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WATER MANAGEMENT EFFECTS OF DIFFERENT TILLAGE SYSTEMS

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Abstract: Due to the climate change and the effect of the resulting warming up the amount of snow is declining in the past few years, so the chances for the autumn sowings to be winterkilled are growing and the amount of water stored in the soil is also significantly reducing. The intensive agricultural production is trying to compensate the conditions for the altered production by changing methods of soil cultivation and building up irrigation systems. The long-term aim of choosing the right method of soil cultivation is the protection of the soil structure and surface, and also the beneficial affecting of its biological activity, moisture and air circulation. The experiment was set in Szarvas, on the experimental area of Szent István University, Faculty of Agricultural and Economical Studies, organised as 5 by 2 repetition. By the planned experiments we were seeking answers for the ways of possible optimisation of soil cultivation in order to reach the highest possible value of water management for the soil, to improve the hydrating ability of the soil and also to provide sustainable agricultural production and to reduce the effects of farming which are hazardous to the water quality to the lowest possible level. The aim of our experiment is the reasonable utilisation, protection and preserving the diverse abilities of functionof the soil resources as parts of our most important natural resources. Within the framework of our monocultural duration experiment we examine the plant physiological and harvest effects of the various soil cultivating systems, deep disintegrating, deep ploughing, semi-deep ploughing, disc ploughing and strip-till cultivation by applying irrigated and non-irrigated cultural techniques. The results of non-rotating soil cultivating techniques show that they have beneficial effects on the water and nutrient management of the soil. The other technology we applied is the strip till technology. The advantage of strip cultivation that instead of the whole area one only cultivates the line/strip. In the cultivated strip the best possible soil conditions are provided for the plant by preparing seedbeds, sowing and fertilizing only in the line.

We were trying to find an answer for the relationship between soil resistance measured on methods of soil cultivation and the estimated average production. The Variance analysis shows significant results, the soil cultivating method influences the soil resistance at 40,231%, and also the expected harvest.

Keywords: soil cultivation, water management

1. Introduction

Considering the effects of climate change, Hungary belongs to the ecologically more vulnerable areas. The average temperature in Hungary grows nearly one and a half times faster than the values of the global climate change. Torrential rains will cause more damages in the future. Hungary is responsible for less than 0.5% of global greenhouse gas emissions; however, Hungary is being heavily struck by global warming, its climate is getting more and more extreme. Due to the changes in the weather in the past few years and the effect of the accompanying warming, the amount of winter precipitation and snow tends to be reducing in the past few years, so that the amount of water stored in the soil is also reducing. 2018 was the 4th hottest year in a row, and increases in global average temperature exceed nearly 1°C any values taken between 1850 and 1900. July of the year 2019 became the hottest month that has ever been recorded. The distribution of the annual precipitation has also changed significantly, considerably wet and dry periods follow each other. During the same year spring floods, possible inland inundations and subsequent summer droughts may appear. The temperature of surface waters has increased, which has had an effect on the water supply of irrigation water canals. The soil conditions of Békés county is considered as one of the most outstanding ones in the country. Spring inland inundations and also summer droughts cause considerable harvest losses year by year, even on these fertile meadow black soils. The climate change globally threatens the living conditions for today's and future generations, and also for the nature excluding humans, which is a considerable challenge for our responsibility for our immediate surroundings. It is getting more and more obvious that human activity alters the climate system resulting global impacts, which has repercussions on the biological, social and spatial living conditions. The conditions changed need responses either by reducing global greenhouse gas emissions and by adapting agricultural producing technologies to the climate change. Since the 1960s technology and science have been improving continuously, the rate of rural population and the utilization of fertilizers and pesticides have been reducing. Besides these, the diversification of crops in the rotation has also been increasing. Due to the decreased number of animals the volume of animal food production has also decreased, only a little good quality previous cropping and livestock manure is used. The new conditions of intensive soil utilisation and also the application of old classical systems (ploughing-rotating) have resulted an increase in the deterioration of the physical condition and structure of soils, plough-soles have appeared, the humus content has decreased, inland inundations have appeared, fertilizers have become less effective, soil acidification, harvest losses and costs have increased. Modern soil cultivating methods shall be used, in order to provide adequate conditions for the germination of the cultivar's reproductive material, its maturing, rooting, then for the growth and harvesting during vegetation. Its long-time purpose is to protect the structure and surface of the soil and to make beneficial impact on its biological activity, humidity and air circulation. These factors in combination describe the physical and biological condition, i.e. the cultivation condition of the soil.

