THE EFFECT OF SOIL TILLAGE PROCESS ON SOIL PHYSICAL PARAMETERS, YILED OF OIL SEED RAPE AND PROFITABILITY OF PRODUCTION

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Abstract. *Large scale exmeriment was established in one growing season (2018/2019) in Hungary, Szeged-Öthalom. Experimental field were 3-3 ha. Applications has the same general agrotechnical control and plant protection, but differed from each other the method of tillage. Our aim was to observe that field cultivator against conventional ploughing, and disc-whether has an effect to the soil physical parameters (soil moisture, mechanical resistance, soil structure),potential yield of oil seed rape and profitability of production. If we ploghed the experimental filed, mechanical resistance was much bigger under the cultivated layer, but it was not created critical soil compaction or plough pan. Because of the mechanical resistance, soil moisture content in the subsoil (30-40 cm deep) was low. Clod forming effect is also determined. For oil seed rape is essential to aggregate soil stuction in the fertile layer, which can be achieve with combinator just before sowing. Unfavorable soil condition influenced development, crop formation, and yield of oil seed rape, furthermore the profitability of production. We have got the lowest yield and profit with conventional ploughing. Primary tillage with disk to 20 cm deep in surface soil evolved enough loose soil structure. In this layer water leaked and soil moisture has better condition. Even deeper layer became harder and drier, which delayed the root development of oil seed rape. Root development has an effect on nutrient and water uptake, thus tillage with disk has a medium yield and profit. Field cultivator with clod breaking roller can be able to change cultivation depth and suitable for stubble stripping, primary tillage, and seedbed preparation too. In this time we have got the best values of physical parameters, and profit from all soil tillage process.*

Keywords*: oil seed rape, field cultivator, plough, disc, soil physical parameters, yield, profitability*

INTRODUCTION

Oil seed rape is one of the most popular oilseed in Hungary. However, farmers are not always able to fulfill its agrotechnical requirement. Even if the farmers know what kind of soil condition requires rape in the phase of germination or root development, they often use an unsuitable machine for soil tillage.

Farmers cannot influence weather factors, but they can make some steps to prevent and repair weather losses (JAKAB ET AL. 2014, KRISTÓ ET AL. 2013, SÁRVÁRI ET AL. 2021). The extreme weather conditions of the last years in Hungary showed that the farmers need to adapt to changing terms by the help of agrotechnical factors (BIRKÁS ET AL., 2020, DEKEMATI ET AL. 2020). The soil, which suffers from tillage defects (soil compaction, texture run-down, gather dust, soil crusting) cannot reduce the losses which were caused by weather conditions. Farmers cultivate field since the ancient times, ploughing was the most widespread cultivation method until the 70's, when they thought it over the disadvantages of the ploughing and looked for opportunities for other methods of cultivation. It has to be promoted to leave out the traditional cultivation methods in the interest of the reduction of soil compaction, organic matter decrease, gather dust, carbon dioxide issue, soil vaporization (BIRKÁS 2000, GYURICA 2000,

HAKANSSSON ÉS VOORHEES 1997, HOLLAND 2004, TÓTH 2005), because of its uneconomical and energy waste effect (BIRKÁS 1993). It is necessary to modernizate cultivation because of the increasing environmental load, increasing cost, climate changes and soil degradation (LINN and DORAN 1984, PAUTIAN ET AL. 1998). So today we are trying to cultivate our land with fewer turns, lower energy input and with sustainable solutions. There are several possibilities among the available cultivation methods which are suitable to save the moisture of the soil and decrease the number of turns (BIRKÁS 2001, BIRKÁS 2010, TÓTH and DUNAI 2015). Land use affects the soil (MORENO ET AL. 1997) and plant (COCIU, 2011, HILL and CRUSE 1985) in all respects, so it is necessary for the farmers to have specialized knowledge to understand the relationship of the soil condition (GYURICZA 2001) so that they can select more suitable field cultivator.

