#7438 PREPARATION OF A PRECISION RIPPING PLAN USING MANUAL VERTICAL PENETROMETER MEASUREMENTS

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ABSTRACT

Large weight tractors and farm machinery used in agriculture significantly contribute to the formation of compacted and thickening layers starting from the soil surface. There are suitable deep ripping technologies to eliminate harmful soil compaction, which are extremely energy and cost demanding.

The presented study was performed in a complex long-term tillage trial set up on calcareous chernozem soil in the eastern part of Hungary, west of Debrecen. A vertical, static hand-held "Penetronik" type penetrometer was used to design precision soil ripping. The device determines the position of the measuring points using DGPS. It measures volumetric soil moisture content with a capacitive sensor and soil penetration resistance (MPa) with a mechanical sensor which has a probe with a 60° cone angle.

Strip tillage shows greater looseness than winter ploughed treatment. Soil ripping has a positive effect on soil resistance even after harvest. The polygons were selected from the vector GIS database that formed the map at a depth of 5 cm, and then their combined area was determined for each layer. These areas were plotted as a percentage of the cultivated area.

According to the measured data, compaction should be reduced in 70% of the total area in the top 10 cm soil layer, where trampling damage due to agro-technical interventions is located. If a medium deep ripper (45 cm effective working depth) is available as a tillage tool, ripping can be designed for this maximum depth. The traditionally (winter ploughing) cultivated area had the highest intervention area. When using precision strip tillage technology, despite the fact that 30% of the area is cultivated within a growing year, a much smaller rate of intervention is required with a medium deep ripper.

INTRODUCTION

Large weight tractors and farm machinery used in agriculture significantly contribute to the formation of compacted and thickening layers starting from the soil surface (Regman et al., 2018). There are suitable deep ripping technologies to eliminate harmful soil compaction, which are extremely energy and cost demanding (Birkás, 2006). In precision agriculture, it is possible to treat spatially delimited unfavourable soil patches. Following this principle, the extent of the zones to be ripped on the field and the depth location of the solid soil layers can also be determined during the planning of the deep ripping. Penetration resistance determined by a contact mechanical sensor is one of the most commonly used methods for studying soil compaction-looseness, depth location and extent of compacted layers, and spatial and temporal changes in soil physical condition, which can be compared with a continuous soil resistance measurement method (Birkás, 2006). The mechanical resistance of the soil varies inversely with the soil moisture content and in direct proportion to the bulk density (Champbell and O`Sullivan, 1991). At a given moisture content, soil resistance increases with increasing bulk density, and with increasing moisture content at a given bulk density, soil resistance decreases (Ehlers et al., 1983). The bulk density ($g\cdot cm^{-3}$) of the soil was calculated from the soil resistance and moisture content values using a pre-defined empirical formula. By means of a penetrometer, measurements with a large number of repetitions can be performed, which can be used to create precision soil ripping maps.

MATERIALS AND METHODS

The presented study was performed in a complex long-term tillage trial set up on calcareous chernozem soil in the eastern part of Hungary, west of Debrecen. A vertical, static hand-held “Penetronik” type penetrometer was used to design precision soil ripping. The device determines the position of the measuring points using DGPS. It measures volumetric soil moisture content with a capacitive sensor and soil penetration resistance (MPa) with a mechanical sensor which has a probe with a 60° cone angle. Soil compaction was determined at 400 measuring points$\cdot$ha^{-1} in the sample area. The experiment was started in 1989 and until 2014, winter ploughing, spring ploughing and spring shallow cultivation were the three tillage treatments, and the experiment also includes two irrigation treatments.

In 2015, winter ploughed tillage remained unchanged; instead of spring ploughing, strip tillage was introduced and spring shallow tillage was replaced by ripping. In the case of winter ploughing, the measurement points were determined randomly. In the ripping tillage variant, measurements were performed in a direction perpendicular to the cultivation. In the case of strip tillage, where 30% of the area is cultivated strip and 70% is uncultivated strip spacing, measurements also took place perpendicular to the cultivation direction in 2018. Depth values for bulk densities above 1.5 g$\cdot$cm^{-3} (Birkás, 2002) were sorted and interpolated by the kriging method, and then displayed using Quantum GIS.

RESULTS AND DISCUSSION

By displaying the precision ripping plan, the demand of different basic crops for ripping after the maize harvest at the end of a growing period can be observed. The map of the ripping plan shows that the winter ploughed treatment requires a greater depth of ripping. Strip tillage shows greater looseness than winter ploughed treatments. Soil ripping has a positive effect on soil resistance even after harvest (Figure 1).

