Harper Adams University

Controlled traffic farming (CTF) delivers higher crop yield a result of improved root development

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Background

- Increasing world population

- Agricultural intensification

- Soil compaction

Soil compaction

Chamen *et al.* (2006) reported that since 1966 **average weight and power** of farm vehicles has approx. **tripled** and the **maximum wheel load** has **increased six times**.

Picture from pictures library www.stockvault.net

Picture by Magdalena Kaczorowska-Dolowy

Farming traffic

Kroulik *et al.* (2009) showed that:

random traffic farming practices, with conventional tyre inflation pressures, for wheat production covered some

86%, 65% and 45%

of the field with at least 1 wheel-pass for conventional (plough based) tillage, minimum tillage and direct drilling/zero-till respectively

Soil compaction's consequences

- increased bulk density and reduced pore size in trafficked areas (Millington, 2018)
- decrease of water infiltration (Godwin at al., 2015)
- Increased draft force (Godwin at al., 2015)

- crop yield penalty (Chyba, 2012, Godwin 2017).
- restricted root growth (Głąb, 2008)

How to produce food efficiently for next generations and maintain good soil health?

Large Marsh experiment

Field experiment launched in 2011 on the field within HAU campus, in Edgmond, TF10 8NB Newport, UK.

It is focused on the **effects of 3 different traffic systems**:

Random traffic with **standard tyres pressure (STP)**

Random traffic with **low tyre pressures (LTP)**

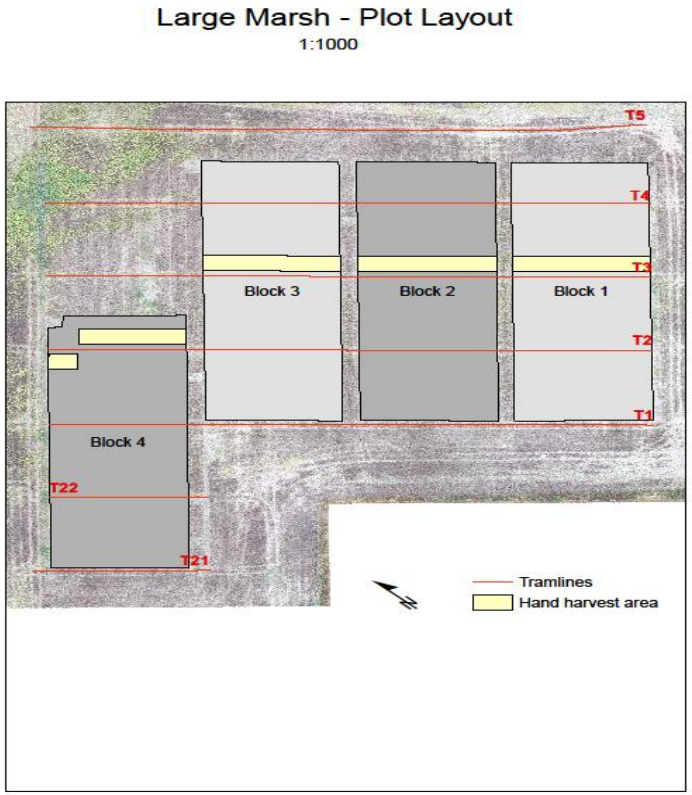
Controlled traffic farming **(CTF)**

Subject to **3 depths of tillage** (250 mm, 100 mm, zero tillage)

on crop yield, plant establishment, root growth and soil health.

Large Marsh experiment

3x3 factorial design in 4 complete randomized blocks (3 traffic x 3 tillage systems).