The aim of our research is to determine the effect of conventional rotary (plough), no-till (disc) and a modern tillage method: filed cultivator with adjustable depth on soil physical parameters (soil moisture content, soil resistance, agronomic structure) and on the yield of oil seed rape and profitability of farming.

MATERIAL AND METHODS

Our farm-experiment was set up in 2018-2019 in Hungary, in Szeged-Öthalom, on 3 ha plots. The soil of the experiment is deeply salty meadow chernozem soil with medium N supply, good P_2O_5 and K_2O supply. The general agrotechnical and plant protection works of each treatment did not differ from each other, they differed only in the tillage procedures (*Table 1*) The precursor of the experiment was winter wheat. In the experiment, the KWS Hybrirock rapeseed hybrid was sown on 30 August 2018 and harvested on 25 June 2019. Typical weather data during the growing season are given in Table 2.

Table 1

The treatments of experiment

number of treatment	name of treatment (tillage mode)	name of machine	time of use	depth of tillage
1.	cultivation	field cultivator field cultivator field cultivator	06. 07. 2018. 23.07. 2018. 21.08. 2018.	4-5cm 10-12cm 18-20cm
2.	plough	light disc plough light disc combinator	06. 07. 2018. 23.07. 2018. 10. 08. 2018. 21.08. 2018.	10-15cm 25-30cm 10-15cm 8-10cm
3.	disc	light disc light disc light disc conventional field cultivator („grubber”) combinator	06. 07. 2018. 17. 07. 2018. 23.07. 2018. 10. 08. 2018. 21.08. 2018.	10-15cm 10-15cm 10-15cm 20-25cm 8-10cm

Table 2

Meteorological data

month	Precipitation (mm)	Temperature (C°)			Sunlight duration (hours)
		middle	max.	min.	
September	7,5	18,6	34,6	1,0	286
October	4,7	14,1	26,5	1,3	205
November	21	7,7	23,5	-6,0	131

December	28	1,3	11,3	-12,2	83
January	20	-0,2	11,4	-13,6	86
February	13	4,1	20,5	-7,9	175
March	2	9,3	23,9	-4,7	236
Ápril	55,5	13,3	30,3	3,0	227
May	136,5	14,9	26,5	2	197
June	134,7	23,1	33,3	14,1	323
Altogether	422,9				1947

During the sowing period, the moisture content of the soil, soil resistance and the soil structure were determined in 3 repetitions. In determining the moisture content of the soil, 5 depth levels (0-10cm, 10-20cm, 20-30cm, 30-40cm, 40-50cm) were taken and then the moisture content of the samples was determined by drier. Measurement of soil resistance was performed with penetrometer at the 5 depth level of the ground (0-10cm, 10-20cm, 20-30cm, 30-40cm, 40-50cm).

To determine the soil structure, soil samples were taken to a depth of 30 cm, which were divided into 6 fractions (0-0.25mm, 0.25-3mm, 3-5mm, 5-10mm, 10-20mm, 20mm <) using a soil sieve. The yield of rapeseed was determined by harvesting 20m^2 sample plots from the farm experimental plots in 4-4 repetitions per tillage system with a small-plot Sampo combine, and then determining the yield of rapeseed per hectare by correcting for 9% moisture.

RESULTS AND DISCUSSIONS

Figure 1 can study the effect of tillage on soil moisture. The highest moisture content in the top 10cm layer of soil was in ploughing (16.3%), with only slightly less moisture content (15.43%) cultivating. The minimum moisture content was measured in the upper 10cm layer of the soil for disc cultivation (15%). In the next layer (10-20cm) of 10cm, tillage methods did not cause much difference in soil moisture.

In contrast, in the 20-30 cm soil layer, the different tillage methods already showed different moisture contents. At the next two soil levels (30-40cm and 40-50cm), however, we were able to detect higher soil moisture when using the field cultivator, which proves that it spares the lower layers of the soil and, unlike other tillage systems (plough and disc), did not dry the soil.

