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THE CHOICE OF THE DIFFERENTIATION CRITERIA OF SOIL TILLAGE USING THE GEOGRAPHIC INFORMATION SYSTEM (GIS)

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Kopsavilkums

Latvijas zemnieku saimniecībās pēdējos gados parādās precīzās lauksaimniecības elementi un vispirms labību kombainu aprīkojums ražu karšu veidošanai. Nākošā etapa: ražu kartes izmantošana saistīta vispirms ar augšņu īpašību izpēti. (Vilde, Lapiņš *et al.* 2005). Tas nozīmē, ka saimniecībās jāveido sava lokālā ģeogrāfiskās informācijas sistēma. Augšņu īpašību izpētes materiāli ir kā bāze diferencētas, uz ĢIS bāzētas resursus taupošās augsnes apstrādes ieviešanai. Latvijā jau iepriekšējos gados ir veikti pētījumi par augsnes apstrādes pasākumu optimizēšanas iespējām, lietojot GPS (Lapins, Vilde, Berzins, *et. al.*, 2006). Pētījumu rezultātu analīzes mērķis ir sistematizēt iegūto datu materiālu un ieteikt augsnes apstrādes diferences kritērijus, lietojot lokālās saimniecības ģeogrāfiskās informācijas sistēmas.

LLU MPS "Vecauce" „Kurpnieku" masīvā 47 stacionāros novērojuma punktos ražošanas sējumos 2004. - 2006.g. veikti pētījumi par faktoru ietekmi uz ziemas kviešu ražu. Meteoroloģiskie apstākli abos gados bija atšķirīgi: 2005.g. raksturojās ar pazeminātām vidējām gaisa temperatūrām, bet 2006.g. – ar izteikti zemu nokrišņu daudzumu un līdz ar to arī mitruma deficītu augsnē. Skaidrotas augsnes apstrādes diferences iespējas saistībā ar augšņu īpašību raksturojumu. Koordinātu noteikšanā izmantota GPS. Ražu noteica ar Claas Lexion 420 GPS izveidotām ražu kartēm, lietojot AGROCOM programmatūru. Kā ražu ietekmējošie faktori pētīti augsnes A horizonta biezums, organiskās vielas saturs, penetrometriskā pretestība augsnes slāņos līdz 50 cm dziļumam, augsnes mitrums aramkārtā un zem tās. Augsnes pretestības atšķirībās konstatēta būtiska novērojumu izpildes laika un augsnes mitruma ietekme. Slēdziens par atšķirīgu augsnes irdināšanas dziļuma izvēli jāizdara augsnes pretestību vērtējot saistībā ar augsnes A horizonta biezumu un irdināšanai paredzēto tehnoloģiju. Atšķirīga augsnes penetrometriskā pretestība augsnes zem aramkārtā vairāk ietekmē ražu par augsnes pretestību tās virskārtā. Augsnes pretestības samazināšanas pasākumi jāplāno, ja augsnes pretestība zem aramkārtā 30 līdz 50 cm dziļumā ir robežās 600 - 700 kPa cm $^{-2}$.

Konstatēts, ka augsnes pirmssējas un arī pamat apstrādes dziļuma diferencei piemērotas ir Ap horizonta biezuma kartogrammas, kuru lietojums ļauj vietspecifiski samazināt pamat apstrādes dziļumu, ja Ap horizonta biezums ir lielāks par 36 cm. Eksperimenta platībā tas sastāda 60.1 % no kopplatības (5.attēls). Izmēģinājumos konstatēts, ka GPS punktos ar palielinātu Ap horizonta biezumu ir arī paaugstināts organiskās vielas saturs, kas kopumā mazina arī augsnes pirmssējas un pamat apstrādes minimalizācijas lietojuma risku attiecībā uz ziemas kviešu ražām.

