AHDB
HORTICULTURE

Grower Summary

CP 121

Towards precision inputs through improved understanding of the underlying causes of in-field variation in lettuce crop maturity and yield

Final 2017

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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.

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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.

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Project title:	Towards precision inputs through improved understanding of the underlying causes of in-field variation in lettuce crop maturity and yield
Project number:	CP 121
Project leader:	Dr Jim Monaghan, Harper Adams University
Report:	Final annual report, April 2017
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Location of project:	Harper Adams University, Newport, Shropshire TF10 8NB and G's Farm Cambridgeshire
Industry Representative:	Emma Garfield
Date project commenced:	7th April 2014
Date project completed (or expected completion date):	7th April 2017

GROWER SUMMARY

Headlines

- Electrical conductivity (EC) measurements can be used to demarcate zones of soil variability but although underlying soil properties are important, particularly soil organic matter, they do not wholly account for the variability that is seen in Iceberg lettuce growth and maturity.
- Transplants in a propagation trays are variable; this project has shown that transplant placement and positioning at planting also impacts on lettuce yields and marketable quality.

Background

Lettuce growth is influenced by soil properties, climatic conditions and agricultural practices as well as the interactions amongst these three factors. Understanding the spatial variation of these factors is fundamental when assessing the spatial distribution of crop yields and making precision farming decisions.

Variability in the growth of lettuce transplants leads to variation in head weight and maturity at harvest and can affect post-harvest quality. This causes a significant issue for growers as they wish to harvest heads of a uniform size and weight. Uniformity of the mature heads determines the efficiency of a single-pass lettuce harvest; oversized and under-developed heads result in crop wastage.

It is known that the availability of soil nutrients and moisture can affect plant growth and that the spatial variability of soil texture, and thus soil properties contribute significantly to crop variability. Variability in growth and development might be explained by dissimilarity in soil properties such as pH, nutrients and water levels. Spatial soil variability can be mapped indirectly by scanning the field soil for electric conductivity (EC). The relationship between soil properties and soil electrical conductivity (EC) has been established and the potential for using EC soil scans to predict yield variation in long season crops has been reported. Yet, no work has been reported in short season crops such as lettuce.

Until recently, growers have treated fields uniformly without considering the natural variation of soil on a field scale. With the promotion of precision agriculture choices, it has become possible to use techniques such as soil EC scanning to identify management zones, target soil sampling and determine variable seeding rates.

The purpose of this project was to understand the causes of in-field variation in lettuce growth as it affects harvest efficiency in lettuce crops. Reducing this variability through agronomic solutions would increase marketable yields. The research work has focused on: a) understanding soil variability and its influence on variation in lettuce growth, spatially and temporally at a field scale; and b) exploring the causes of variability in transplant growth and establishment.

This research investigated in-field variation in lettuce growth by quantifying variation in soil properties and establishing the relationships between soil variation and lettuce growth. Commercial EC scans were used initially to identify soil zones. A few studies have shown that EC scans are useful for targeting soil sampling across a field, as soil EC maps coincide with soil variation. Work in 2014/2015 identified different yield zones; with zone differentiation being guided by soil EC scans which were generated by commercial equipment (Veris3100). The variability in soil properties, and lettuce growth and quality in the zones was investigated further, in order to relate growth responses to a limited number of soil factors.

Summary

Year 1

Two field experiments were carried out in 2014 in the field 'Redmere P36', at G's growers Ltd in Cambridgeshire, to identify different soil zones within the field. Lettuce yields, and soil physical and chemical properties in these zones, were then examined. Multiple soil and plant samples were taken from the zones over two successive crops in the spring with further samples taken over the summer (June-October). Samples were transferred to Harper Adams University (HAU) for further assessments and lab soil analysis. It was concluded from the first-year work that:

- EC scans can be used to identify different soil zones within a field and enable targeted soil sampling.
- Samples from soil zones that varied in EC range varied statistically in percentage clay content and in the nutrients magnesium, Mg; potassium, K and phosphorus, P. However, all samples had a significantly high level of organic matter (above 20%) so they were classified as organic.
- Plant growth varied between the zones mid-season and at harvest.
- Demarcating variable soil-EC zones at a smaller scale (less than 3 m^2) proved inefficient for studying the potential for increasing lettuce crop uniformity through variable management.

