# THE IMPACT OF SOIL PENETRATION RESISTANCE ON WINTER WHEAT YIELD AND DEVELOPMENT

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**Abstract**

Formation of yield in crop cultivation is affected by influence of many factors. Simple summation of individual factors is quite rare occasion. Interaction among factors is a dynamic value. The effect of interactions varies depending on the crop development stages as well as by graduation of factors. The study aimed to evaluate the soil penetration resistance effect on winter wheat grain yield and development. It allows to specify recommendations for soil treatment difference criteria for use in site-specific soil tillage. Field trials were carried out at the Research and Study farm Vecauce of Latvia University of Agriculture during the years 2005-2007 to investigate factors influencing formation of winter wheat grain yield. Forty seven points (distributed as grid 50x50 m) were selected in the winter wheat *Triticum aestivum* L. field. All points were attached to their geographic coordinates. Data shows significant effect of soil resistance to grain yield - increase of soil penetration resistance by 100 kPa $cm^{-2}$ reduced yield of winter wheat by 0.37 to 0.48 t $ha^{-1}$. By contrast in 2007 a significant linear regression relationship between soil penetration resistance and the yield was not detected. Differences of fresh weight of winter wheat plants in tillering stage and the beginning of stem elongation were insignificant compared to different groups of soil penetration resistance at soil layers 0.10-0.30 m in both experimental years. Higher impact of soil penetration resistance on flag leaf area difference had soil resistance at the layer of 0.20-0.30 m and differences were significant in both trial years.

**Key words:** precision field management, winter wheat, soil resistance, yield, cereal development.

## Introduction

Precision crop cultivation is a form of modern field management using new technologies, machinery and equipment, including GPS (Global Positioning System). GPS allows detect, analyze and respectively respond to unevenness of cultivable area. It is closely associated with the new information technologies - GIS (Global Information System) and GPS – and includes development and use of structural planning of production processes and management of modelling of optimal solutions. Precision crop cultivation operational functionality requires computerized management of this process (Vilde et al., 2005; Vilde et al., 2008; Lapins et al., 2007; Lapins et al., 2008).

Formation of yield in crop cultivation is affected by influence of many factors. Simple summation of individual factors is quite rare occasion. Interaction among factors is a dynamic value. The effect of interactions varies depending on the crop development stages as well as by graduation of factors. Rising of value of a single factor resulted in a rise of value of interactions effect (Lapins et al., 2003).

Investigations in precision agriculture were initiated in 2004 at Latvia University of Agriculture. The results are already partly reflected in Latvia and foreign editions. This study is aimed to evaluate effect of soil penetration resistance on development and yield of winter wheat. It allows to specify recommendations for soil treatment difference criteria for use in site-specific soil tillage.

## Materials and Methods

Investigations were carried out in 2005–2007 in Kurpnieki field at Research and Study Farm Vecauce of Latvia University of Agriculture. Winter wheat variety 'Tarso' was grown in 2006 and 2007. Forecrop of wheat was winter rape *Brassica napus* ssp. *oleifera*. The agrotechnology used in wheat cultivation was equal in the whole field and in both trial years. 47 points (distributed as grid 50x50 m) for sampling were selected in the winter wheat *Triticum aestivum* L. field. All points were attached to their geographic coordinates. The coordinates of observation points were defined by GPS receiver Garmin IQ 3600 using AGROCOM software AgroMAP Professional that allows to find the coordinates by accuracy of ±3 m, as well as to determine the field boundaries. Information from Garmin IQ 3600 was transferred into a computer and processed by the program AgroMAP Professional.

Soil penetration resistance, kPa $cm^{-2}$ was determined in soil layers from 0.00 to 0.50 m with Eijkelkamp soil penetrometer in 4 replications twice in vegetation period – in autumn at crop one-two leaf stage (BBCH 11-12) and in spring at wheat tillering growth stage (BBCH 21-29).

Number of crop plants per $m^2$, fresh weight of plant and coefficient of tillering were determined at the same time. Flag leaf area was determined at wheat dough development stage (BBCH 80-83) by using a specialized computer program WinFOLIA. The yield was harvested by combine CLASS LEXION 420 GPS.

Data analysis was performed using a mathematical descriptive statistics and correlation analysis.

