Using technology of data collection and data processing in precision farming

Sběr a vyhodnocení dat v precizním zemědělství

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Abstract: Data collection, data processing, data presentation and data application in the System of Precision farming guarantee a success of this system in the market. Difficulties of technologies, which are currently and continually involved in this system, argue against its practical using by farmers. In this case, service company wants to create a suitable environment not only for data collection, but also for the high quality of the information distribution to customers. One of such tools is the MapServer placed on Internet web sites.

Key words: Precision Farming, MapServer, GIS, PREFARM, data collection

Abstrakt: Sběr, zpracování, prezentace a aplikace v systému Precizního zemědělství zaručuje úspěch tohoto systému na trhu. Složitost technologií, které neustále se zavádějí do tohoto systému odrazují koncové uživatele od jejich praktického využití. Proto servisní společnost působící na trhu chce vytvořit vhodné prostředí pro zajištění nejen sběru informací, ale rovněž kvalitní distribuci těchto informací zákazníkovi.Jedním z takových to nástrojů je MapServer umístěn na webových stránkách internetu.

Klíčová slova: Precizní zemědělství, Mapserver, GIS, PREFARM, sběr dat

INTRODUCTION

The precision agriculture offers the potential to fundamentally alter agricultural decision-making. The use of large machinery and hired labour has caused many farmers to think of large fields as the basic management unit. Even though farmers know from the experience that yields are higher in some parts of the field than in others, conventional management practices have focused on applying inputs at a uniform rate to the entire field. Information technologies permit the modern grower to obtain a detailed explicit information at a small scale common to farming practices of earlier times but with a considerably more information, enabling them to efficiently manage the land at these finer scales.

The basic principle of precision farming technology is an exact positional controlling of fertilisation with the accuracy of few meters. The whole process requires a big amount of data to be collected, which enable controlling of the whole process. For better understanding, to the whole of this process, it is necessary to improve access to these data and to make analysis of it. Mathematical analysis of the data can bring a new quality to the whole process of precision farming. The real end-users of the technologies are farmers and agricultural managers. The limitation of better utilisation of the data is, unfortunately, their limited knowledge of the new technology of precision farming which limits a better utilisation of these data and the possibility of using new data sources. For this reason and in the connection with building of the system for better data access, the simultaneous education of managers and farmers will be provided. The distance learning methods are used.

The Premathmod model brings a new way for precision farming based on new architecture of the system. This new way could be expressed by the following formula:

Data $\rightarrow$ Information $\rightarrow$ Knowledge

Without data, there will not be information and without information, there will not be knowledge. Nevertheless, without knowledge there will not be the request for information and for data. The data are the first step of precision farming. These data are usually transformed into information how to apply fertilisation. For these purposes, it is necessary to have knowledge how to provide it. However, this knowledge is in many cases used in the system as a black box. This knowledge is often invisible

in commercial systems and farmers in many cases only use predefined functions.

Precision farming is usually divided into the following steps:
– Data capturing (soil, crop, yield)
– Data analysis and data processing
– Data access
– Variable application (soil tillage, seedling, fertilizing, chemical crop protection)
– As applied processing
– Data archive.

NEW MOBILE INTERNET BASED SOLUTION

The new system is developed on the base of two European projects, WirelessInfo and Premathmod.

The Wirelessinfo IST-1999-21056 project aims to implement advanced wireless communications into the multimedia systems and services for agriculture and forest administrations to improve access to agricultural and forest information. The project demonstrates the improved effectiveness of agriculture and forest data and information access as compared to the existing systems. The whole project is oriented on the connection of GIS platforms with wireless communication. The communication possibilities via Internet solution and spatial tools for wireless communication were compared. In precision farming, the main aim of companies performing services and consulting is to provide their customers with a high quality service and really professional consulting based on true information. For the best result of service and consulting, a company needs ensure precise information as many as they can. The mobile communication is very useful in communication between a manager and the people in the field, which is collecting data, or applying a service by final application.

The basic WirelessInfo solution is based on the University of Minnesota Map Server Open Source development environment for building up spatially enabled Internet applications. The important part was the system of remote data processing in the central database and mobile data editing. Map server is a powerful Internet tool to handle a big amount of data. The service organisation, which is offering precision farming system in the market, needs to work with professional GIS software for data collection, data transport, data processing and data presentation to farmers or Agricultural Company. The central database collects all data and information in geographic information system. Output of data results is placed on Internet, rather on the Map Server. In this way, all information placed on the Map Server, from where it is easily accessible for the authorized end user any time from anywhere. Data on the Map Server are periodically (up to needs) updated for right using in crop production and farm management by end user. Electronic equipment is placed in tractor cab. The driver can through a calibrator manually change or set an application rate of fertilizer on the output gate independently on the application speed. The application rate can be also managed by the application running parallel on the connected iPaq.