By the planned experiments we were seeking answers for the ways of possible optimisation of soil cultivation in order to reach the highest possible value of water management for the soil, to improve the hydrating ability of the soil and also to provide sustainable agricultural production and to reduce the effects of farming which are hazardous to the water quality to the lowest possible level. The aim of our experiment is the reasonable utilisation, protection and preserving the diverse abilities of function of the soil resources as parts of our most important natural resources.

For choosing the right irrigation method and increasing the utilisation of irrigation water, the water resources of the soil shall be optimised. By choosing the right methods of soil cultivation we are addressing this issue.

2. Bibliographical overview

The physical degradation of soil, in particular, the degradation of soil structure and compaction are the most widespread, most serious injury causing and the most difficult to avoid processes of the soil-threatening degradation processes. (Várallyay 1999) Compaction can occur on the surface or below it. 34.8% of the soils of Hungary is specifically sensitive to compaction. (Várallyay 2005)The frequent or heavy rainfall and evaporation increase deposition caused by the own weight of soils, as a result, disadvantageously compacted soil layers can occur even under natural conditions. Pedologic factors, such as low organic material content and degraded structure, similarly to moisture content, also increase the tendency for compaction. (Birkás 1996)The most striking consequences of excessively compacted soils include water stagnation, siltation, chapping, accumulation of chemicals and blocking of soil moisture circulation. The roots of cultivars grown under such circumstances tend to develop rather vertically, theirgrowth is poor, and suffer water shortages early during heatwaves. (Birkás 2002) All soils have a distinctive penetrance limit value, which varies in accordance with the type of soil. The compaction can be considered favourable where the penetrance limit value is around 1.5-2.5 MPa/mm², and unfavourable where the limit value exceeds 3.0 MPa/mm².

Soil cultivation directly and indirectly alters soil conditions. It alters directly the position of relating particles, i.e. the soil structure. The agronomic structure, apparent specific gravity, porosity and three-phase system of the soil change, the water, air and heat circulation of the soil alter.(Gyárfás1922)The experiences gained through applyingnon-rotating soil cultivating techniques for years show that these techniques have beneficial impact on the water and nutrients management of our soils and result considerable gasoline savings compared to ploughing techniques. Besides beneficial features, plant protection issues raised by the pieces of stem and root remaining after previous cropping, and also factors having negative effects on the sowing quality of follow-up crops keep emerging. (Hajdu 2014)A significant lesson of the past few years' periods of draughts is that to obtain the aims mentioned above one shall pay special attention to provide appropriate moisture conditions for the soil, i.e. to allow as much precipitate reaching the surface as possible to get in the ground, and to make it possible for the soil to store such waters in a considerable amount. According to Beke's experiences gained through his studies on compaction and moisture content, in dry years less moisture results generally higher penetrance limit values. (Beke 2006) While examining interim protective plants Ujj found that the amount of precipitate and the success of weed control greatly affects penetrance. As he puts it, only the protective plants harvested in time can prove their cultivating effect, otherwise when utilising the working water supplies of the soil, compaction can be expected. (Ujj 2004) Rátonyi's studies show that the physical features of the soil significantly affect the growth of crops. For his studies he used linear regression equations with 2 variables of moisture content and compactionto describe soil penetrance. He found that within the range of moisture examined, the decrease in moisture content resulted anincrease in soil penetrance. (Rátonyi 1999)

3. Material and methodology

We found the 'school land' experimental area of Szent István University, Faculty of Agricultural and Economical Studies suitable for our studies and to deliver soil cultivating experiments on this area. The soil type of this area is meadow soil with high clay content and of high consistency. The consistency and tendency for compaction offer excellent conditions for adjusting experiments. Conditions for irrigation are also provided on the area, which offers an opportunity to compare irrigated and non-irrigated control parcels.