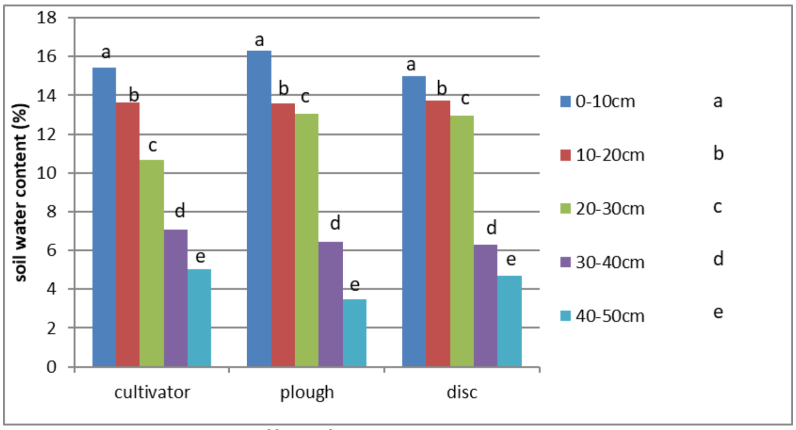

Figure 1. Effect of soil tillage on the soil moisture

Figure 2 can see soil resistance of the upper 50 cm part of the soil depending on the soil cultivation systems. Within the soil resistance, the penetrometer was punctured without almost resistance to the upper 10cm layer (0.16MPa) when the cultivator is self-use. In the case of plowing and disc cultivation, almost the same (0.80MPa) soil resistance was observed. When applying the field cultivator, the soil resistance increased almost uniformly to the 40cm soil layer, ie a compacted, hard sole layer wasn't found, and then the soil resistance in the lower layers (40-50cm) decreased.

By using ploughing, the soil resistance at 20 and 30cm was almost the same, and then the value increased from 30cm. When cultivating with the disc, the maximum soil resistance is measured. Unlike the other two soil tillage systems tested, the soil (3,43MPa) became more compact from the upper 20cm soil layer, which increased to 4.25 MPa in the 40cm layer of soil and 4.41MPa at 50cm depth.

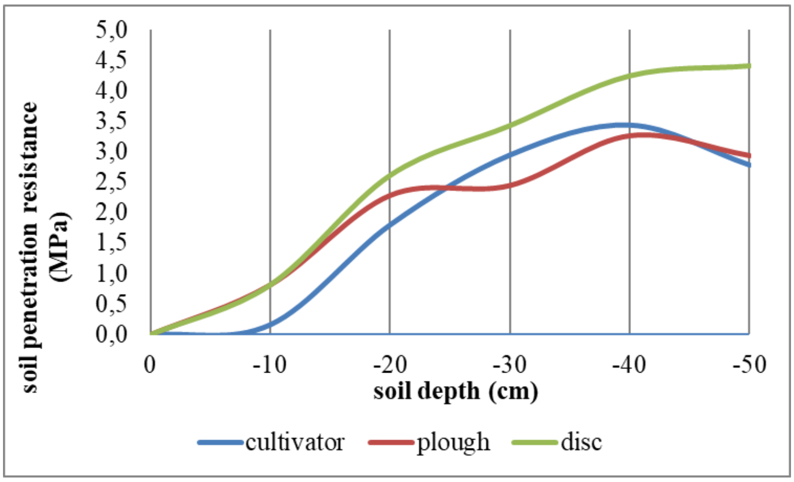

Figure 2. Effect of soil tillage on the soil resistance

Using the ploughing at the soil depths of 20 and 30 cm, the agronomic structure of the soil in the cultivated layer was determined with a separate series of sieves in the case of the applied tillage systems. The weight percentage distribution of the soil grain fractions formed in the case of the studied tillage practices can be studied in Figure 3.

When the field cultivator was used on its own, only 1.36% of the soil was present in the 0-0.25 mm grain fraction, ie hardly any dust was formed during cultivation. When plowing soil preparation was applied, the 0-0.25 mm grain fraction included 1.43% of the soil, i.e. the proportion of dust fraction was slightly higher than in the previous tillage system. However, in the case of the disc tillage system, much higher dusting was observed, 2.3% of the examined soil sample belonged to the 0-0.25 mm grain diameter category.