The goal of the *Premathmod* is to connect this solution with analytical tools and supported knowledge management. The expected architecture will be according to the following scheme.

The new tools in architecture are:
– Internal Application Server
– External Application server
– Metadata.

PRACTICAL TRIALS

Mapserver Prefarm is a powerful Internet and Mobile tool to handle a big amount of data coming, for example from the precision farming system. Service organization, which is offering precision farming system in the market, needs to work with the professional GIS software for data collection, data transport, data processing and data presentation to farmers or agricultural company. Precision farming database collects many raw data sources, processed data, statistical data and so on.

The large scale practical testing is realised by the MJM group. Since 1997, the MJM group, a.s. has the experience with the precision farming. With further development and associating with another parts the system, PREFARM was developed. Nowadays, the database represents 160 satisfied users with 200 000 ha. "Prefarm" is a complex system using precision farming tools. It is focused on the increase of the agricultural profitability and on reducing the fertiliser stress. The system presents the use of hi-tech technologies, as are soil and crop analysis, modern navigating tools (GPS, DGPS) and software tools for data processing. These allow us to apply fertilisers variably according to the position (the application rate is changing according to position and the prescription map).

System advantages:
– Easy introduction to precision farming rules
– Higher effectivity in the use of fertilizers
– Low costs
– Reducing of the ecology stress.

"THE PREFARM" METHODOLOGY

Data collecting is divided into several parts

Boundary mapping

Off-road equipped with DGPS, GPS receiver

Placement of the control points (soil sample points).

The points are placed on sites according to soil survey (airborne images, satellite images and the EM 38 sensor).

Another possibility is to set the sample points by the mathematical modeling.

The sample points are set by the DGPS/GPS. The density of the points is optional.

3 ha per a soil sample are the most popular raster.

Soil sampling

Each soil sample represents a certain locality and is made from 20–25 partial samples.

Soil samples laboratory analysis:
– Phosphorus
– Magnesium
– Potassium
– pH
– CEC
– Sulfur
– Organic matter
– Microelements.

The following analysis is divided into the next steps:
– Nutrition classification according to results, nutrition maps processing.
– Prescription processing for site-specific application, also economic calculations are included.
– Consulting with the customer and adding database with another data, this data enriches the information about soil characteristics.
– On demand of the customer, we are able to process into the database:
  – Airborne and satellite images, for the yield estimation
  – Processing yield maps
  – Soil conductivity measurement – soil type and fertility determination
  – Agro-manager comments
  – Etc.

Central database of soil and crop information and data providing

Central database collects all data and information in the geographic information system. Output of data results is placed on Internet, rather on the Map Server. In this way, all information is placed on Map Server, from where it is easily accessible for the authorized end user any time from anywhere. Data on the Map Server are periodically (up to needs) updated for right using in crop production and farm management by the end user. Data can be also transported to the end user via E-mail, floppy disc, CD.

Application equipment for variable application of fertilizer

1. Spreader for dry fertiliser – Bogballe-Bin capacity – 2 500 kg, application mash 12–36 m.
2. Calibrator B 2003 – Electronic equipment is placed in tractor cab. The driver can through the calibrator manually change or set the application rate of fertiliser on the output gate independently on the application speed. Application rate can be also managed by application running parallel on the connected iPaq. Data communication between iPAQ and calibrator is set automatically after iPAQ is connected to the calibrator through the data cable and variable application on iPAQ is running.
3. iPAQ – hand held with multifunction using in crop production. Beside a variable application, the iPAQ can be used for variable sowing, variable tillage, yield data collection and others (Processor ARM, Windows CE, RAM 32 and more. Serial port, USB port).
4. GPS and DGPS receiver – NAVMAN – 12 channels receiver as an iPAQ extension, 12V power.
5. SITE MATE – Software for variable application of dry fertiliser. Running under Windows CE, Data format- .SHP, .SHX, .DBF.
6. Other facilities – Handle, power supply.

PREFARM MAPSERVER TOOLS

These tools help to display all information you have stored in on the server. These tools are divided into several groups according to the character of information and time to be collected or created.

Field

Information of the field boundary and field are divided as follows (Figure 1):
– Year
– Crop rotation
– Organic matter spreading.