Meteorological condition differs between trial years. Observed average air temperatures were above long term in both trial years, especially in the second part of the year 2006 (Figure 1).

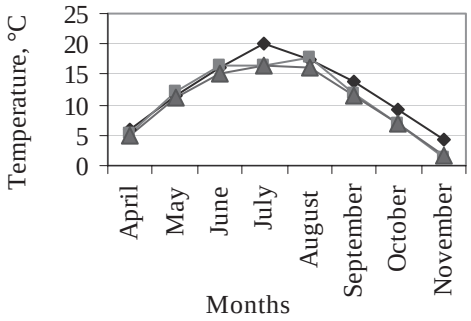


Figure 1. Average day and night air temperatures in years 2006 and 2007, °C (according to Vecauce Metpole and long term to Dobele HMS): ◇2006; □2007; △long term.

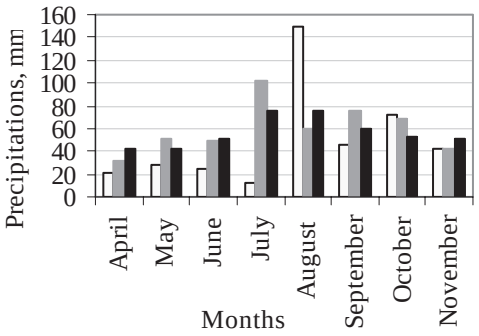


Figure 2. Average amount of precipitations in years 2006 and 2007, mm (according to Vecauce Metpole and long term to Dobele HMS): □2006; ■2007; ■long term.

Average temperature of July 2006 was by 3.5 °C higher than long term observed. Alongside with insufficient amount of precipitations it causes rapid ripening and early harvesting of winter wheat compared with long-time observed harvesting time. The sum of precipitations was low in both trial years, but during the period April–August it was lower in year 2007 compared to 2006 despite of high amount of precipitation in August 2006 (Figure 2).

**Results and Discussion**

Coefficients of linear correlation shows a significant $p<0.05$ ($r_{crit.}=0.288$) positive effect of flag leaf area and a significant negative effect of soil penetration resistance in subsoil on winter wheat grain yield in 2006 (Figure 3).

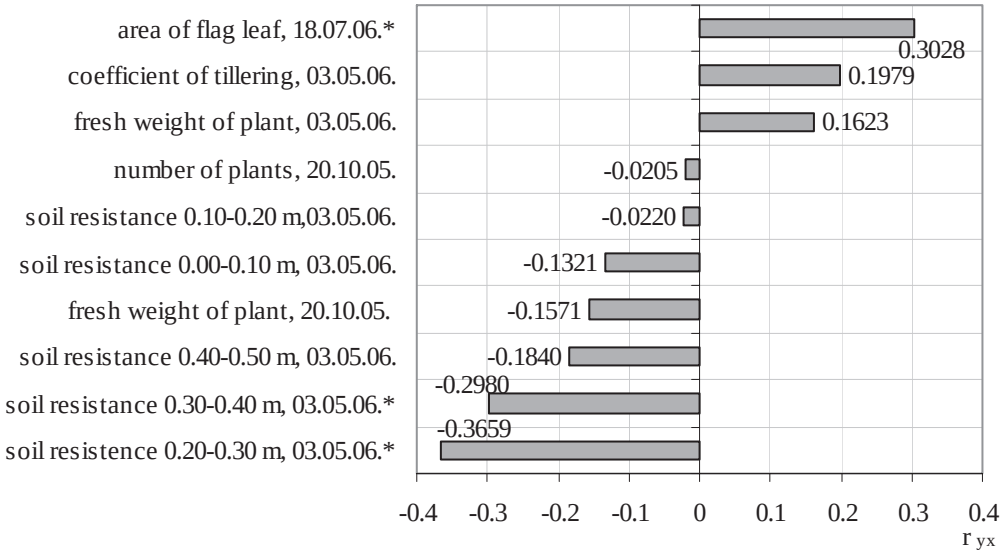


Figure 3. Coefficients of linear correlation, $r_{yx}$, among winter wheat yield (y) and factorial indices (x), in year 2006; *$p<0.05$.

