The effects upon soil bulk density and tillering in winter wheat (*Triticum aestivum*), under conventional plough and shallow non-inversion tillage systems.

NIABTAG New Farming Systems

Aim Higher Easton & Otley College Associate College

UEA University of East Anglia

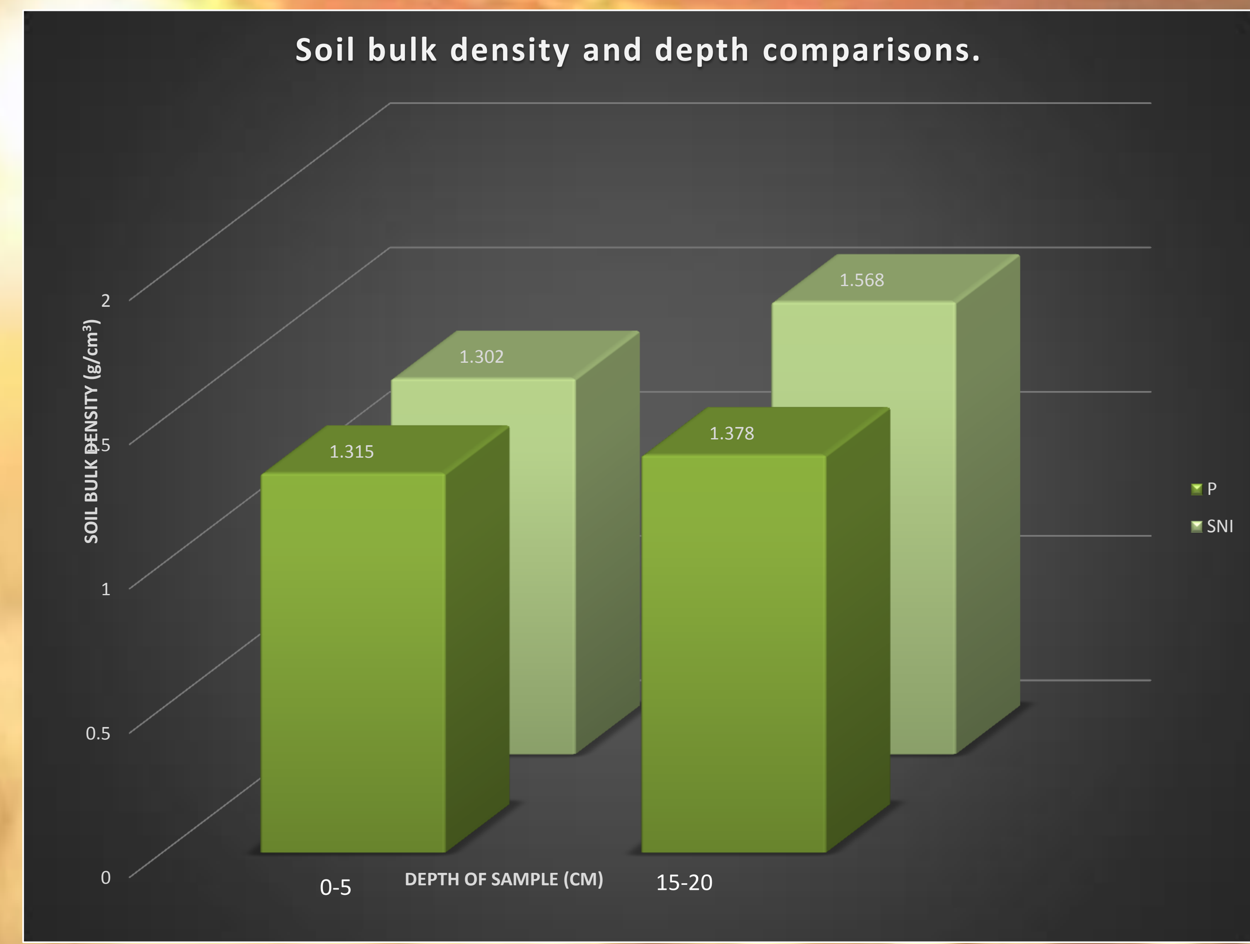
The New Farming Systems Project
is managed by NIAB TAG in conjunction with an independent advisory group
and supported by The Morley Agricultural Foundation and The JC Mann Trust.