Soil tests maps

The information about all nutrients is stored in the system (Figure 2):
– Year
– Control points GPS
– NDVI
– Ca
– K
– Mg
– P
– PH
– CEC
– K/Mg

The above information helps to make immediately a quick overview about the soil sample test and nutrients needs.

Period differences

Soil test data are monitored also in the time of sampling (Figure 3). This part can give a quick overview about soil nutrients level moving in the topsoil. Color maps are prepared for each nutrient separately, for example:
– Ca 1999–2002
– CEC 1999–2002
– K 1999–2002
– K/Mg 1999–2002
– P 1999–2002
– PH 1999–2002.

Maps show just very general results in three levels of categories as are:
– Decrease
– No change
– Increase.

VRA recommendation

This tool helps to get the information about Variable Rate Application or Multi Variable Rate Application by tables or variable color map for the followed nutrients (Figure 4):

– Phosphor (in fertilizer)
– Potash (in fertilizer)
– Calcium (in fertilizer).

Price map

This tool helps to make a short overview about prices per hectare including application for the followed nutrients (Figure 5):

– Potash
– Phosphor
– Calcium
– Potash and Phosphor.

Others

The PREFARM MAPSERVER tools allow adding other information to the GIS database (Figure 6) as are:

– Airborne pictures
– Satellite imagery
– Cadastral maps
– Geographic maps.