Area of flag leaf had significant $p<0.05$ effect to winter wheat grain yield also in 2007. Significant positive effect to yield showed also fresh weight of plant ($p<0.05$), but negative effect – soil penetration resistance at depth of 0.20-0.30 m ($p<0.05$) and at depth of 0.00-0.10 m ($p<0.1$; $r_{crit.}=0.243$) (Figure 4). Significant correlation among other factorial indices was not found.

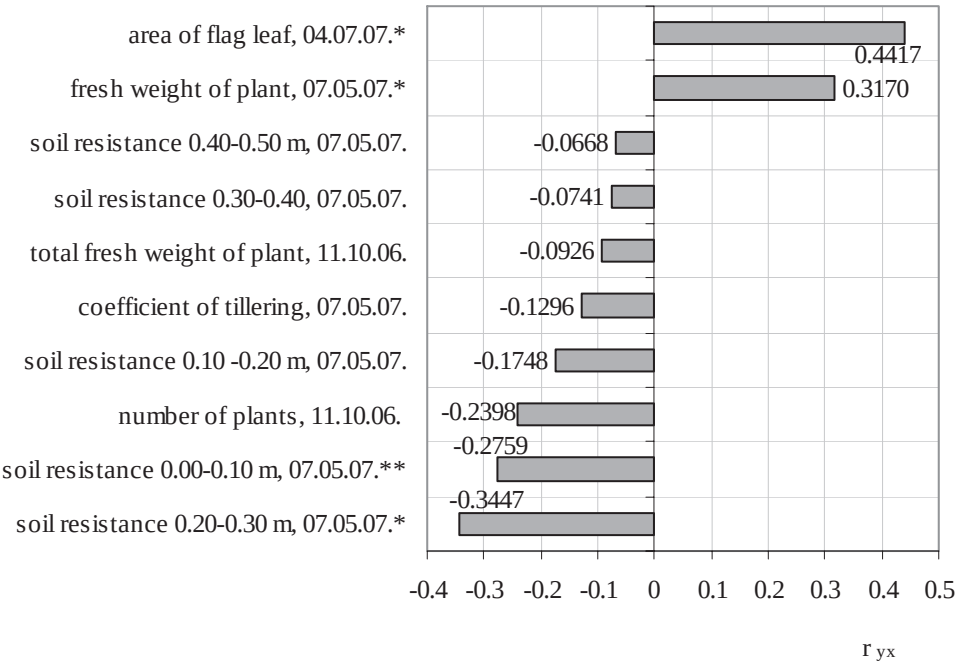


Figure 4. Coefficients of linear correlation, $r_{yx}$, among winter wheat yield (y) and factorial indices (x), in year 2007; *p<0.05; **p<0.1.

Overall soil penetration resistance was higher in 2006 compared to 2007. Data analysis shows that higher soil penetration resistance at depth of 0.20-0.30 and 0.40-0.50 m resulted in significant lower yields of winter wheat in both trial years whereas there were no significant differences in grain yield between soil penetrations resistance groups at depth of 0.30-0.40 m (Figure 5).

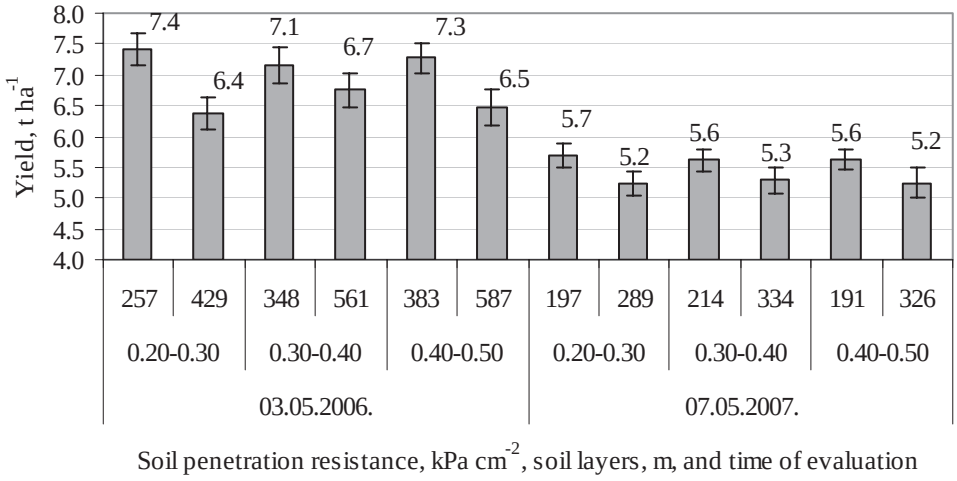


Figure 5. Winter wheat yield and soil penetration resistance in years 2006 and 2007.