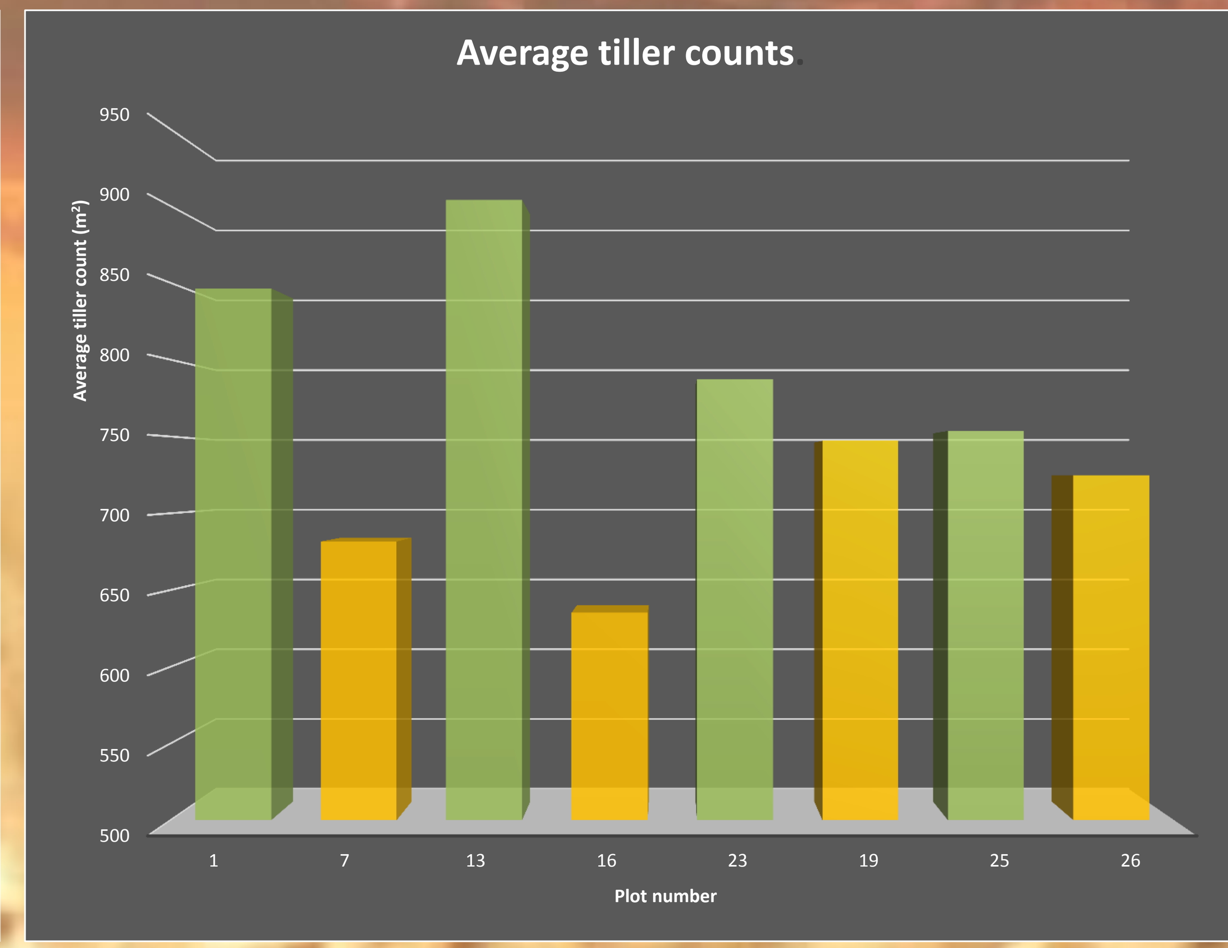
Methodology.

Results were obtained from an existing trial site, at the National Institute of Agricultural Botany (NIABTAG), New Farming Systems; Evaluating cultivation approaches study ~~project~~, established in 2008 upon a sandy loam, Ashley series soil. This investigation utilises 8 plots, of two treatments namely shallow non-inversion (SNI), performed by a modified SUMO implement and a conventional plough (P) system under the crop winter wheat (*cv. Evolution*). Two cores were collected at random, at surface level, to provide a soil bulk density (SBD) value at 0-5cm, and two at 15-20cm. Utilising the SOP as provided by Morris, (2017). This action was taken in response to findings published by Dam, et al. (2005), who established significant variation in BD between the layers, specifically a higher BD value in the lower profile of non-inversion tillage systems. In addition to this tiller counts were carried out at growth stage 31, taking five counts from each plot, to provide an average per m^2 .

Aim: To establish a relationship between the soil structure created under SNI and P systems, and tillering in winter wheat.

Hypothesis: The P cultivation system will sustain a higher tillered plant population, despite having created a higher level of soil compaction as expressed through higher SBD.





Literature review summary.

The average yield penalty has been found to be roughly a 2-4% penalty for a SNI system in comparison to P systems (Stobart, et al. 2014). The depth of cultivation has also proved influential in investigating soil properties, with consistent findings of higher BD values below 15cm, over both cultivation treatments (Dam, et al. 2005). Poor root growth within wheat can be attributed to SBD values within the range of 1.46-1.90Mgm^{-3}, and penetration levels exceeding 3MPa (Lamperlanes, et al. 2003), which have proved critical in decreasing nitrogen and water uptake, resulting in reduced root lengths (Hakkenson, et al. 2000).