GPS punktos ar organiskās vielas saturu virs 2 % Ap horizonta vidējais biezums 33.4 cm bija būtiski mazāks (P<0.05) nekā pie organisko vielu satura augsnē virs 2 % (38.8 cm). Atbilstoši pie šiem pašiem GPS punktiem ar organisko vielu saturu vidēji 1.8 un 3.1 % ziemas kviešu sēklu iestrādes dziļums bija attiecīgi 3.2 un 3.7. cm (P<0.05) un sējas dziļuma variāciju koeficienta S% lieluma 9.2 un 16.9 %. Tas liecina, ka platības daļās ar palielinātu organisko vielu saturu virs 2 % un arī Ap horizonta biezumu virs 40 cm jālieto augsnes pirmssējas apstrādē vai arī reizē ar sēju pievelšana. Augsnes pirmapstrādes vai sējas optimizēšanas nolūkam var izmantot organisko vielu vai arī Ap kartogrammas, kuru veidošanai lietotais lokālā GIS izejmateriāls cieši korelē.

No regulējamiem faktoriem lokālas GIS veidošanai lietota augsnes penetrometriskās pretestības noteikšana GPS punktos. Pētījumu rezultāti par penetrometrisko augsnes pretestību izmaiņām liecināja par to lielo un būtisko sezonalitāti, ko raksturojam ar diviem pretestības noteikšanas rezultātiem rudenī un pavasarī. Konstatēts, galvenais sezonalitātes cēlonis augsnes penetrometrisko pretestību izmaiņās ir augsnes mitrums. Lai izvēlētos starp diviem iespējamajiem augsnes pretestības noteikšanas iespējamajiem laikiem: rudenī vai pavasarī, kā kritēriju lietojām sakarības un ietekmi uz ziemas kviešu ražu. Konstatēts, ka palielinātas augsnes zem aramkārtas pretestības virs 600 kPa cm $^{-2}$ negatīvā ietekme parādās uz ziemas kviešu ražu pretestību nosakot to pavasarī. Taču rudenī pirms sējas noteiktai augsnes pretestībai un izveidotai GIS ir ātrāks pielietojums. Pētījumu rezultāti „Kurpnieku” masīvā 2005. un 2006.g. apstiprināja jau iepriekš konstatētos secinājumus, ka augsnes dziļirdināšana izpildāma, ja augsnes penetrometriskā pretestība pārsniedz 600 kPa cm $^{-2}$. Uz augsnes penetrometriskās pretestības mērījumu datiem veidotā lokālā ĢIS karte ļāva secināt, ka augsnes dziļirdināšanas kopējo apjomu „Kurpnieku” masīvā var samazināt par 48 % no kopplatības.

Atslēgas vārdi

GPS, ĢIS, precīzā laukkopība, augsnes apstrāde, ziemas kvieši, augsnes raksturojums

Abstract

Investigations were carried out in 2004 – 2006 at 47 stationary observation points on the production plantations of the Kurpnieki massif, the Vecauce Research and Training Farm (Vecauce RTF) of the Latvia University of Agriculture (LUA), into the factors that affect the yields of winter wheat. The differentiation possibilities of soil tillage were clarified in relation to the characteristics of soil properties. The Global Positioning System (GPS) was applied to determine the coordinates. The yield was determined by means of the yield maps developed by using the Claas Lexion 420 GPS and the AGROCOM Software. As the factors affecting the yield were studied: the thickness of horizon Ap of soil, the organic matter content, the penetrometric resistance of soil in its deeper layers to the depth of 50 cm, the soil and the subsoil moisture. A significant impact of the observation time and soil moisture was established on the differences in soil resistance. The conclusion about the choice of a different soil loosening depth should be drawn by evaluating soil resistance in connection with the thickness of the horizon Ap of soil and the technology intended for soil loosening. The different penetration resistance of the subsoil layer affects the yield rather than soil resistance in its upper layer. Measurements for the minimisation of soil resistance should

be planned when the penetrometric resistance of soil in its deeper layers to the depth of 30 to 50 cm is within the range of 600 - 700 kPa cm $^{-2}$.

It was established that the main factor which differentiates the yields of winter wheat, starting from the autumn of the sowing year and also spring, was soil moisture. The GIS cartograms allow site specific reduction of the depth of the basic tillage when the thickness of the horizon Ap is greater than 36 cm. On the parts of the area with an increased organic matter content over 2 % and also when the thickness of horizon Ap is more than 40 cm the soil presowing tillage or simultaneous sowing and rolling down should be used. The local GIS map allows a conclusion that the total amount of the deep soil loosening in the Kurpnieki massif can be reduced by 48 % of the entire area.

