EFFICACY OF SOIL DEEP LOOSENING IF GROWING WINTER OIL SEED RAPE AND WINTER WHEAT IN CONDITIONS OF UNEVEN RELIEF

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Abstract. The aim of the investigation: to clarify the effect of direction and depth of soil deep loosening. The field trials were carried out in winter oil seed rape followed by winter wheat. The field was characterized with wavy mesorelief. Soil deep loosening was done in the depths of 0.5 and 0.35 m, in the direction of slope and across the slope. In 48 observation points placed as a grid of 25x25 m the following parameters were determined: content of phosphorus and potassium, soil penetrometric resistance and soil moisture in soil arable layer and in subsoil layer. The yield of winter oil seed rape and winter wheat was determined to create yield maps. The results showed that significant increase of winter oil seed rape and the yield of winter wheat has ensured soil deep loosening across the slope at the depth of 0.5 m. The soil resistance in both crops in the soil layer 0.4 – 0.5 m was significantly higher after soil deep loosening at the depth of 0.35 m than in treatments with soil deep loosening at the depth of 0.5 and without soil deep loosening. Soil deep loosening at the depth of 0.35 m in the direction of slope caused significantly higher soil moisture and higher reduction in the content of phosphorus and potassium in the subsoil layer at the depth of 0.2-0.4 m in the lowest points of the slope if compared with soil deep loosening at the depth of 0.5 m across the slope.

Keywords: winter oilseed rape, winter wheat, soil deep loosening.

Introduction

The number of farms that implement precision farming technologies with GPS and GIS applications gradually increases in Latvia. Typically results from the soil arable layer are used for differentiation of technologies and for explanation of differences in yields, as well as characteristics of photosynthetic mass are used for description of the development of processes in the field. Already in the previous research carried out on the Research and training farm "Vecauce" of the Latvia University of Agriculture, high importance of soil agrochemical properties for differentiation of technologies was determined [1 – 3]. Researches on differentiation of field management technologies were carried out also in the EU and the USA [4; 5]. However, researches with cereals and winter oil seed rape show that crops in favourable growing conditions have a very deep root system thus a hypothesis can be drawn that the soil subsoil layer has an important role to growth and development of crops as well.

Compaction of the soil arable layer and subsoil layer is an important topic in all EU, including Latvia. According to researches Latvia is ranked among those EU countries with increase risk of soil compaction. Proper soil tillage, including soil deep loosening, is essential to keep soil in normal conditions for crop growing [1; 3; 8]. Trial results show important role of subsoil layer to harvest high yields of crops [2; 5 – 8].

If soil deep loosening is applied in the hilly morainic landscape, than the soil moisture content has significant importance on yield formation as well as possible movement of plant nutrients in the soil caused by water flows [3; 5; 8; 9]. Another hypothesis can be drawn that efficacy of soil deep loosening is determined not only by the depth soil deep loosening but also by the direction of tillage towards slopes.

The objectives of this study: to determine the basis for the view that developing of cartograms for differentiation of growing technologies for winter wheat and winter oil seed rape need also analyses from the subsoil layer; to determine the significance of root system development for precision field management technologies.

Materials and methods

The field trials were carried out on the Research and training farm "Vecauce" of the Latvia University of Agriculture during the years 2008 to 2010. Growing of winter oil seed rape cv. *Catalina* in the season 2008/2009 followed by winter wheat cv. *Tarso* in 2009/2010. Soil deep loosening was done by using the subsoiler Kverneland CLE in two different depths – 0.5 and 0.35 m, in two different directions – in the direction of slope and across the slope. Soil ploughing at the depth of 0.2 m was done after soil deep loosening. 48 observation points in a grid of 25x25 m were determined. The coordinates of the observation points were defined by GPS receiver Garmin IQ 3600 using AGROCOM software AgroMAP Professional. The altitude of the stationary observation points was determined by using Trimble GeoXT. The field characterized by wavy mesorelief and relative height above the sea level was between 88.5 and 98.6 m. On the top and as well on the slopes of the moraine hills in the trial area eroded sod-calcareous and eroded sod-podzolic soils can be found, but sod-gley soils were found on the foot of the hills. In all observation points the following data were determined: organic matter content, soil texture class, content of phosphorus and potassium, soil reaction pH_{KCl}. All data are determined in two soil layers – in the soil arable layer at the depth of 0-0.2m and in the subsoil layer at the depth of 0.2-0.4 m. The soil analysis was done in the certified laboratory "Valsts SIA Agroķīmisko pētījumu centrs" using nationally approved standard methods. The organic matter content in the trial field in the soil arable layer was between 15 and 87 $g \cdot kg^{-1}$ but in the subsoil layer 11 to 98 $g \cdot kg^{-1}$, soil reaction pH_{KCl} in the soil arable layer was from 5.1 to 7.6 but in the subsoil layer 5.2 to 7.4, available for plants the content of potassium in the soil arable layer 73 to 344 $mg \cdot kg^{-1}$ but in the subsoil layer 85 to 228 $mg \cdot kg^{-1}$, available for plants the content of phosphorus in the soil arable layer 76 to 282 $mg \cdot kg^{-1}$ but in the subsoil layer 99 to 310 $mg \cdot kg^{-1}$. In all 48 GPS observation points the following data were determined: soil penetrometric resistance (determined using Eijkelkamp soil penetrometer in soil layers from 0 until 0.5 m (0 – 0.1; 0.1 – 0.2; 0.2 – 0.3; 0.3 – 0.4; 0.4 – 0.5)), soil moisture (determined by means of Eijkelkamp Agrisearch equipment in soil layers from 0 until 0.45 m (0 – 0.05; 0.2 – 0.25; 0.40 – 0.45)). The soil texture class was determined by using the field method and described as the content of physical clay [6; 7].