In the 0.25-3mm particle size category, 21.9% of the soil was classified in the cultivator process, 18.28% of the soil was used for ploughing, while in the case of the disc tillage system we were able to classify 25.53% of the soil sample tested.

The particle size fraction of 3-5mm included 28.5% of the soil using the field cultivator, ploughing was classified as 24.98% of the soil, and 30.45% of the soil sample was 3-5mm particle size using the disc tillage system.

Soil crumbs of 5-10 mm were present in the soil samples in 31.24% of the cultivator tillage, 36.7% in the ploughing, and 25.28% in the case of disc tillage.

10-20 mm soil clusters were produced in 11.53% of the field cultivator, 11.85% in the summer ploughing, and 10.19% in the disc tillage process.

During the study, the soil sample contained more than 20 mm of soil in cultivator tillage in 5.48%, in ploughing in 6.76%, and in the case of disc tillage in 6.25%.

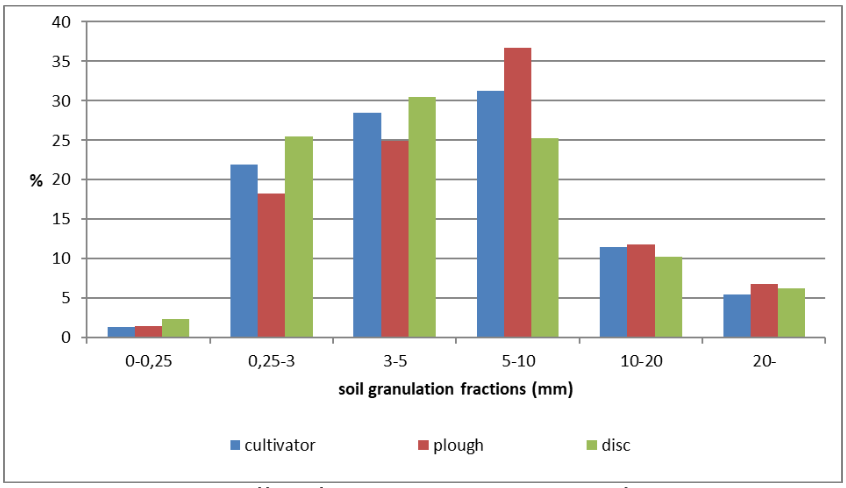

Figure 3. Effect of soil tillage on the soil particle fraction

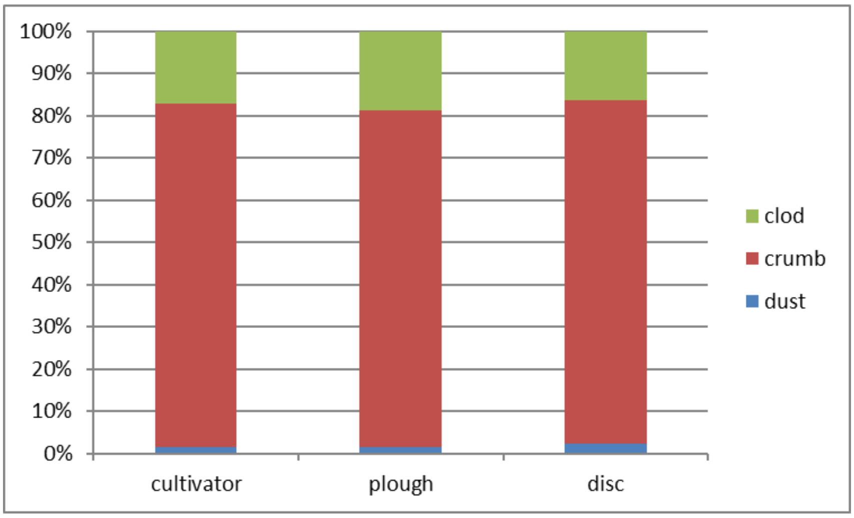

Figure 4 Effect of soil tillage on the soil agronomic stucture

The effect of the applied tillage systems on the agronomic structure of the soil was also examined. From the point of view of agronomic structure, the soil particles of 0-0.25 mm size can be separated into dust, the soil parts of 0.25-10 mm into crumbs, above 10 mm into clod categories. Figure 4 shows the relative proportions of dust, crumbs and clod soil structural units as a function of the studied tillage systems. The proportion of unwanted dust fraction was the lowest when using the field cultivator (1.36%), while the dusting was the highest when using disc tillage (2.3%). Studying the crumb fraction most favorable for plant development and sustainable soil condition, it can be concluded that the cultivated area had the highest proportion (81.63%). The clod fraction, which is undesirable from the point of view of production, especially when germinating small seeds (such as rapeseed), was the highest in plough soil preparation (probably due to the ploughing effect of the plow) (18.61%), while field cultivator (17%) disc (16.45%) systems were obtained lowest values.

Table 3 shows the yield per hectare of winter oilseed rape, the profitabily per hectare, depending on the tillage systems used. Looking at the yield, it can be stated that the highest yield was achieved in the field cultivated area, and the lowest was produced in the application of ploughing, although we could not detect a significant difference between them. Studying the impact of tillage practices on profitability, it can be concluded that the trend has become the same, but much more marked differences have emerged in the application of individual tillage practices.

Table 3

Effect of soil tillage on yield of oil seed rape and profitabily

treatment	**yield (t ha^{-1})**	**profitability (EUR ha $^{-1}$)**
cultivator	2.07	313
plough	1.89	184