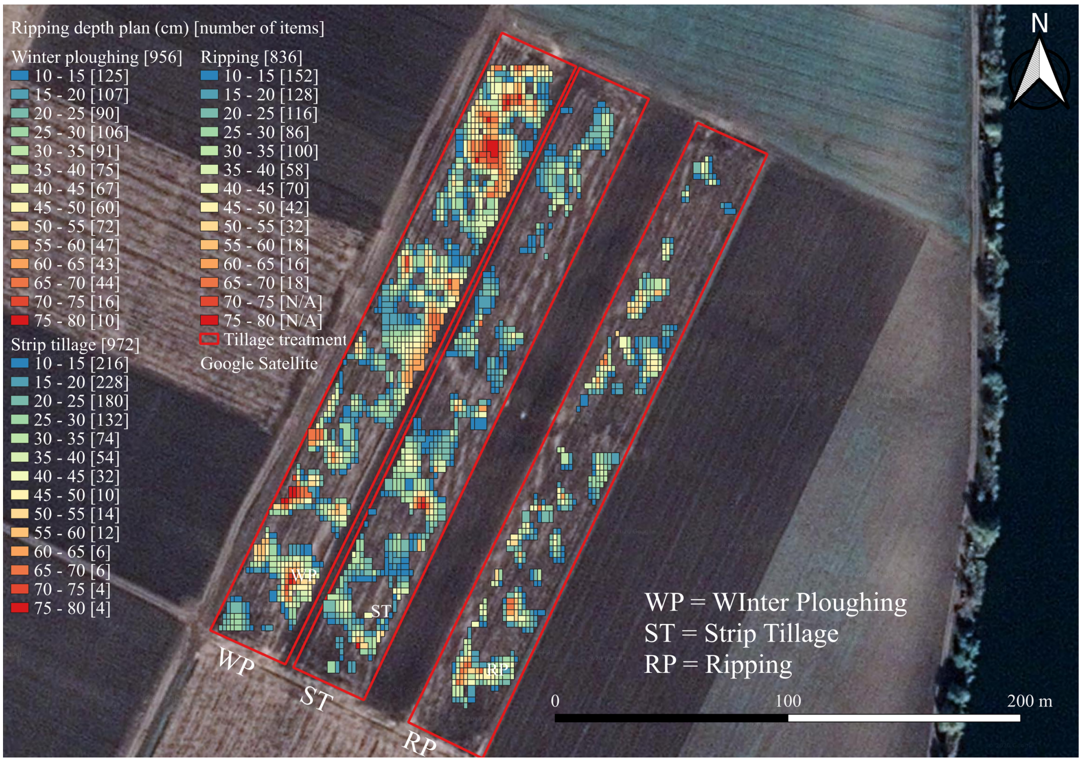

Figure 1. Precision ripping plan for different primary tillage and irrigation treatments

The polygons were selected from the vector GIS database that formed the map at a depth of 5 cm, and then their combined area was determined for each layer. These areas were plotted as a percentage of the cultivated area.

According to the measured data, compaction should be reduced in 70% of the total area in the top 10 cm soil layer, where trampling damage due to agro-technical interventions is located. If a medium deep ripper (45 cm effective working depth) is available as a tillage tool, ripping can be designed for this maximum depth. In the case of the winter ploughed cultivation at a depth of 45 cm, 16.5% of the area, in strip tillage 3.2% of the area, and in the case of ripping 6.7% must be cultivated with a medium deep ripper. For a depth of 40 cm to be ripped, 20% should be ripped in the case of winter ploughing, 5% in strip tillage and 10.4% in the case of ripping cultivation. At a cultivation depth of 35 cm, the proportion of the area to be ripped is 23.9% in the case of the winter ploughing treatment, 8.7% in strip tillage and 10.4% in the case of the ripped area. In the upper 30 cm layer, the proportion of the area to be cultivated is 28.8% in the case of winter ploughed treatment, 14.1% in strip tillage and 18.8% in the ripped. (Figure 2).

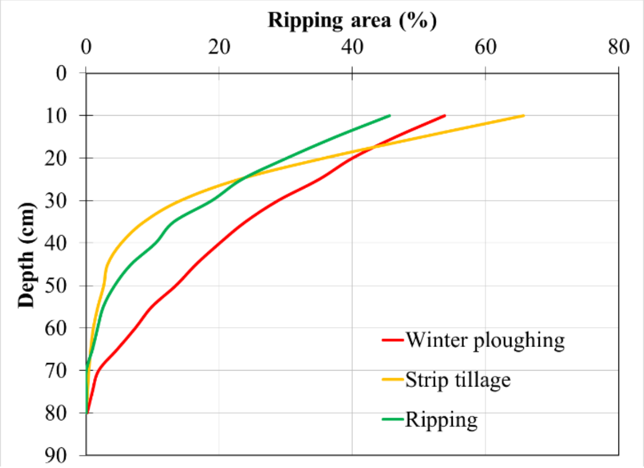

Figure 2. Correlation between the area and the depth of planned ripping

It was confirmed that soil mapping based on measurements with a contact mechanical sensor is suitable for preparing a precision ripping plan. A proper sampling strategy is required for the measurements, and soil moisture data must also be available to determine soil compaction. The method and depth of primary tillage determine the proportion and depth of intervention with a medium-depth cultivator relative to the cultivated area. The traditionally (winter ploughing) cultivated area had the highest intervention area. When using precision strip tillage technology, despite the fact that 30% of the area is cultivated within a growing year, a much smaller rate of intervention is required with a medium deep ripper.

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