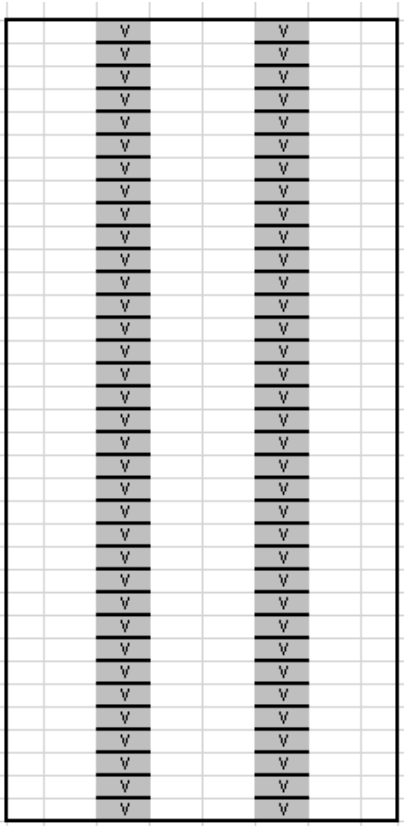
All plots have been posed to additional compaction treatment to reflect farming practice and average traffic on a field as reported by Kroulik (2009), however due to local limitation we obtained:

75%, 65% and 45% depending on different tillage practices

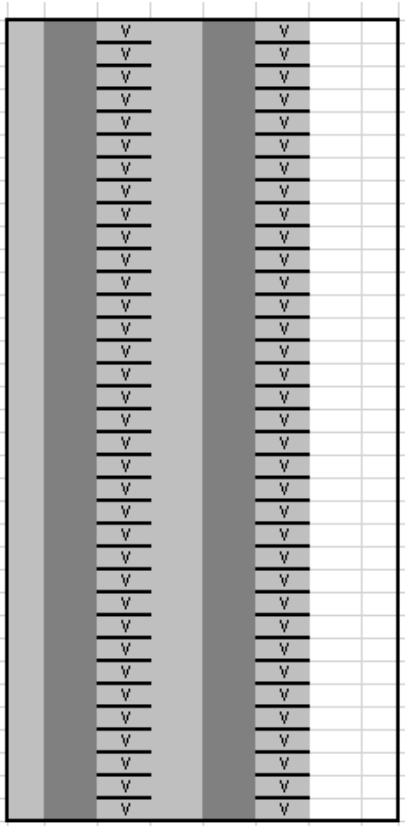
- **75% on STP and LTP plots with DEEP tillage;**
- **60% on STP and LTP plots with SHALLOW tillage;**
- **45% on ZERO tillage plots;**
- **30% on CTF plots- as a consequence of permanent wheelways for tillage and seeding operations. No additional compaction treatment was applied on CTF plots.**

Compaction layout

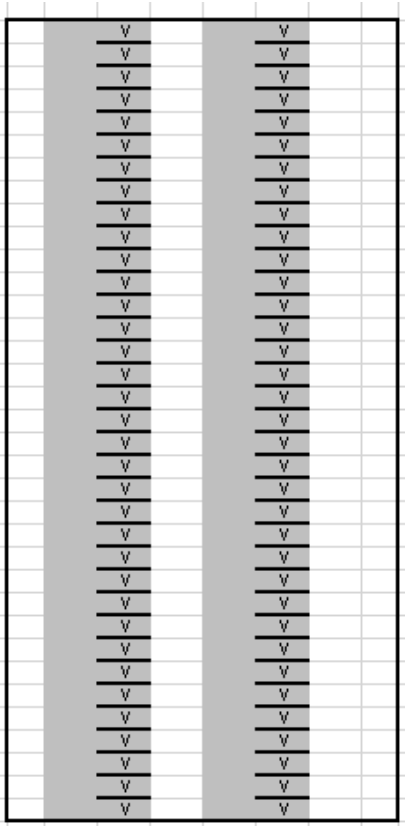
CTF (30%)