Values of linear regression coefficients and their probability levels indicated that the differences in soil penetration resistance at depth of 0.20-0.30 m and 0.30-0.40 m and winter wheat grain yield had significant negative linear functional relationship in 2006 (Figure 6). It was established that increase of soil penetration resistance in subsoil by 100 kPa $cm^{-2}$ reduces winter wheat grain yield by 0.37 to 0.48 t $ha^{-1}$.

On the contrary, significant linear regression relationship between soil penetration resistance and the yield was detected only for subsoil layer at the depth of 0.20-0.30 m in 2007. Also a significant negative effect $p<0.1$ to winter wheat grain yield showed soil resistance in topsoil layer at depth 0.00-0.10 m (Figure 6).

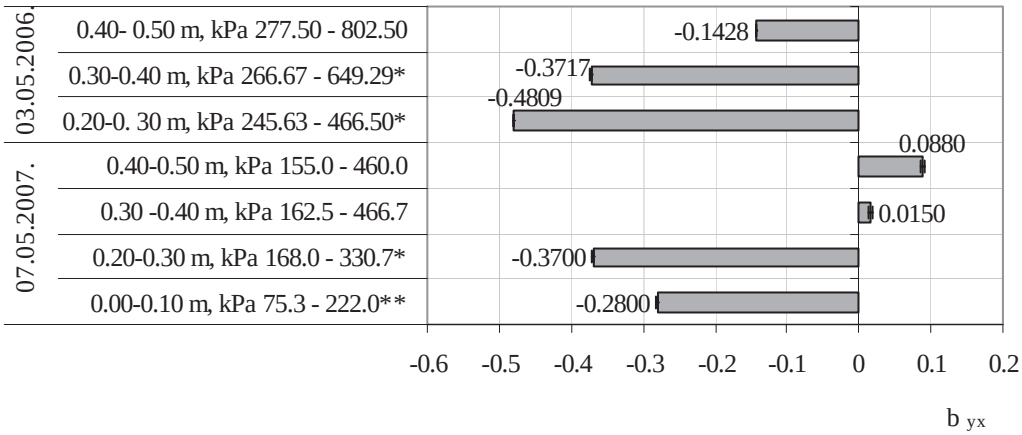


Figure 6. Effect of soil penetration resistance increase by 100 kPa $cm^{-2}$ to winter wheat yield; *p<0.05, **p<0.1.

Differences in coefficient of tillering in connection with determined soil penetration resistance (Figure 7) demonstrated that increased soil penetration resistance resulted in smaller coefficient of tillering of winter wheat in 2006 although differences were insignificant between soil layers 0.00-0.10 and 0.10-0.20 m. Soil penetration resistance was overall smaller in year 2007, but higher coefficient of tillering was observed in places with higher soil penetration resistance and differences are significant in both soil layers from 0.00-0.10 and 0.10-0.20 m.

