparisons did not provide any evidence that varying the N rate increased total marketable yield or produced a more consistent sized crop in this demonstration field.

Variable rate N management will only be of benefit if N is the main cause of variability in the crop canopy. At this site, the N response experiments showed that the crop response to N was similar across the length of the field, and we think it is likely that the variability in crop canopy measured by the UAV was due to other soil or crop factors.

2. Controlled traffic farming – Barfoots

Controlled traffic farming (CTF) aims to reduce the proportion of each field area that is wheeled by machinery to avoid widespread soil compaction. CTF has been defined as "confining compaction to the least possible area of permanent traffic lanes" and involves greater discipline in use of routeways and tramlines. Improvements in soil structure can lead to fewer and less energy-intensive cultivations; reduced fuel use; improved seedbeds; better drainage; more machinery work days; improved water and nutrient use efficiency; and increased yields in some years. Increasing yields by 10-15% can result in increased revenue of *c*. £150 to £700 per hectare, depending on the initial yield and crop type. These benefits can be accrued within a few years of adopting CTF systems.

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

i. Capturing detailed technical information on machinery to compare the extent of tracking and fuel consumption 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 and health; and implications for productivity, versatility and profitability of the cropping system

The tracking study was based on a rotation of sweetcorn, pumpkins, tenderstem broccoli (TSB) 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 (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 and crop measurements will be taken within the 2017 sweetcorn crop in two fields (one field in the second year of CTF and a second field in the 6th year of CTF) to determine the within-field variability in soil quality and crop yield resulting from adoption of the CTF system. A soil quality baseline has also been established in three fields under CTF, conventional tillage and grassland management, to assess the cost and medium term benefits of a reduced tillage and controlled traffic approach.

3. Options for soil mapping – F.B. Parrish & Sons

Soil variability (i.e. spatial variability in soil properties such as soil texture, soil depth, stoniness, soil compaction, soil pH, soil nutrient reserves and soil organic matter content) is one of the key factors determining differences in crop yield potential within and between fields. Soil mapping is used to delineate the boundaries between soil types and to define or characterise the soil types themselves (e.g. soil nutrient reserves).

A demonstration focussing on soil mapping was hosted by F.B. Parrish & Son in Avenue field (10 ha) at Chicksands in Bedfordshire. The overall aim of this demonstration was to use Avenue field as a case study to discuss options for soil mapping.

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 the following sampling methods:

- Single field sample using 'W'-sampling technique – a single composite sample (of 25 soil cores) was taken by walking a 'W'-shaped path across the field.
- 1 ha soil sampling – the field was divided into approximately 1 ha blocks and a single composite sample (of 25 soil cores) was taken from each 1 ha block by walking a 'W' in each block
- Grid soil sampling – topsoil samples were taken on 25 m grid across the field (total of 143 soil samples). Each grid sampling point was GPS located. A single composite sample was taken from a GPS located point; each sample consisted of 16 soil cores taken in a spiral within a 3 m radius of the central point.

The detailed (25 m grid) soil samples showed significant within field variability in soil pH and nutrients; soil pH varied from 5.3 to 7.1, P Index varied from 2 to 4, K index from 1 to 4 and Mg Index from 2 to 4.

The soil analysis results were used to create soil pH and soil extractable P, K and Mg maps for Avenue field to demonstrate grid and zone based sampling strategies and the impact of sampling intensity. These maps highlight the impact of soil sampling intensity on the soil pH and nutrient maps produced. Where there is significant small scale variability, as seen in

Avenue field for soil pH, this variability can be concealed when only taking one sample per hectare, which is the typical commercial standard sampling intensity.

The Avenue field demonstration provides a case study to discuss the principles and methods of soil mapping with growers, in particular –

- Soil sensing methods (soil EC scans and soil brightness maps).
- Difference between grid and zone based soil sampling.
- Methods and information that can be used as a basis for creating soil zones.
- Data interpolation – understanding how the precision farming providers produce a contoured map from point soil samples.

Financial Benefits

This project will provide information on the state of horticultural soils and provide 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 will assess the potential for precision farming techniques to better target soil management and nutrient inputs to horticulture crops. The potential benefit of variable rate inputs (fertiliser/seed) is greatest in fields which 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 factor limiting yields. Growers can manage the impact of soil compaction by identifying and alleviating compaction where it has occurred and by avoiding soil compaction in the first place, where possible.
- Assess soil structure when soils are moist. If soils are compacted, identify the depth of compaction and target the depth of cultivations to just below the compacted soil layer.
- 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.