Key words
GPS, GIS, precision field management, soil tillage, winter wheat, soil characteristics

Introduction

During recent years the elements of precision agriculture are appearing on Latvian farms, es for instance, the equipment of grain harvesters for the formation of the yield charts. The next stage: the application of the yield chart is connected with the investigation into soil properties (Vilde, Lapiņš et al. 2005). It means that the farms should form their own local geographic information system. The research material of the soil properties is used as a basis for the introduction of differentiated, GIS-based resources-saving soil tillage. Already in the previous years research was conducted in Latvia into the possibilities to optimise the measures of soil tillage by using the GPS (Lapins, Vilde, Berzins, et. al. 2006). The aim of the analysis of the research results is to systemise the obtained data material and to recommend the difference criteria of soil tillage using the local geographic information systems on the farms.

Materials and Methods

Field trials were carried out at the Vecauce Research and Training Farm of the Latvia University of Agriculture during the years from 2005 to 2006. The weather conditions in both the years were different: the year 2005 was characterised by lowered mean air temperatures but the year 2006 – by a pronounced low rainfall and subsequent moisture deficit in the soil (Figures 1 and 2). During the production trials on the Tarso winter wheat variety at 47 stationary observation points of the Kurpnieki massif the differentiation possibilities of soil tillage were clarified in relation to the characteristics of soil properties. The same wheat growing agrotechnology was used on the entire massif, the principle of the single difference being applied at the GPS points. Positioner Germin iQ 3600 was used to determine the point coordinates. The yield capacity was determined by means of the yield maps developed by using the Claas Lexion 420 GPS and the AGROCOM Software. The factors affecting the yield which were studied were: the thickness of horizon Ap of soil; the organic matter content (which was determined in a certified agrochemical soil laboratory); the penetrometric resistance of soil in the layers to the depth of 50 cm being determined before the sowing of wheat (at the stage of one or two leaves in autumn, at the end of the clostering stage in spring by means of the Eijkelkamp Agrisearch Equipment) soil moisture in the arable layer and under it, alongside with the penetrometric resistance of soil determined by means of the same Eijkelkamp Agrisearch Equipment.

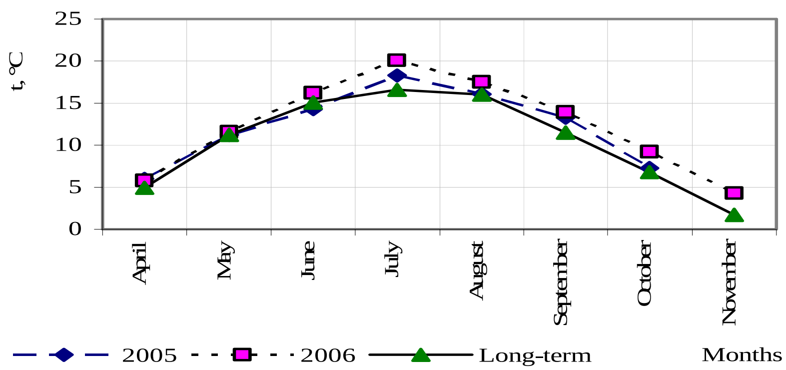

Figure 1. The mean day-and-night air temperature in the years 2005 and 2006, °C (acc. to Dobele HMS).