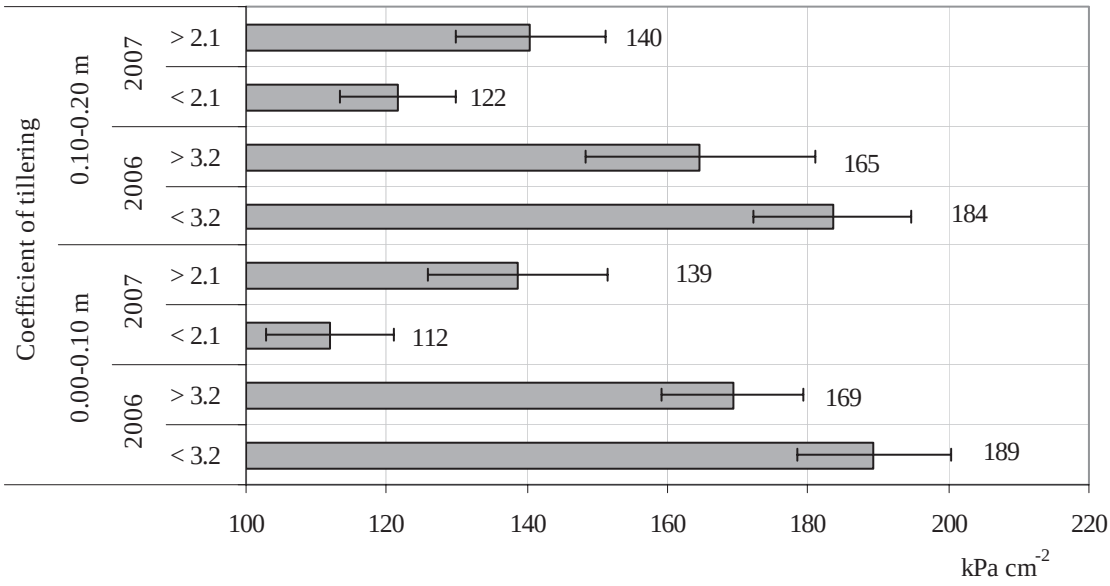


Figure 7. Dependence of coefficient of tillering on soil penetration resistance in years 2006 and 2007.

Differences of fresh weight of winter wheat plants in tillering stage and the beginning of shooting stage was insignificant compared by different groups of soil penetration resistance at soil layers 0.10-0.30 m in both experimental years (Figure 8). Significant effect to winter wheat plant fresh weight caused by the soil penetration resistance was observed only in 2007 in the soil layer 0.00-0.10 m.

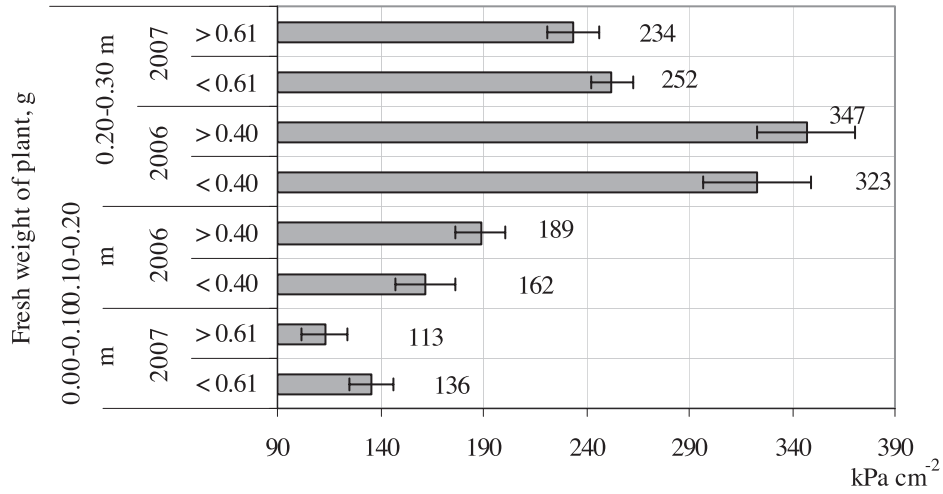


Figure 8. Fresh weight of plant and soil penetration resistance in years 2006 and 2007.

Soil penetration resistance at depth of 0.20-0.30 m gave a significant negative effect to the area of winter wheat flag leaf (Figure 9). Results from other soil layers showed no significant impact on the area of the flag leaf.