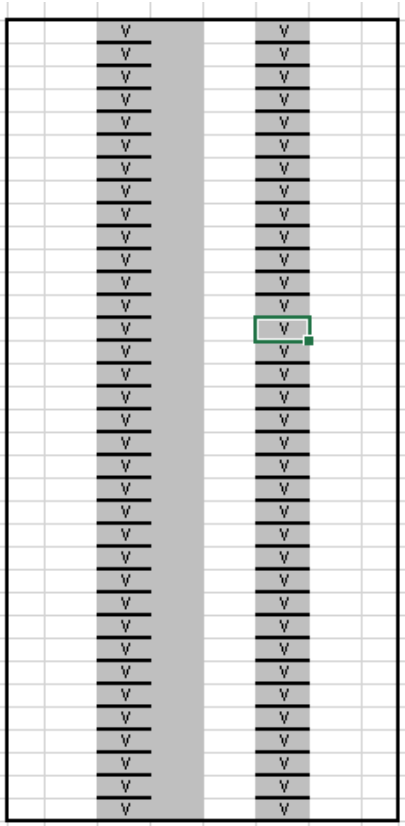
DEEP (75%)



SHALLOW (60%)



ZERO (45%)



So-far results (2018)

Crop – winter bean (*Vicia faba)*,

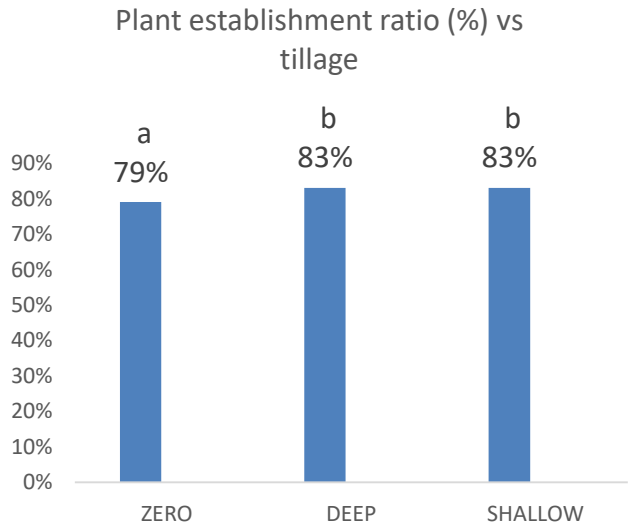
sawn Nov. 2017, harvested Aug.2018

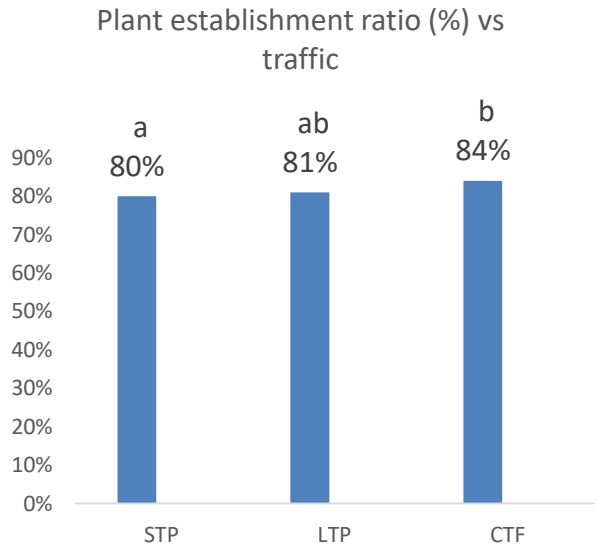
- Plant establishment
- Root analysis
- Combine crop yield

Plant establishment - results

Traffic *p=0.061*, tillage *p=0.029*, interactions *p=0.012*

Significant differences between means are represented by different letters





Tillage	Mean	
ZERO	79%	a
DEEP	83%	b
SHALLOW	83%	b

Traffic	Mean	
STP	80%	a
LTP	81%	ab
CTF	84%	b

Root analysis results

Analysis done at two strata:

0-50mm

>50mm

There was no significant difference found of any root characteristics for contrasting tillage systems with $p \leq 0.05$.

For most root characteristics, statistically significant differences were found between contrasting **traffic** systems **at the depth > 50 mm**.