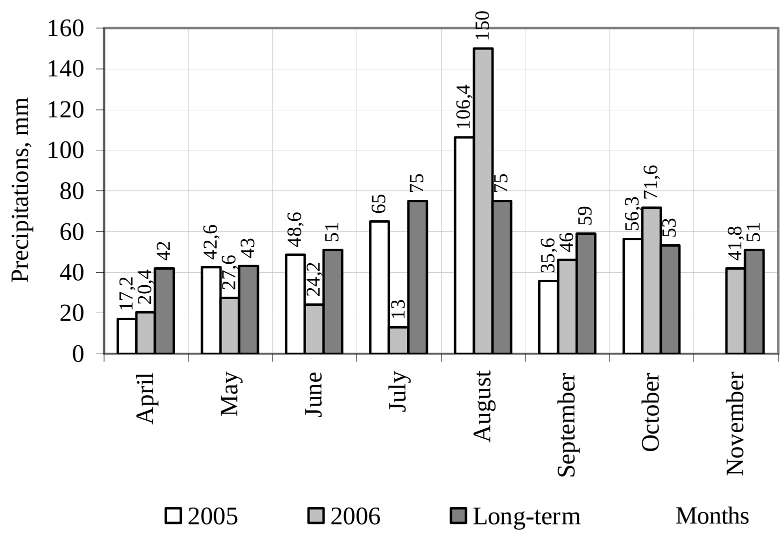

Figure 2. The mean amount of precipitation in the years 2005 and 2006, mm (acc. to Dobele HMS).

Analysis of the research and discussion

Uncontrolled factors: the organic matter content in the soil and the thickness of horizon Ap, which are of essential importance in the decision making system on the soil tillage differentiation in the aspect of the yields of winter wheat (Figure 3). No linear correlation with the yield was established for the granulometric content of soil characterised in the trials as physical clay content in soil, %.

The thickness cartograms of horizon Ap are appropriate for the differentiation of presowing and the postsowing depth of soil tillage the use of which allows site specific reduction of the depth of the basic tillage when the thickness of horizon Ap is greater than 36 cm. On the experimental field it constitutes 60.1 % of the total area (Figure 5). It was established during the field trials that there is increased organic matter content at the GPS points with an increased thickness of horizon Ap, which generally reduces the minimisation risk of the presowing tillage and the basic soil tillage, too, in relation to the yields of winter wheat.

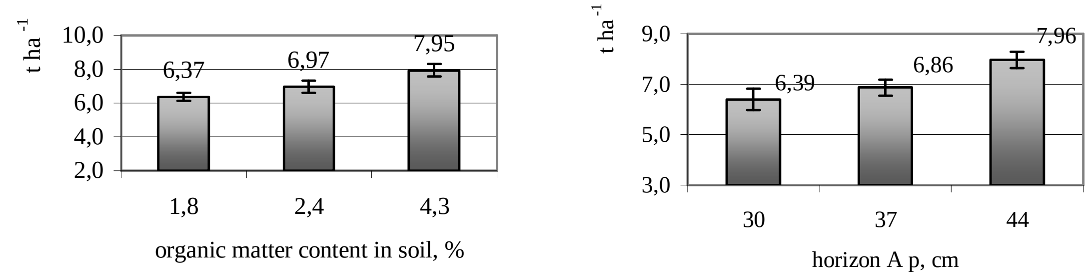

Figure 3. Organic matter content in soil, thickness of horizon A p, and the yield of winter wheat in the year 2006.

At the GPS points with an increased organic matter content over 2 % the average thickness of horizon Ap of 33.4 cm was significantly less ($P<0.05$) than with the organic matter content over 2 % (38.8 cm). Correspondingly, at the same GPS points with the average organic matter content 1.8 and 3.1 % the introduction depths of the seeds of winter wheat were 3.2 and 3.7 cm respectively ($P<0.05$), and the values of the variations coefficient S % of the sowing depth were 9.2 and 16.9 %.

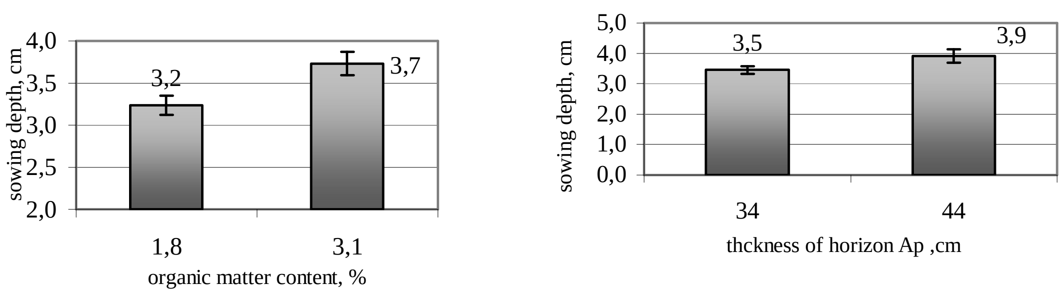

Figure 4. Dependence of the sowing depth of winter wheat on the organic matter content and the thickness of horizon Ap.