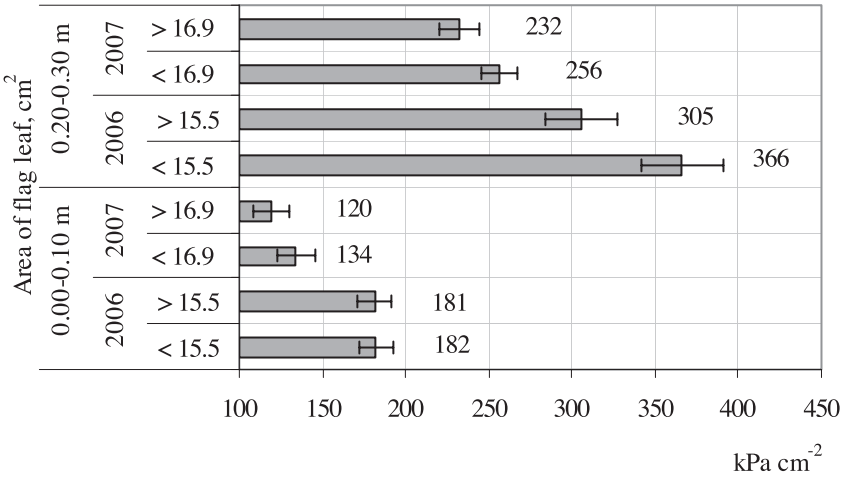


Figure 9. Flag leaf area and soil penetration resistance in years 2006 and 2007.

Winter wheat grain yield ranged from 2.0-9.5 t ha$^{-1}$ in Kurpnieki field in 2007 with an average yield of 5.53 t ha$^{-1}$ (Figure 10). In comparison with the year 2006, the winter wheat grain yield ranged from 4.5-9.2 t ha$^{-1}$ with average yield of 6.75 t ha$^{-1}$.

