1. Title of the project

The effect of low ground pressure and controlled traffic farming systems on soil properties and crop development for 3 tillage systems (Part III).

2. Project summary

This project is aimed at extending the unique “3 tillage X 3 traffic systems” study at Harper Adams University for the 6th to 8th cereal-cropping seasons. The work is now showing positive economic benefits from improved soil management, but is season and crop dependant. There is growing interest from farmers, agronomists and researchers in the UK and overseas in this study. To illustrate this two similar programmes are underway in Zambia and Illinois and there is one more program being developed in Cambridgeshire, UK.

Whilst the core aspect of the programme is the field experiment other more focussed satellite work is conducted into applying new techniques and in depth data analysis (such as the X-ray Computed Tomography work with Nottingham University) where the 9 soil environments are a valuable resource. In addition to the core programme, which is estimated to take about 50% of the doctoral scholars time, this programme aims to also use the experimental site and the tomography to determine the impediments to crop establishment in the wheel marks of the controlled traffic (CTF) plots and to investigate the benefits of current and novel wheel mark eradicator equipment. It is also intended to further understand the relative effects of conventional and increased flexion tyres at the rated inflation pressure on the subsoil pressure and soil deformation.

3. Project background

Near random field traffic used in crop production can have a negative effect on soil and water sustainability as it causes compaction of agricultural soils (which prevents crop root development and water infiltration), with machines weighing up to c. 30 t and covering 80 – 90 % of the field area. This problem has arisen due to the increasing size and weight of agricultural machines and is the main reason for not reaching yield potential on arable fields (c. 10 – 15 % loss), water logging, runoff and soil erosion, which can lead to flooding and soil loss/deposition in streams and on roads, and a greater demand for irrigation water. Finally, repairing soil compaction requires a significant amount of energy (100 – 200 MJ/ha), time (1 – 2 ha/hr) and cost (c. £50/ha).

Controlled Traffic Farming (CTF) concept is an eco-efficient technology that restricts all heavy field traffic to compact pre-determined parallel laneways, covering about 15 % of the field. These compacted lanes provide firm conditions conducive to greater tractive efficiency and improved timeliness, by allowing operations to continue in soil moisture conditions that may inhibit random machinery traffic (CTF Europe, 2011). CTF concept with minimum and no-till farming systems can improve soil structure, gaseous exchange, water storage, water infiltration (100 % increase) and nutrient use leading to better root development and greater plant production (Chamen, 2011). This can also improve the economics of agricultural production through minimising fuel consumption (60 – 70 % energy reduction) and improving water and soil use efficiency. CTF system can potentially have a positive effect on agri-food production, efficient water management, global warming and climate change.

CTF together with reduced tillage operations has been promoted in order to minimise

the negative effect of field traffic on soils in the UK. Recent analysis of the results of the first four cropping seasons (Godwin et al., 2017) has shown the economic benefits of CTF and the continuing reduced crop yield from “no-till” systems. The depletion in yield is not unexpected in wetter climates and in the early years of the adoption of “no-till”, only to recover after a few years when the soil structure has stabilised. Those wishing to save on establishment costs are watching these and future results with great interest.

4. Project aim and objectives

Overall, this project aims to develop sustainable agricultural production systems that utilize CTF/LPT principles together with the appropriate cultivation systems that enhance farm productivity and provide a sustainable soil and water resource, and a design of an eco-product for efficient energy use in soil cultivation.

1. To determine the longer-term benefits of low ground pressure (LGP) and controlled traffic faming (CTF) over the conventional random traffic farming (RTF) systems for the 6th to 8th cropping season upon soil structure and crop yields for a typical arable rotation for 3 tillage systems (deep, shallow & “no till”).
2. To determine the effects of the contrasting traffic management & tillage systems on the soil structure below the vehicle wheel tracks and the effects of wheel mark eradication techniques on crop development.
3. To compare the pressure distribution to depth in the soil below both conventional and increased flexion (LGP) tyres at the rated inflation pressure.
4. To update the economic analysis of the farming systems to cover 8 cropping seasons.

The study will investigate the effect of CTF/LPT on the properties of trafficked and non-trafficked soils and will promote the best cultivation system required. The suitability of no/reduced tillage systems to produce good soil working conditions will be assessed. This will be achieved by evaluation of soil and water properties (structure and infiltration), power requirements (tillage forces, power and fuel) and agronomical aspects using plot and field scale studies under a typical arable rotation.

5. Programme of work

The proposed 3-year study will investigate the following in 5 Work Packages: -

WP 1: The effect of the 3 traffic systems and 3 tillage depths on crop development, soil and water properties, energy requirements and farming economics as initiated by Smith (2016) and managed by Millington will be continued for 3 more seasons. This will enable 8 seasons of arable cropping to be studied. This will be conducted on the existing experimental site of the Tillage x Traffic study at Harper Adams and currently co-funded by the Douglas Bomford Trust, Michelin and Vaderstad between 2011 and December 2017.

WP 2: The effects of the (i) high and low tyre pressures & tillage systems on the soil structure below the vehicle wheel tracks of the CTF treatments and (ii) effects of wheel mark eradication techniques, on crop development will be investigated. This will be conducted by correlating the soil porosity (using X-ray computed tomography) with root growth (hand excavation and root washing) at periods shortly after establishment (with depths to 250mm) in small zones of the main experiment.

WP 3: To compare the pressure distribution to depth in the soil below both conventional (high pressure) and ultra-flex (low pressure) tyres at the rated inflation pressure in controlled laboratory conditions using the pressure matting technique (Tekscan) pioneered by Misiewicz et al. (2015).

WP 4: Conduct an economic analysis over eight crop seasons using the crop performance and fuel use data, together with machine and labour costs for all traffic and tillage systems.

WP 5: Based on the project findings, recommendations on traffic and tillage management will be made and disseminated to growers through the routes indicated in Part 3.2.

The above programme is demanding and the relative emphasis between WP 2 and WP 3 is to be finally agreed with the co-sponsors and other stakeholders with whom we are in discussion, including the DBT.

The following parameters will be investigated:

- Soil and water:
  a) Soil structure and porosity: X-ray computed tomography
  b) Bulk density: core sampling at the soil surface and selected depths
  c) Penetrometer resistance: Eijkelkamp electronic penetrometer to 700mm depth
  d) Shear strength: shear vane at the soil surface and selected depths
  e) Available water: gravimetric moisture content measurements/Theta Probe/Time-Domain Reflectometer (TDR)/Neutron Probe
  f) Infiltration rate: double ring infiltrometer/mini disc infiltrometer

- Crop:
  a) Establishment: plant counts, soil cover and emergence rate
  b) Yield: combine (field experiment) and hand sampling (experimental plots)

- Energy:
  a) Number of work days: calculated from the field experiment
  b) Tillage forces and energy requirements: according to soil shear strength and fuel flow in the field experiment, respectively
  c) Practical mechanisation issues on the integration of a working system: according to the problems occurring in the plot and field experiment

6. Location

Location: Harper Adams University

References

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