Due to the continental impact, the climate of Békés county is dry and warm. The annual average rainfall is 550-560 mm; however, the northern and southern parts of the county, including the experimental area of Szarvas, belong to the driest areas of the country. The average annual temperature and the average number of hours of sunshine is higher than the national average; in July, the south-eastern corner of the county is the hottest region of the country. Considering agricultural production, the best quality fertile soils with a nationally outstanding value can be found throughout most of the region. The middle area of the Körös-Maros region has the best soil properties, where the thickness of the soil exceeds 1 metre almost everywhere, the soil is exceptionally well-drained and has an outstanding water retention capacity, and its quality is worth more than 35 Golden Crowns. Due to its physical geographic features, agriculture has a leading role in Békés county, including arable crops. At present, 402.000 hectares of land are utilised agriculturally in Békés county, which is the second largest area in the country, after Bács-Kiskun county. The rate of utilised areas compared to the entire territory of the county is the highest in the country, more than 77%. 362.000 hectares of the agricultural areas are utilised as arable lands, which is 9.5% of all arable lands of the country. To preserve these valuable arable lands and to increase their productivity are the main goals of our experiment.

Applied soil cultivating methods:

1. Deep disintegrating (at least 60-70 cm deep meliorative disintegrating that discontinues the effects of possible clogged layers with respect to the soil profile)
2. Traditional deep cultivation, deep ploughing (regular rotating cultivation, in accordance with the crop's needs)
3. Semi-deep ploughing (40-45 cm deep disintegrating on annual basis)
4. Shallow ploughing, disc ploughing (20-22 cm deep disc cultivating)
5. Applying strip-till technology (strip cultivating in the rows of crops)

We chose maize as a crop for testing. Maize is grown in the largest quantity in the world, so the sustainable maize production is a major issue in animal nutrition, food industry and biofuel industry, as well. The situation is the same in Hungary; maize is also one of the country's most important export product. When choosing the crop for testing, after taking into consideration three consecutive years, the choice was limited to maize. Our chosen crop, the maize is a good choice, since the crop's dimensions, biomass yield, harvest and its quantity may indicate well-measurable ranges by numbers and appearance. Livestock manure and fertiliser were spread in the same amount on the experimental parcels. Yield is measured by providing the same amount of irrigation water. It is expected to experience differences. Besides yield, the total amount of biomass is measured as well, trying to find the cultivating method that utilizes the provided nutrient and irrigation water the best. When measuring the amount of biomass, the range and composition of weeding are also included. We are also trying to find the answer to the question if various soil cultivating methods affect the composition of stress enzymes and hormones.

Soil penetrance is measured to examine the physical conditions of the soil and also to compare the effects of various soil cultivating systems on soil conditions, using a penetrometer. The penetrance and current physical condition of the soil can be determined fast and relatively accurately. The validity of soil penetrance values taken with a penetrometer is determined by the accuracy of the measuring instrument, the performance of measuring and the inhomogeneity within the experimental parcels. The range of soil penetration variation is considerably affected by the relatively small surface of the probe cone's base and the variability of soil parameters strongly related to soil penetrance (e.g. moisture content). (Rátonyi 1999)

4. Findings and evaluation

We have compared numerous parameters examined. The most important test values refer to the moisture content and water management parameters of the soil. The constant monitoring of moisture content and soil penetrance is a significant part of the test, since we are trying to find the best cultivating method that provides lasting and constant water absorption for our crop. Soil penetrance measurement served as a basis to examine the physical condition of the soil and also to compare the effects of various soil cultivating systems on soil condition. The penetrance and current physical condition of the soil can be determined fast and relatively accurately with a penetrometer. The range of soil penetrance is affected by the moisture content of the soil and soil compaction.