This demonstrates that on the parts of the area with an increased organic matter content over 2%, and the depth of horizon Ap over 40 cm rolling down should be applied during the presowing tillage or alongside with the sowing (Figure 4). The cartograms of the organic matter or Ap may be applied for the optimisation of the primary soil tillage or sowing (see Figure 5) with which the source material used for the formation of the local GIS closely correlates.

The controlled factor, used to form the local GIS, was the penetrometric resistance of soil determined at the GPS points. The research results into the variations of the penetrometric resistance of soil bore witness of their great and essential seasonality characterised by two results of the resistances determined in autumn and in spring. It was established that the main factor of seasonality in the variations of the penetrometric resistances of soil is the moisture of the soil. In order to make choice between the two possible times when soil resistance is determined – autumn and spring, the correlations and the impact on the yield of winter wheat were used as the main criterion (Figure 6).

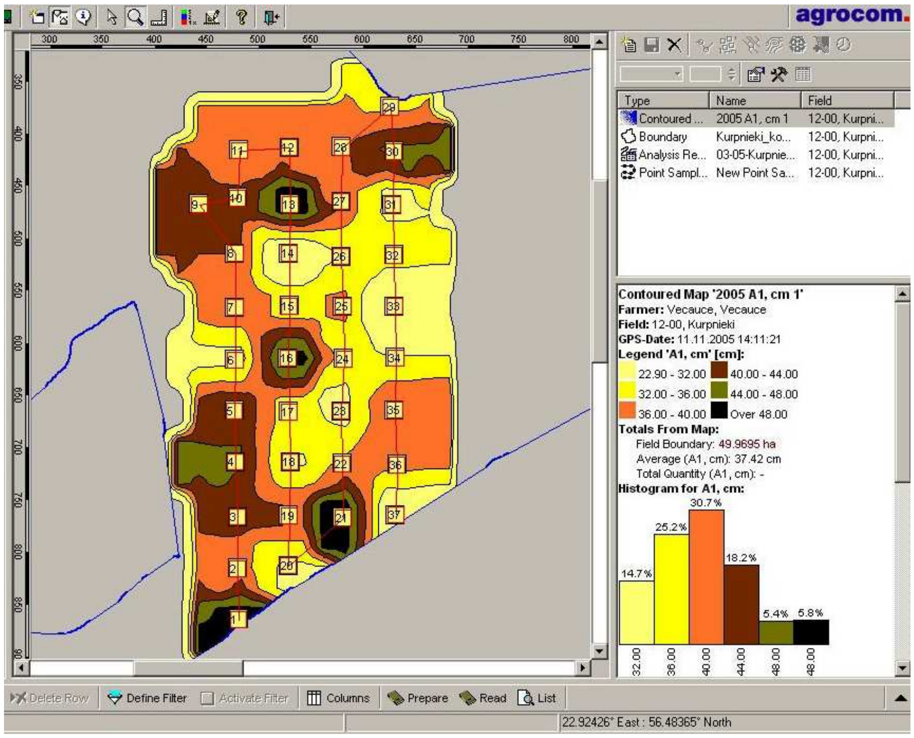

Figure 5. The GIS cartogram of the thickness of horizon Ap in the Kurpnieki massif.

It was established that increased resistance of the subsoil layer over 600 kPa cm^{-2} (resistance being determined in spring) has a negative impact on the on the yield of winter wheat. However, in autumn the soil resistance, which is determined before sowing, and the GIS has a more positive impact. The research results of the years 2005 and 2006 in the Kurpnieki massif confirmed the previous conclusions that deep loosening of soil should be carried out when the penetrometric resistance of soil exceeds 600 kPa cm^{-2} (see Figure 6).