The yield of winter oil seed rape was harvested with the harvester Claas Lexion 420 to create the yield map using AGROCOM software, but the yield of winter wheat was determined by taking 3 plant samples in each observation point from 0.1 m^2 areas. The determination of the winter wheat yield formatting elements was done at the same time.

The crop root mass and the length of the main root were determined in autumn after crop germination and in spring after renewal of vegetation. 3 oil seed rape plants and 10 winter wheat plants were taken in the autumn at the growth stage BBCH 11-13 and in spring at BBCH 21-22 for oil seed rape and at BBCH 25-29 for wheat.

The meteorological conditions in the trial years were characterized by the increased amount of precipitation in both summers of 2009 and 2010, but the temperatures, especially in July 2010, were highly above the long term observed (Table 1).

The data analysis was performed using mathematical descriptive statistics and correlation analysis.

Table 1

Average day and night temperature and precipitation during growing season in 2009-2010 and in comparison with long term average

Month	Long-term average temperature	Temperature, ºC		Long-term average precipitation	Precipitation, mm	
		2009	2010		2009	2010
May	11.2	11.0	11.9	43	18.0	72.6
June	15.1	13.7	14.6	51	95.0	37.8
July	16.6	17.1	20.8	75	136.0	131.8
August	16.0	15.8	18.2	75	38.8	133.4
September	11.5	12.9	10.8	59	39.8	78.0

Results and discussion

The results showed that differences in the yield of both winter oil seed rape and winter wheat were not significant ($P < 0.05$) among treatments with soil deep loosening at the depth of 0.35 m in both directions as well as with soil deep loosening at the depth of 0.5 m in the direction of slope. Significantly higher yields were harvested in treatment with soil deep loosening at the depth of 0.5 m across the slope and also in untreated plot without soil deep loosening; moreover differences between those two treatments were not statistically ($P < 0.05$) significant (Fig. 1 and 2).