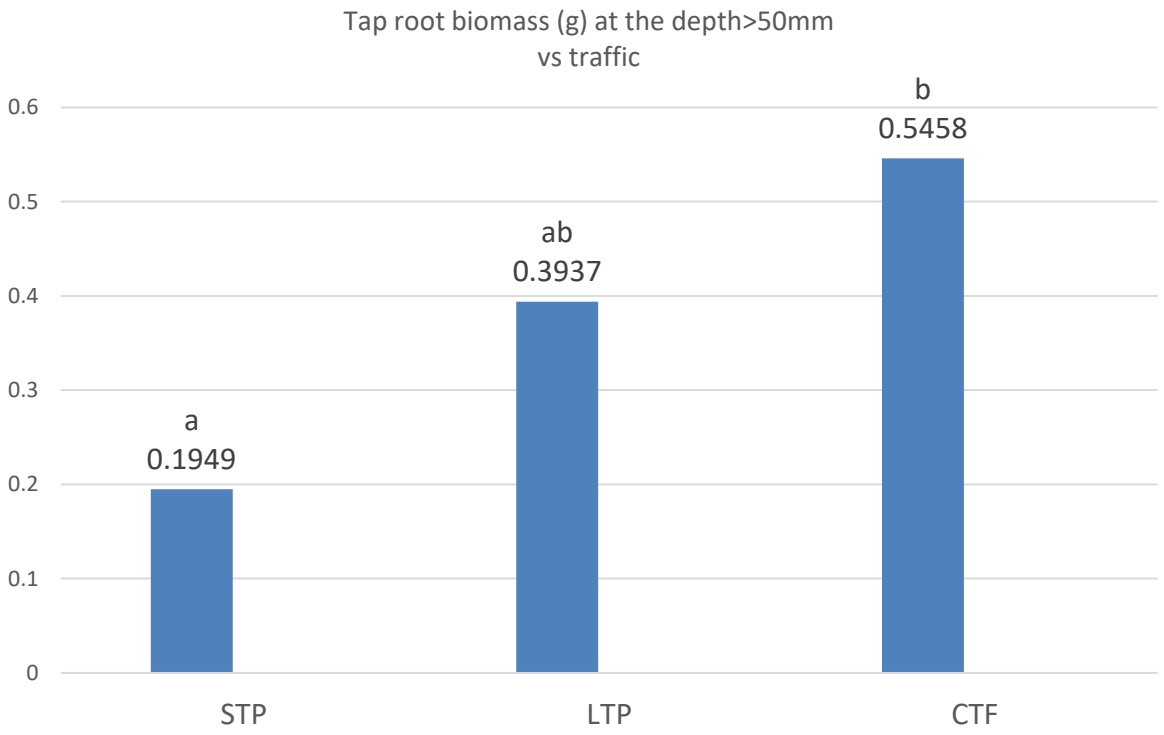
Root analysis results

At the depth > 50 mm, all analysed roots characteristics featured significantly different results for contrasting traffic systems:

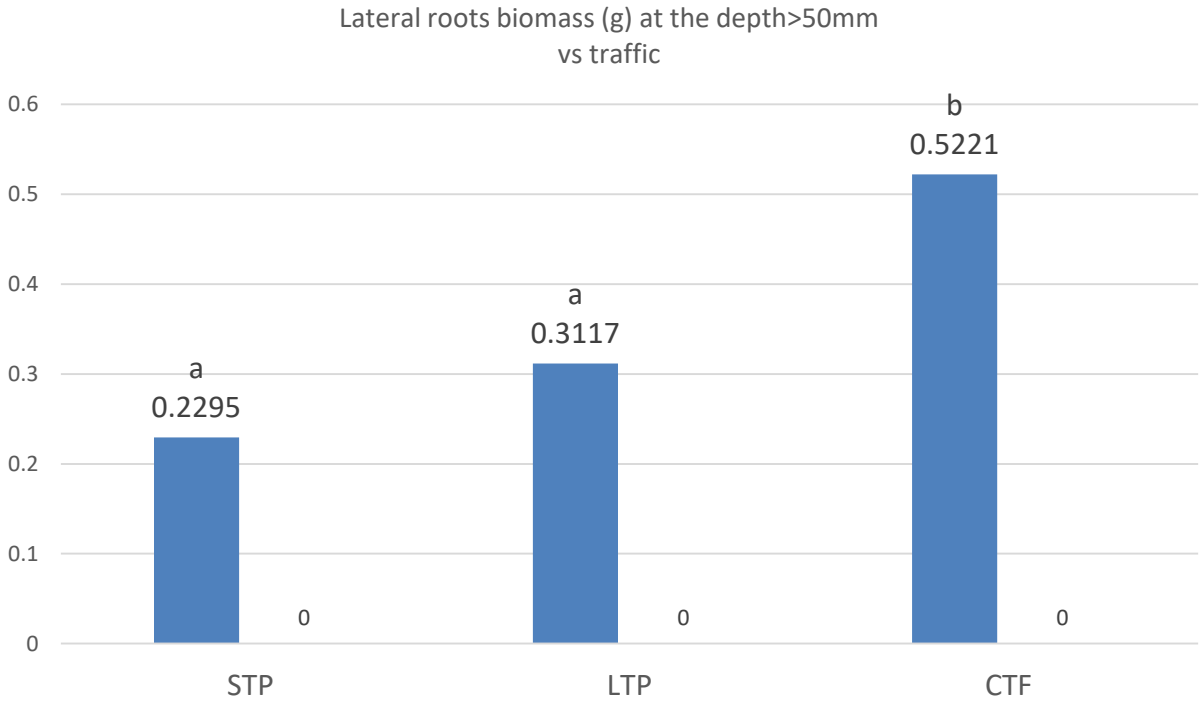
- tap root biomass,
- lateral roots biomass,
- total roots biomass (tap+lateral),
- number of lateral roots were

giving significanly greater results for CTF than STP.