Compaction caused by cultivation additionally effects soil oxygen concentrations for gaseous exchange and soil biological activity through reducing soil aeration. Critical limits have been established at 10% macropore volume with <8% air capacity (Dorner, *et al* 2010). In terms of the soil water potential and infiltration rates, P systems are seen to provide higher rates due to the increase in macropores. Soil gravimetric water content is known to increase as SBD increases which can lead waterlogging (Lamperlanes, *et al.* 2003), however Atkinson (2008) concluded a strong trend between water content and tillers per m^2, establishing the optimum mesostructure at 0.4-1.0mm pore area, at 18% porosity. Tillering determines the number of spikes bearing grain at maturity, with low porosity known to decrease tillering and lead to partial crop nutrient deficiencies.

Results and Analysis.

Influence of SBD; No statistically different variation was noted in SBD between the systems at 0-5cm, showing that the initial imbibition and establishment processes were unaffected by treatment, supported by the initial ~~tiller~~ plant counts at growth stage (GS) 21 of **203/m^2** for P and **207/m^2** for the SNI system. BD was significantly influenced at the deeper 15-20cm zone, with an average value of **1.568g/cm^3** within the SNI plots as compared to **1.378g/cm^3** under P, exceeding the level, known to restrict root growth. The lower porosity of the structured created within the SNI plots was consistent at depths below 5cm. The penetration resistance results support the trends represented through which soil strength exponentially increased below 8 inches, the cultivated depth, with the SNI system at 14 inches reading 3.278MPa, above the threshold known to restrict rooting.

Influence to tillering; The average counts amounted to **697/m^2** under SNI and for P, **823/m^2.** Green area index scores at GS 25 were **0.51**. SNI **0.71,** respectively, showing a clear trend in favour of conventional tillage, representing the influence of factors limiting growth even at these early stages.

Discussion.

The results produced conclude that SNI systems will not affect the establishment of a crop, through these parameters but the subsequent root and shoot development, supported by the F value of 0.021, representing significance in similarity between SBD at 0-5cm, between the treatments. The results provided evidence that mechanical intervention increases porosity, aiding root penetration, positively influencing water availability and soil aeration. The penetrometer reading of 3.27 MPA obtained from 14 inches under SNI treatments, is sufficient to restrict growth (Lamperlanes, *et al*. 2003), which corresponds with the SBD at 15-20cm, leading to conclusions that the soil structure is the factor influencing the decrease in tiller numbers. These results both match the hypothesis through the P system sustaining a higher tiller population, and negate it through decreasing levels of SBD seen under P, consistently throughout the profile. Further analysis into this research would suggest looking into rooting assessments, in relation to, and solely the yield achieved. Physical root assessments would represent the influence of the soil structure, in relation to BD upon the crops growth, to support these findings. From this it is clear, for optimum yields, conventional P cultivation will provide substantial benefits.

References: 1) Atkinson, B.S. 2008. Identification of optimum seedbed preparation for establishment using soil structural visualisation. *HGCA; PhD Summary Report No. 6*. 6 (1), p8, 17. 2) Dam, R.F., Medhi, B.B., Burgess, M.S.E., Madramootoo, C.A., Mehuys, G.R., Callum, I.R. 2005. Soil bulk density and crop yield under eleven consecutive years of corn with different tillage and residue practices in a sandy loam soil in central Canada. *Soil and Tillage Research*. 84 (1), p41-53. 3) Dorner, J., Sandoval, P., Dec, D. 2010. The role of soil structure on the pore functionality of an utisol. *Journal of Soil Science and Plant Nutrition.* 10 (4), p495-508. 4) HaÊkansson, I., Lipiec, J. 2000. A review of the usefulness of relative bulk density values in studies of soil structure and compaction. *Soil and Tillage Research*. 53 (1), p71-85. 5) Lampurlanes, J., Cantero-Martı´nez, C. 2003. Soil Bulk Density and Penetration Resistance under Different Tillage and Crop Management Systems and Their Relationship with Barley Root Growth. *Agronomy Journal*. 95 (3), p526-536. 6) Morris, N.L., Miller, P.C.H., Orson, J.H., Froud-Williams, J.H. 2010. The adoption of non-inversion tillage systems in the United Kingdom and the agronomic impact on soil, crops and the environment—A review. *Soil and Tillage Research*. 108 (1-2), p1-15. 7) Stobart, R., Hallett, P.D., George, T.S., Morris, N.L., Newton, A.C., Valentine, T.A., McKenzie, B.M. 2014. Platforms to test and demonstrate sustainable soil management: integration of major UK field experiments. *Aspects of Applied Biology*. 127 (1), p233-240.