disc	1.99	262

CONCLUSIONS

Weather factors and the level of technology often does not allow to farmers to preparate soil on a sufficient quality for rape growing. Oil seed rape requires a soil, which loose enough in 25-30 cm, a sufficiently compact, crumbly but non-dusty at the depth of sowing (BIRKÁS, 1993, 2010). Only in this way can it explode and develop, which also determines the quantity of the crop and the profitability of cultivation.

In our field experiment, we were looking for an answer to the question that has the field cultivator affects the physical parameters of the soil (soil moisture content, soil resistance, agronomic structure) and the yield of rapeseed in addition to the conventional rotary (plough and non-rotation (disc) tillage methods. the profitability of cultivation.

In our field experiment, we sought to answer the question of how conventional rotary (plowing), non-rotational (disc) and cultivator tillage methods affect soil physical parameters (soil moisture content, soil resistance, agronomic structure), and yield of rapeseed and profitability of production.

From the results of our study we could see that during the ploughing the soil resistance was higher under the cultivated layer, although the cultivating layer has not yet formed, the critical level has not been established. Similar to the results of FÖLDESI and GYURICA (2012), it was also observed in our experiment that due to the higher soil resistance the soil moisture circulation was already obstructed, the moisture content of the lower 30-40cm layer was low. The clump-forming effect of ploughing (DEKEMATI ET AL. 2020) could also be detected, therefore the crumbly soil structure essential for rapeseed could be achieved in the upper soil layer only by combining before sowing. The unfavorable soil condition also affected the development, yield formation, yield and profitability of rape. With conventional rotary tillage, we achieved the lowest yield and the lowest gain.

Disc cultivation formed a sufficiently loose soil structure up to the upper 20 cm. Even water could leak in this layer, the soil moisture content was favorable. The soil layer underneath was already harder, drier, which also hindered the development of the rapeseed root. Unfavorable root development also affects nutrient and water uptake, so we were only able to achieve medium yields and gains with disc tillage.

The field cultivator with a variable tillage depth, is also suitable for stubble, stubble, basic cultivation and seedbed preparation. Both the physical parameters of the soil and the rape profitability were favorable when using the cultivator.

Ultimately, we can conclude that the choice of the right tillage machine serves not only the short-term interests of crop production (yield and profitability of year), but also its long-term objectives (sustainable and energy-efficient soil use, soil-saving cultivation) (BIRKÁS ET AL., 2018).

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