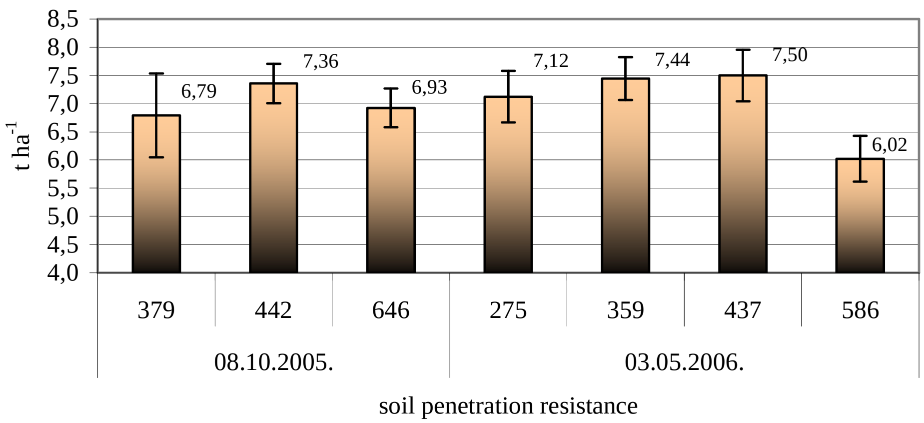

Figure 6. The yields of winter wheat in various soil resistance intervals in the lower layer of the arable land from 20 to 50 cm.

The local GIS map formed on the basis of the data of the penetrometric resistance measurements of soil allowed the drawing of the conclusion that the total amount of deep loosening of the soil in the Kurpnieki massif can be reduced by 48 % of the entire area.

Conclusions

Concerning the question of yield capacity of winter wheat the organic matter content in soil and the thickness of horizon Ap are of essential importance in the decision making system about the soil tillage differentiation.

The GIS cartograms allow site specific reduction of the basic tillage depth when the thickness of the horizon Ap is greater than 36 cm, which constituted 60.1 % of the total area of the experimental field.

At the GPS points with the average organic matter content 1.8 and 3.1 % the introduction depths of the seeds of winter wheat were respectively 3.2 and 3.7 cm ($P<0.05$), and the variation coefficient of the sowing depth S % was respectively 9.2 and 16.9 %. This demonstrated that on the parts of the area with the organic matter content over 2 % and also the thickness of horizon Ap over 40 cm rolling down should be applied during the presowing soil tillage along with sowing.

The results of the variations of the penetrometric resistances of soil bore witness of their essential seasonality. The main factor of seasonality was the moisture of soil. The significant negative influence of increased resistance over 600 kPa cm^{-2} (resistance being determined in spring) of soil under the arable layer was established on the yield of winter wheat.

It was established that deep loosening of soil should be carried out when the penetrometric resistance of soil exceeds 600 kPa cm^{-2}. The local GIS map allows reduction of the total amount of deep loosening of soil by 48 % of the entire area.

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NUTRIENT BALANCE AND AGROCHEMICAL PROPERTIES IN SOILS DIFFERING IN PHOSPHORUS AND POTASSIUM STATUS AS INFLUENCED BY FERTILISATION SYSTEMS

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Abstract

Experiments were conducted in 2001-2005 on sandy loam Calc(ar)i – Endohypogleyic Luvisol on two sites. The first site's soil was with higher amount of phosphorus and potassium (available P 0.082 – 0.108, available K – 0.0 93 – 0.136 g kg^{-1}), while the second site's soil was with lower amount of this nutrients (P 0.030 – 0.043, K – 0.067 – 0.093 g kg^{-1}).

The best nitrogen balance (close to 0) was achieved when nitrogen fertilisation rates were adjusted according to the mineral nitrogen content in soil in spring. When 60 t ha^{-1} of manure were applied once per crop rotation cycle, negative nitrogen balance was calculated only for the plots not fertilised with nitrogen fertilisers.Nitrogen balance was negative when crops were not fertilised with manure and received average mineral fertilisation rates or the rates calculated using balance method, also in the case where winter wheat straw was ploughed-in once per crop rotation cycle. In spring mineral nitrogen content in soils of plots fertilised with different nitrogen fertilisation rates was quite similar. Mineral nitrogen content depended mainly on precipitation (0-40 and 0-60 cm – $R = 0.66$ and 0.71)and somewhat less on air temperature ($R = 0.41$- 0.45).