Year 2

In 2015, two field experiments were done to map out lettuce yield and soil factors in another field, P57 at a G's Growers Ltd farm in Cambridgeshire. In addition, the influence of texture (particularly sand proportion) on lettuce biomass production was investigated in a glasshouse pot experiment. Conclusions from year 2 work were that:

- The variability pattern of lettuce yields was consistent over the zones, suggesting that yield distribution was mainly influenced by soil properties. Yield variation was mainly driven by underlying soil properties rather than by seasonal variation in moisture and weather conditions.
- Statistical analysis showed that variability in sand proportions and soil organic matter were key soil factors causing yield variation. The data showed that the relationship between the yield and soil properties varied particularly when the organic matter levels varied.
- Although variable field zones could be identified using soil EC scans or soil properties' maps along with the yield maps, there was no statistical correlation of yields with EC scans or conformance with maps.
- A preliminary glasshouse study suggested that the variability that exists in propagated lettuce transplants before they are planted is an important source of variation. This was further investigated.

Year 3

Redmere P57 zones were further examined by excavating four profile pits to investigate soil structure. Two pits were excavated in the high yielding zones and two in the low yielding zone. There was an apparent difference in soil structure between the North and the South regions of the field. The difference was characterized primarily by the depth of the organic matter and the topsoil (red soil) layer (Appendix 1).

Additionally, the third year of the project focused more on the transplant propagation stage and placement of transplants in the field.

Four experiments were done in 2016. The first investigated the impact of varying soil organic matter levels on water holding capacity and soil bulk density.

The second and the third glasshouse experiments investigated variation in transplant sizes at a tray level. The experiment was carried out at Second Willow Nursery, G's, Littleport, Cambridgeshire. The persistency of transplant variation was tracked during growth in a glasshouse experiment at HAU.

Finally, field trials was established at Kenny Hill 44 field, G's growers, Ely, Cambridgeshire to investigate the impact of variable transplant placement (Figure A) at planting on the yield and marketable quality of harvested heads.

Conclusions were that:

- Increasing soil organic matter increases the amount of soil moisture held at field capacity and decreases bulk density.
- There is a considerable amount of variation amongst transplants grown from uniform seeds under uniform conditions.
- Transplants that vary in size (length) within the same tray vary in fresh weight. This variability increases after transplanting.
- Planting position (in terms of orientation, and the depth or the proportion of peat block covered or in contact with soil) affects the marketable yield (Figure B); relatively uniform transplants develop into variable mature heads in terms of head size, fresh weight and marketable quality and particularly appearance when placed differently at planting. The most favourable planting position was the normal position (1) as shown in Figure A.

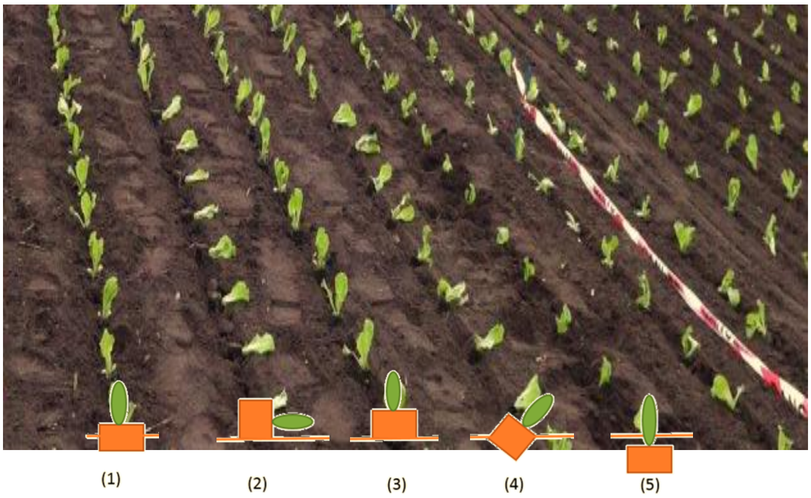

Figure A. Transplants field placement treatments, from left to right; 1) normal, 2) on the side, 3) above soil surface, 4) tilted or 50% of the peat block covered with soil, and 5) buried (approximately 2 cm of the green shoot was underneath the soil).