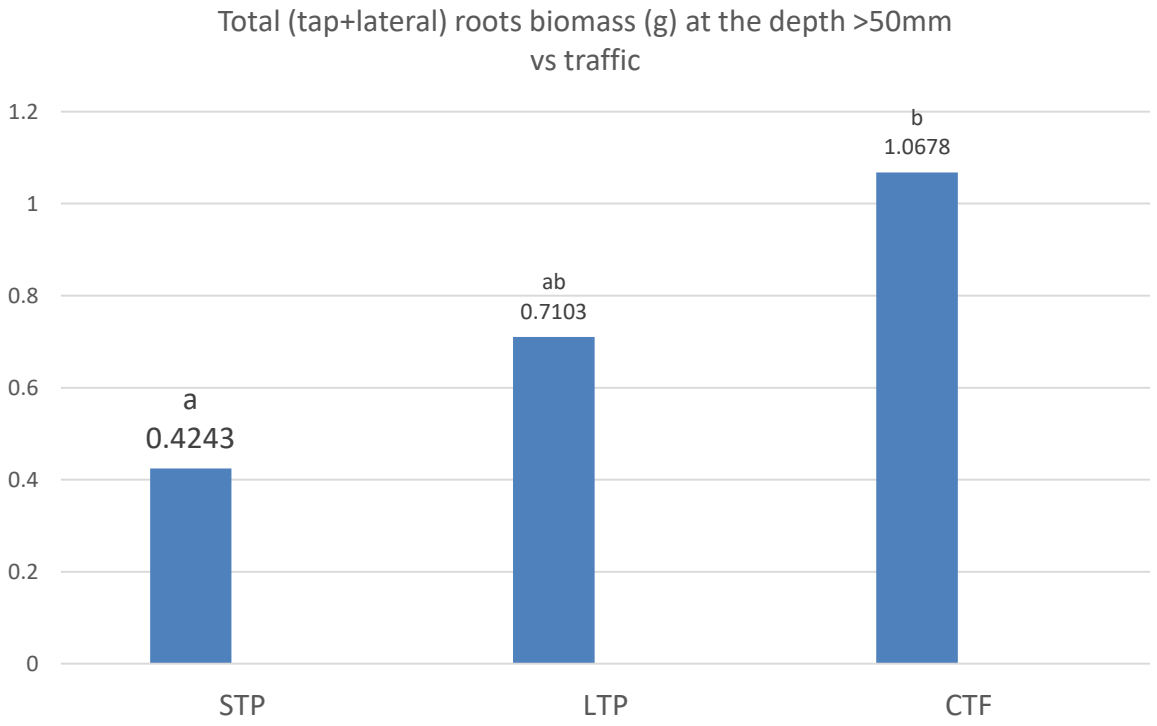
Tap root biomass



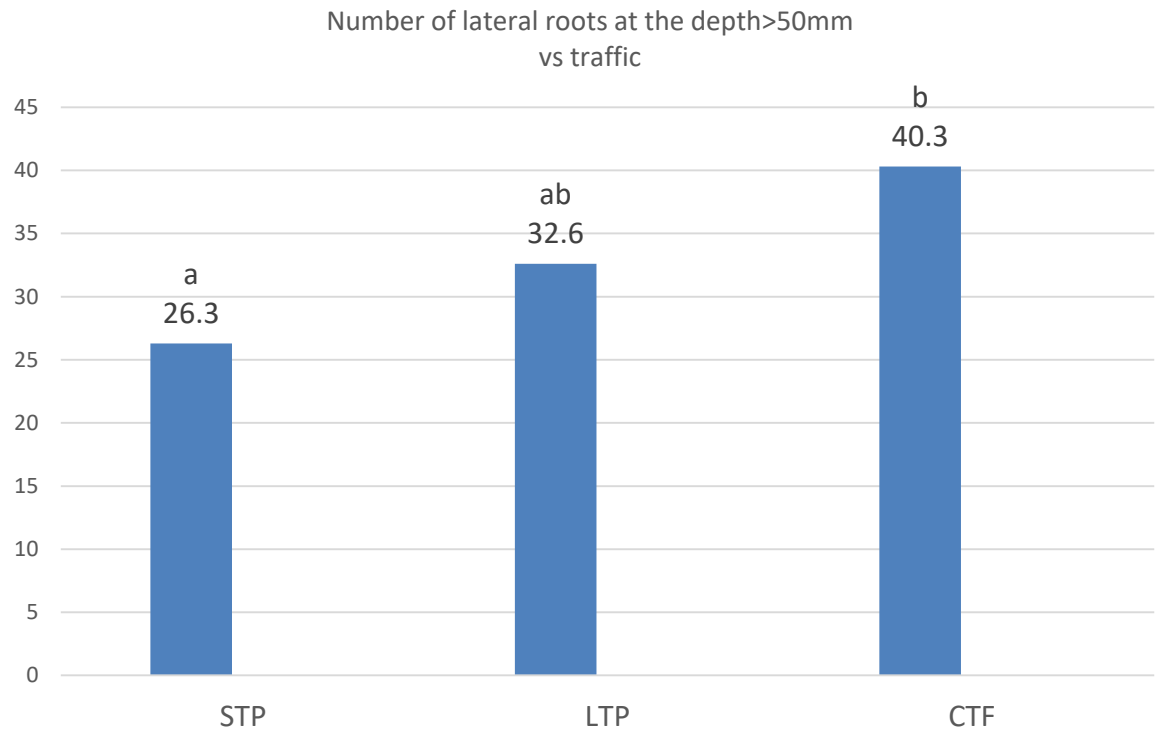
Lateral roots biomass



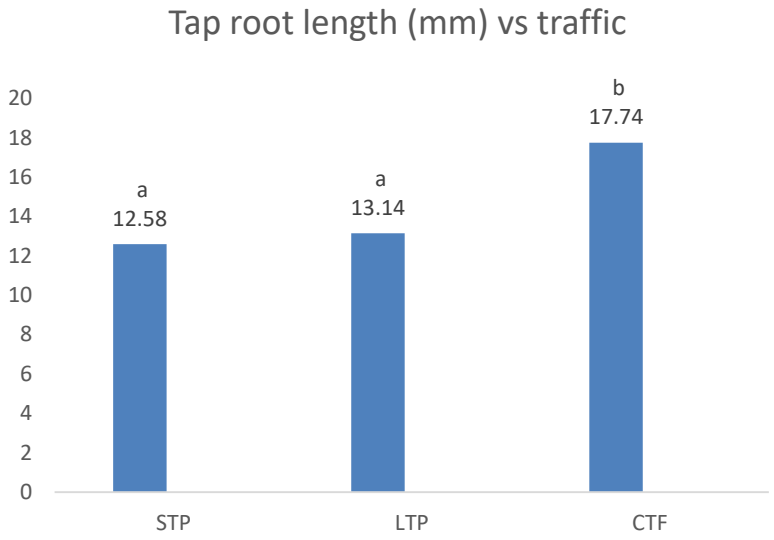
Total (tap+lateral) roots biomass

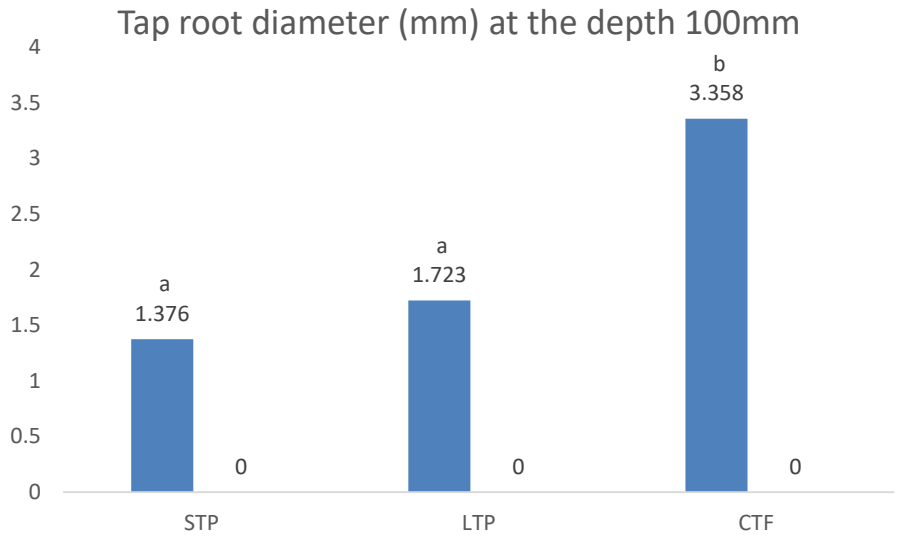


Number of lateral roots



Tap root length and diameter at the depth of 100mm





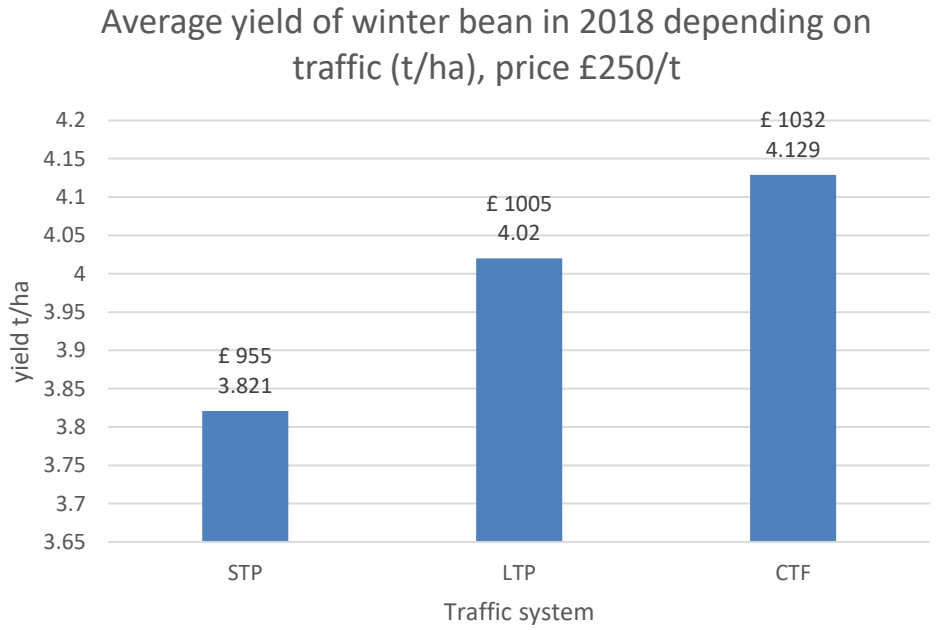
Winter bean yield in 2018

No significant differences between tillage treatments, only between traffic.

CTF delivered the highest crop yield.

Value of the yield/ ha from CTF was £77 greater than from STP and £27 greater than from LTP.

LTP wasn't found statistically significantly different from STP or CTF however it delivered higher crop by £50/ha in comparison to STP and £27 lower than from CTF.



Tillage/ Traffic	CTF	LTP	STP	Mean
DEEP	4073	4172	3794	4013
SHALLOW	4188	3869	3847	3968
ZERO	4127	4019	3821	3989
Mean	**4129**	4020	3821	3990

Conclusions

CTF delivered significantly greater yield of winter bean than STP;

CTF featured significantly improved plant establishment ratio in comparison to STP;