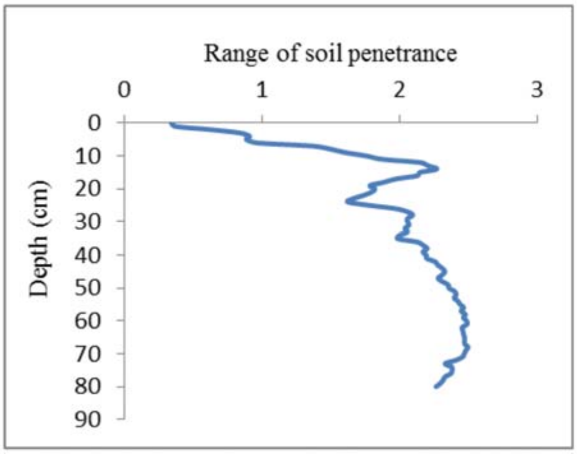

Figure 1. Semi-deep ploughing

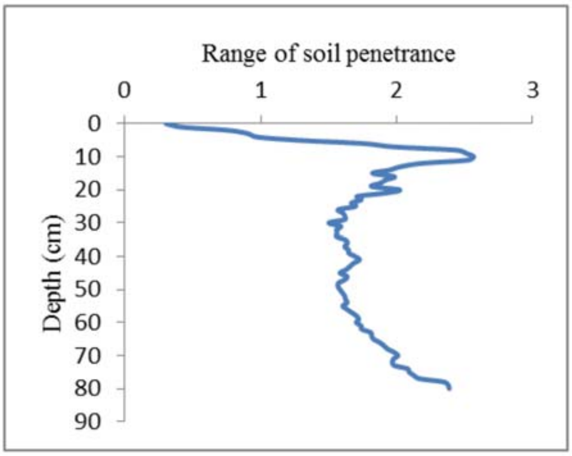

Figure 2. Deep ploughing

Another important part of our experiment are the soil physical measurements, with which we would like to point out how certain cultivating methods with the same cultivating techniques affect soil porosity and how this value alters as an effect of irrigation; also, in which cases and at what quantity of water the values vary positively or negatively. The constant measurement of soil respiration and the climate of stand may provide an answer to our questions.

Together with the absorbable amount of water present in the soil we also constantly measure the water balance coefficient values (VHE), trying to find the answer for how post-rainfall and irrigation values change. Certain parameters of soil life are also measured. We are examining the number of earth worms, in accordance with soil cultivating technologies. Earth worms react rather sensitively to certain elements of modern agriculture, such as plant protection products, or soil compaction. Soil cultivation is a sensitive issue, since it disturbs earthworms and destroys their tunnel systems.

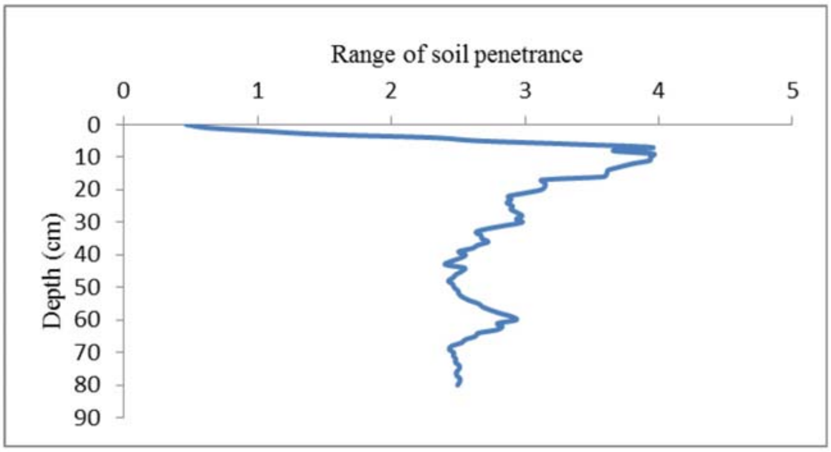

Figure 3. Disc ploughing

The achievable targets using a well-chosen soil cultivating method are:

–Soil dust prevention or control, thereby reducing degradation caused by wind or rain.
–Trample damages caused by cultivation and expenses of production can be reduced.
–The water absorbing ability of the soil can be improved; the loss of moisture can be reduced.
–By this, the degradation of soil structure can be reduced. The stability of aggregate can be increased considerably.

The experiment average production did not reach the 31.6 tonnes per hectare amount which was measured at an American harvest competition in 2014; however, it exceeded the five-year average production in Hungary and over 6.0 tonnes per hectare could be harvested.

Table 1. Production results

Deep ploughing	Semi-deep ploughing	Disc ploughing
13.680	11.490	8.820
estimated average production kg/ha		

Conclusion

In the past few decades, the pursuit of large average productions and intensive production of plants has overshadowed land use focusing on the productivity, physical, biological and chemical condition of the soil. The findings of the research allow us to choose and apply further soil cultivating methods for the best soil structure. By taking advantage of the opportunities for irrigation experiments at Szarvas, further opportunities become available to optimise irrigation and soil cultivation. The test results can be integrated into the structure of education or into the curriculum of current trainings, such as the Agricultural Water Management specialist training. A well-chosen, adaptive soil cultivation method that fits into the site and climate conditions also provides the conditions for sustainable plant production.

“The only good way is to apply such methods that also ease climate damages in the long-term.” (Márta Birkás)

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