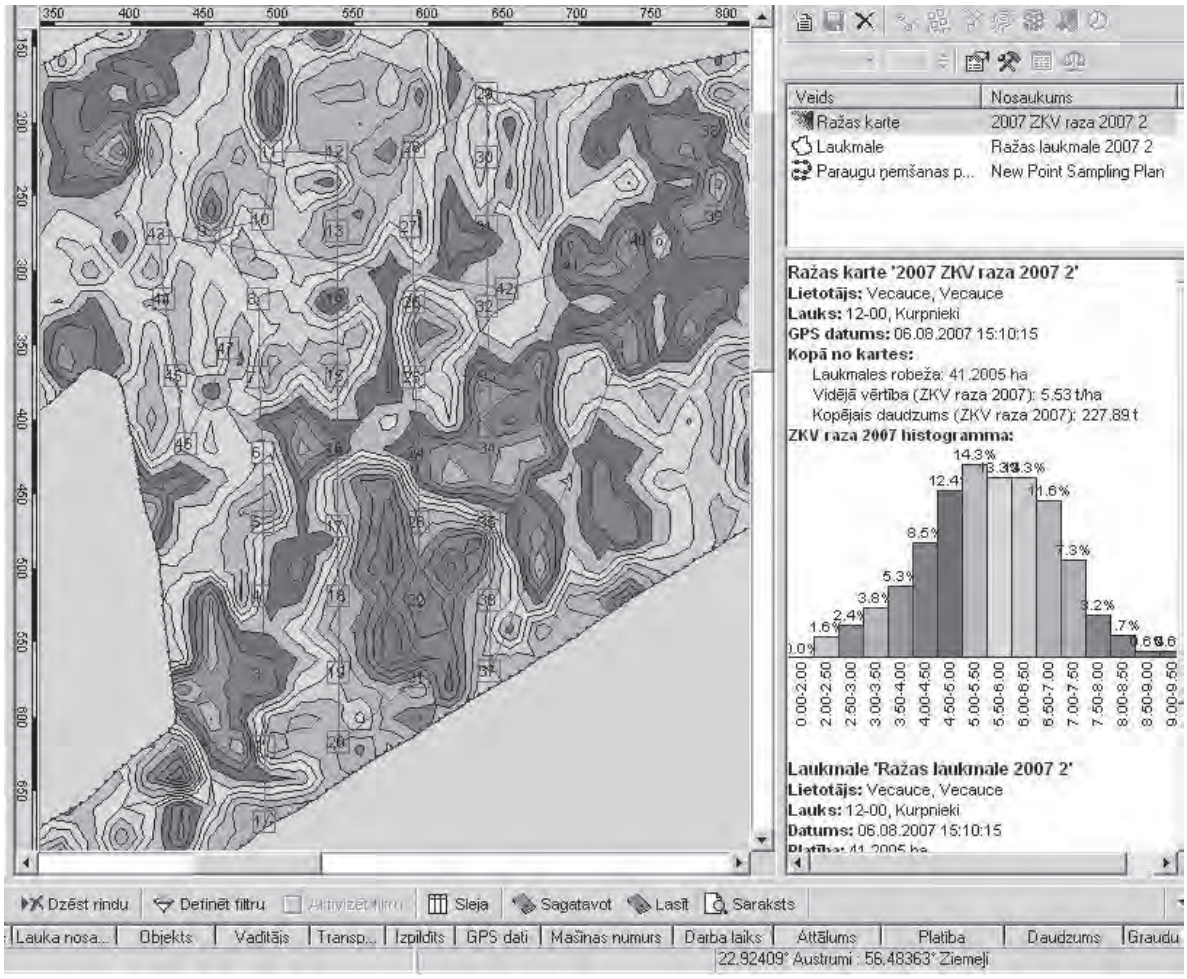


Figure 10. Cartogram of the winter wheat grain yield in Kurpnieki field in 2007.

**Conclusions**

1. Coefficients of linear correlation shows a significant $p<0.05$ positive effect of the flag leaf area and a significant negative effect of the soil penetration resistance in subsoil on the winter wheat grain yield in 2006.
2. Area of flag leaf had significant $p<0.05$ effect to the winter wheat grain yield also in 2007. Significant positive effect to the yield showed also fresh weight of a plant ($p<0.05$), but negative effect – soil penetration resistance at depth of 0.20-0.30 m ($p<0.05$) and at depth of 0.00-0.10 m ($p<0.1$).
3. Linear regression coefficient values show that higher soil penetration resistance at the depth of 0.20-0.30 and 0.40-0.50 m resulted in significant lower yields of the winter wheat in both trial years.
4. Increase of soil penetration resistance in arable layer by 100 kPa $cm^{-2}$ reduces the winter wheat grain yield by 0.37 to 0.48 t $ha^{-1}$.
5. Increased soil penetration resistance in 2006 resulted in smaller coefficient of tillering of the winter wheat although differences were insignificant between soil layers 0.00-0.10 and 0.10-0.20 m, but in 2007, when the overall soil penetration resistance was smaller, higher coefficient of tillering was observed in places with higher soil penetration resistance and differences were significant in both soil layers: from 0.00-0.10 and 0.10-0.20 m.
6. Differences of fresh weight of winter wheat plants in tillering stage and the beginning of shooting stage was insignificant compared by different groups of soil penetration resistance at soil layers 0.10-0.30 m in both experimental years.
7. Soil penetration resistance at depth of 0.20-0.30 m gave significant negative effect to the area of the winter wheat flag leaf.

**Acknowledgments**

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**References**

1. Lapiņš D., Bērziņš A., Gaile Z., Oboļeviča D., Grenovska K., Koroļova J., Sprincina A., Kopmanis J. (2003) Augsnes apstrādes un sējas tehnoloģiju ietekme uz ziemas kviešu graudu ražu un tās kvalitāti (The Soil Treatment and Sowing Technology Impacts on Winter Wheat Grain Yield and Its Quality). *Agronomijas Vēstis*, 5, pp. 109-116. (In Latvian).
2. Lapins D., Vilde A., Berzins A., Dinaburga G., Plume A., Rucins A. (2008) Investigations of Technologies for the Precision Agriculture and Estimation of Their Efficiency. In: Rutkauskas G. et. al. (eds) *Biosystems Engineering and Processes in Agriculture*, Raudondvaris, Lithuania, pp. 157-161.
3. Lapins D., Vilde A., Berzins A., Plume A., Dinaburga G. (2007) Criteria For the Site Specific Soil Tillage. In: Kirsis M. et al. (eds) *The 6th International Scientific Conference,* Engineering for Rural Development, Jelgava, Latvia, pp. 268-275.
4. Vilde A., Lapins D., Dinaburga G., Rucins A., Cesnieks S., Berzins A., Plume A., Repsons J. (2008) Investigation of Technologies for Precision Agriculture and Estimation of Their Efficiency. In: Ertekin C., Çanakci M. et al. (eds) *The 10th International Congress on Mechanization and Energy in Agriculture*, Antalya, TŰRKİYE, pp. 585-591.
5. Vilde A., Rucins A., Skrastins M., Cesnieks S., Lapins D., Berzins A., Aizsilnieks A., Kopmanis J., Plume A. (2005) Investigations in Precision Agriculture in Latvia. *New Technological Processes and Investigation Methods of Agricultural Engineering.* The International Conference, Raudondvaris, Lithuania, pp. 32-38.