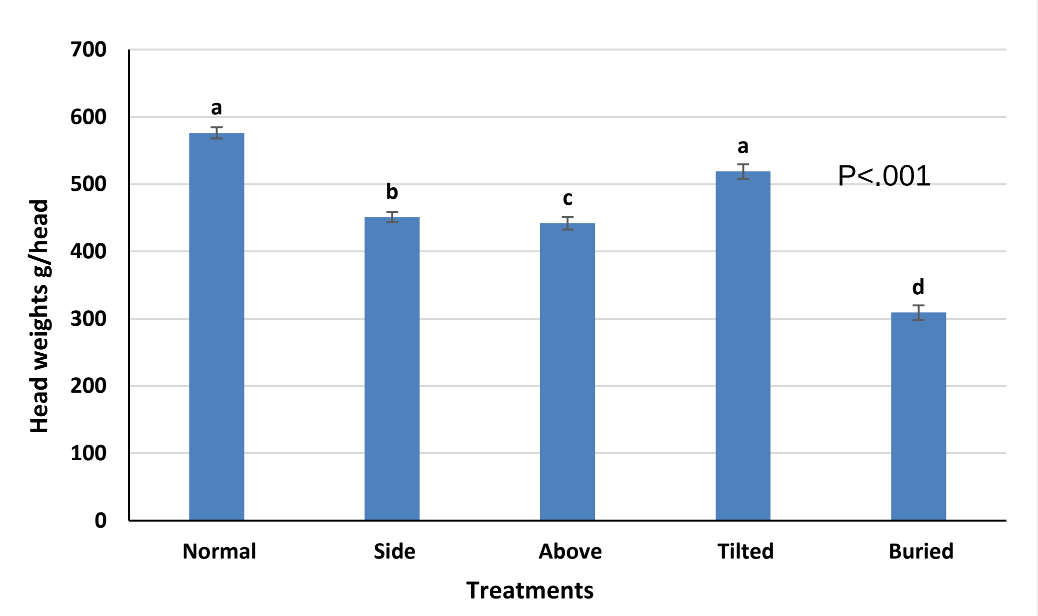

Figure B. Mean trimmed head weights for five different planting positions (P<.001) (n=60). Error bars show the standard error of the samples for n=60.

Financial Benefits

Not quantified but G's opinion is that providing information to manage crops more precisely could result in increased marketable yields of Iceberg lettuce.

Action Points

- EC scans can be used to identify different soil zones within a field and enable targeted soil and crop sampling as a first step to quantify yield variation across the field.
- Zones smaller than 3 m^2 proved inadequate for precision management in lettuce.
- Attention should be given to variability in soil organic matter and sand content across the field. Statistical analysis showed that variability in sand proportions and soil organic matter were key soil factors causing yield variation. The data showed that the relationship between yield and soil properties varied in particular when organic matter levels varied.
- Yield variation in lettuce crops was mainly driven by underlying soil properties rather than by seasonal variation in moisture and weather conditions during plant growth.
- Uniform handling of propagated transplants (growing media, light, and moisture) should be given more attention during propagation at a tray scale, to reduce transplant variability. There were no clear in-tray positional effects. However, excluding significantly small transplants from planting is recommended as the transplants that vary in size (length) within the same tray vary in fresh weight after planting. Moreover, the smaller sized

transplants do not normally catch up larger sized transplants. They either result in smaller heads or do not form marketable heads.

- Planting position requires attention when transplanting, in terms of orientation and the depth and proportion of peat block covered or in contact with soil, as this impacts on marketable yield. Similar or relatively uniform transplants develop into variable mature heads in terms of head sizes, fresh weight, marketable quality and particularly appearance, when positioned differently at planting. Transplants that were planted too deep in the soil, too high, or left tilted in the soil, all resulted in reduced yield due to pest damage or rotting due to contact with moist soil, and they were misshapen.