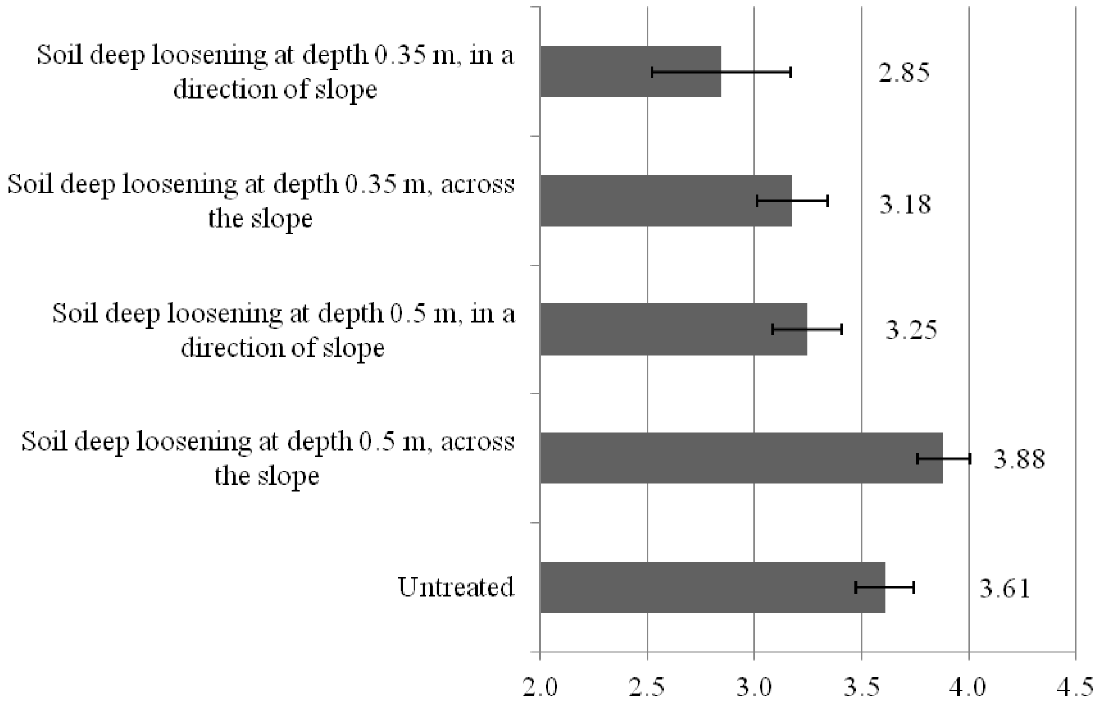

Fig. 1. **Yield of winter oil seed rape (t·ha^{-1}) after soil deep loosening, 2009**

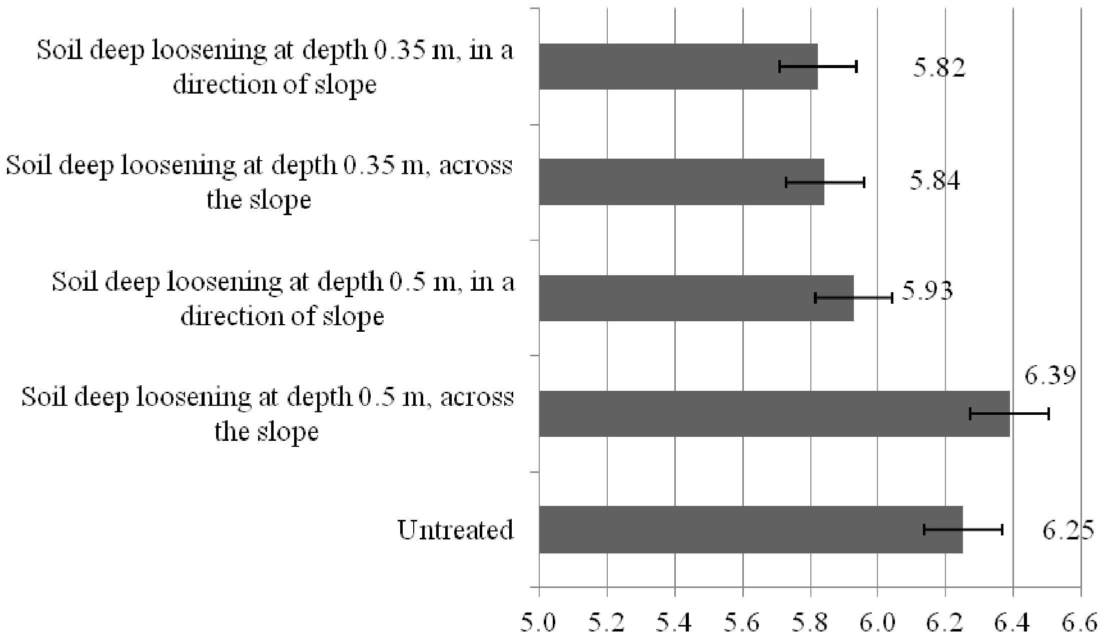

Fig. 2. **Yield of winter wheat (t·ha^{-1}) after soil deep loosening in previous year, 2010**

Soil penetrometric resistance in both crops in the soil layer 0.4 – 0.5 m was significantly higher after soil deep loosening at the depth of 0.35 m ($P < 0.05$) if compared with treatments with soil deep loosening at the depth of 0.5 and without soil deep loosening (Fig. 3). The differences of the soil penetrometric resistance between treatments with soil deep loosening at the depth of 0.5 and without soil deep loosening were not significant.

Soil deep loosening at the depth of 0.35 m in the direction of slope caused significantly higher soil moisture in the subsoil layer at the depth of 0.2 – 0.4 m and higher reduction in the content of moisture in the subsoil layer at the depth of 0.4 – 0.45 m in the lowest points of the slope if compared with soil deep loosening at the depth of 0.5 m across the slope (Fig. 4).