CTF ensured better conditions for roots growth than STP (the total root biomass, tap root biomass, number of lateral roots, and biomass of lateral roots in the deeper stratum (>50 mm) of the winter bean crop, were significantly higher for the CTF treatment, in comparison to STP).

Plant establishment ratio, root development and crop yield of the LTP treatments was greater but not significantly different from the STP treatments.

Further questions

What characteristics of CTF improves the plant establishment, root growth and crop yield?

- soil moisture, and earthworms population to be examined in 2019;

Do monocots also feature improved root development on CTF in comparison to STP?

- Root morphology of current crop (winter wheat) to be analysed in 2019;

What is the economy behind contrasting tillage and traffic system – economical analysis.

References

- Godwin, R. J., Misiewicz, P., White, D., Smith, E., Chamen, T., Galambošová, J. and Stobart, R. 2015. Results from recent traffic systems research and the implications for future work. Acta Technologica Agriculturae, 18 (3), pp. 57-63.
- Godwin, R. J., Misiewicz, P. A., Smith, E. K., Millington, W. A., White, D. R., Dickin, E. T. and Chaney, K. 2017. Summary of the effects of three tillage and three traffic systems on cereal yields over a four year rotation. Aspects of Applied Biology 134 pp. 233 – 241.
- Kroulik, M., Kumhala, F., Hula, J. and Honzik, I. 2009. The evaluation of agricultural machines field trafficking intensity for different soil tillage technologies. Soil & Tillage Research, 105 (1), pp. 171-175.
- Millington, W. A., Misiewicz, P. A., White, D. R., Dickin, E. T., Mooney, S. J. and Godwin, R. J. 2018. How to relate X-ray Computed Tomography derived porosities to physical soil porosity in a randomised 3x3 factorial traffic and tillage field experiment. American Society of Agricultural and Biological Engineers 2018 Annual International Meeting 1801651
- Misiewicz, P. A. 2010. The evaluation of the soil pressure distribution and carcass stiffness resulting from pneumatic agricultural tyres. Cranfield University.
- Soane, B. D. and van Ouwerkerk, C. 1994. Soil compaction in crop production. Amsterdam: Elsevier.
- Spoor, G., Tijink, F.G.J. and Weisskopf, P. 2003. Subsoil compaction: risk, avoidance, identification and alleviation. Soil and Tillage Research, 73 (1-2), pp.175-182.

Thank you for attention

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