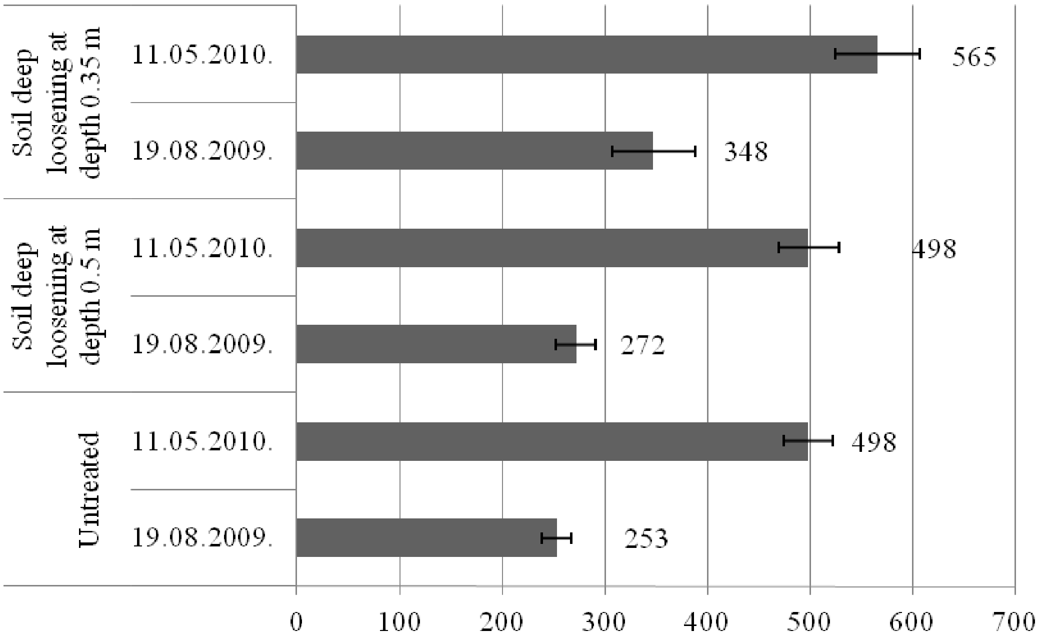

Fig. 3. **Soil penetrometric resistance ($N \cdot cm^{-2}$) in soil layer at depth of 0.4 – 0.5 m after harvesting of winter oil seed rape (19.08.2009.) and in winter wheat (11. 05.2010.)**

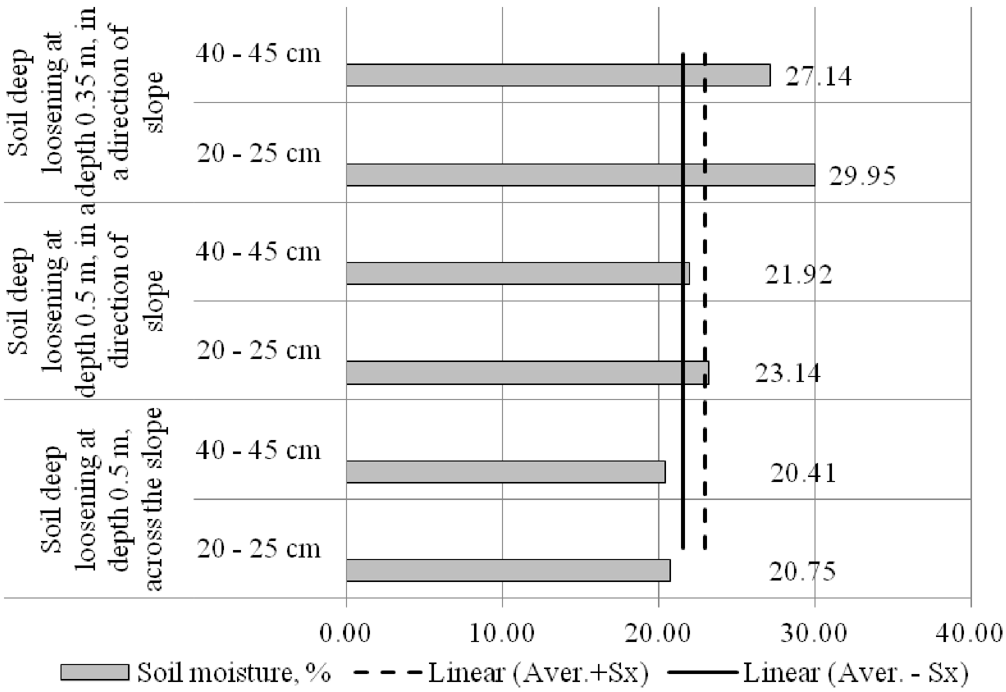

Fig. 4. **Soil moisture at lowest points of slopes in winter oil seed rape in autumn at BBCH 23-24**

To evaluate the changes of the content of phosphorus and potassium in the subsoil layer caused by soil deep loosening, the results from soil analyses taken before winter oil seed rape drilling in 2008 and after harvesting in the autumn 2009 were compared.

The results showed that soil deep loosening in both depths 0.35 and 0.5 m decreased the content of phosphorus and potassium in the subsoil layer at the depth of 0.2 – 0.4 m at the lowest points of the slope (Fig. 5). Significant ($P < 0.05$) decrease was observed for the content of phosphorus. Soil deep loosening at the depth of 0.5 m across the slope does not cause significant changes of the content of phosphorus.

Many researchers stated that increased soil penetrometric resistance in the subsoil layer in conditions of wavy mesorelief caused water flow in the direction of slopes together with leaching of plant nutrients [3; 4; 9]. Our researches confirm these conclusions.

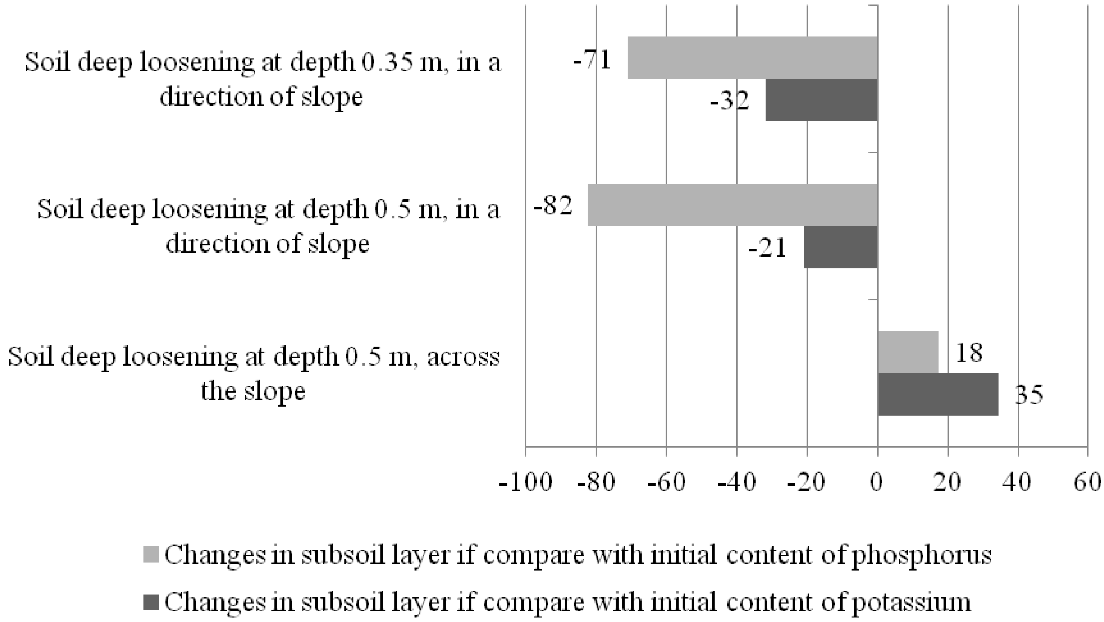

Fig. 5. **Changes of content of K_2O and P_2O_5 (mg kg^{-1}) in subsoil layer at depth of 0.2 – 0.4 m in winter oil seed rape at the lowest points of the slope**

Conclusions

The results showed that significant ($P < 0.05$) increase of the winter oil seed rape yield has ensured soil deep loosening across the slope at the depth of 0.5 m. Also the highest yield of winter wheat was harvested in treatments with soil deep loosening across the slope.

The soil penetrometric resistance in both crops in the soil layer 0.4 – 0.5 m was significantly higher after soil deep loosening at the depth of 0.35 m than in treatments with soil deep loosening at the depth of 0.5 and without soil deep loosening.

Soil deep loosening at the depth of 0.35 m in the direction of slope caused significantly higher soil moisture and higher reduction in the content of phosphorus and potassium in the subsoil layer at the depth of 0.2 – 0.4 m in the lowest points of the slope if compared with soil deep loosening at the depth of 0.5 m across the slope.

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