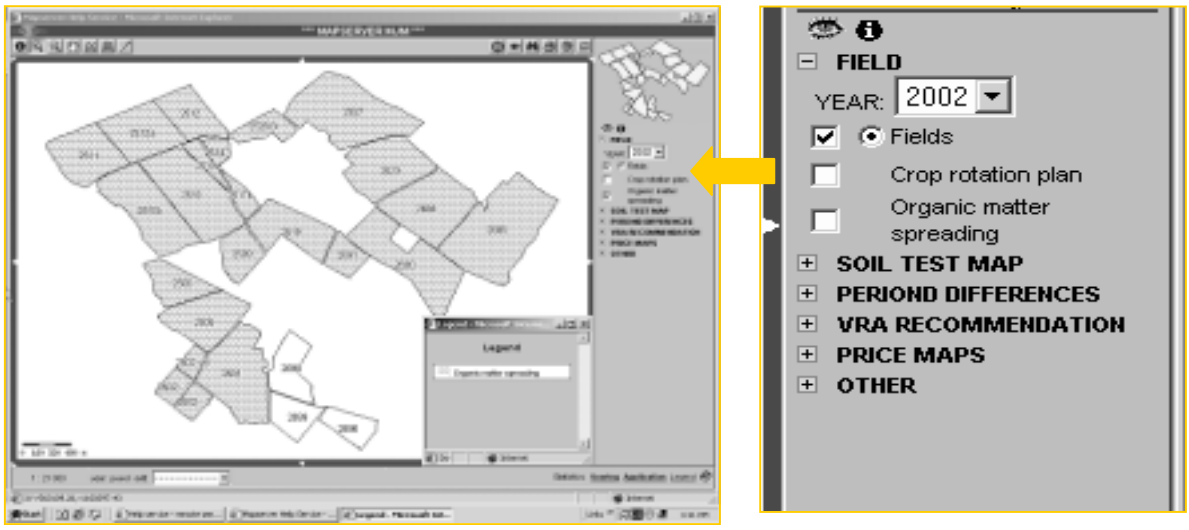

Figure 1. Farm – field boundary

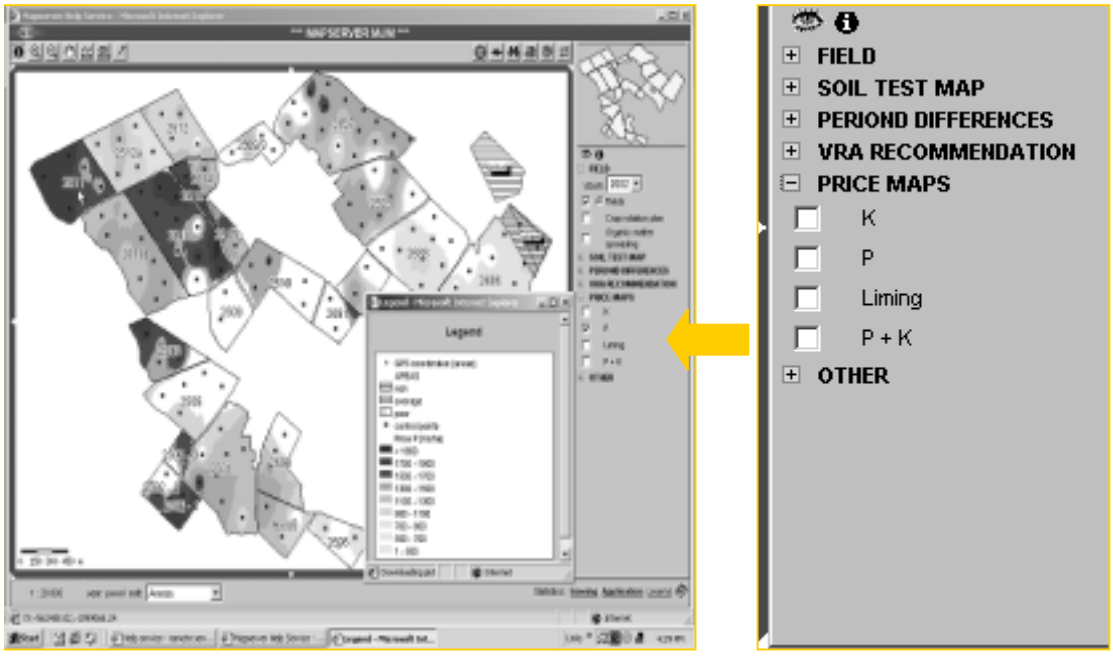

Figure 2. Map of nutrient's content in soil

Map Server – capacity of using by Service Company

Map Server Prefarm is a powerful Internet and Mobile tool to handle a big amount of data coming, for example, from precision farming system. The service organization, which is offering precision farming system in the market, needs to work with the professional GIS software for data collection, data transport, data processing and data presentation to farmers or Agricultural Company. Precision farming database collects many raw data sources, processed data, statistic data and so on. For example, we can take one co-operative farm, which applies the system of precision farming on approximately 1 487.61 hectares of arable land since 1998.

The current database of precision farming system collected the following data:

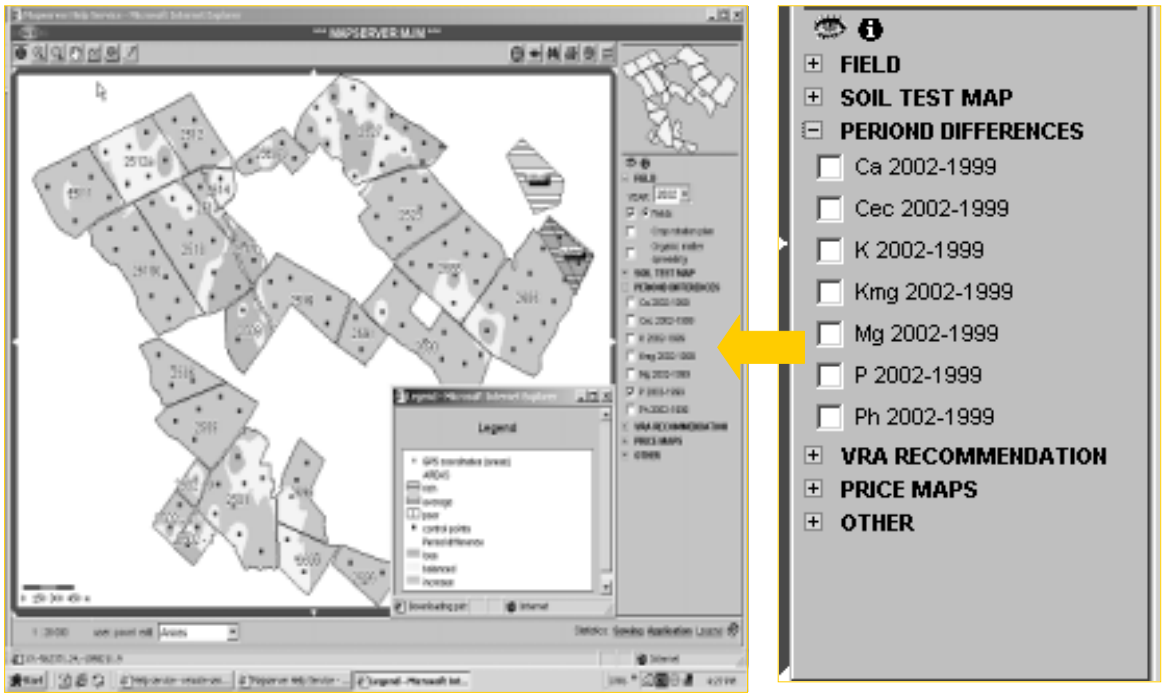

Figure 3. Map of nutrient's content differences in soil between two soil sample periods

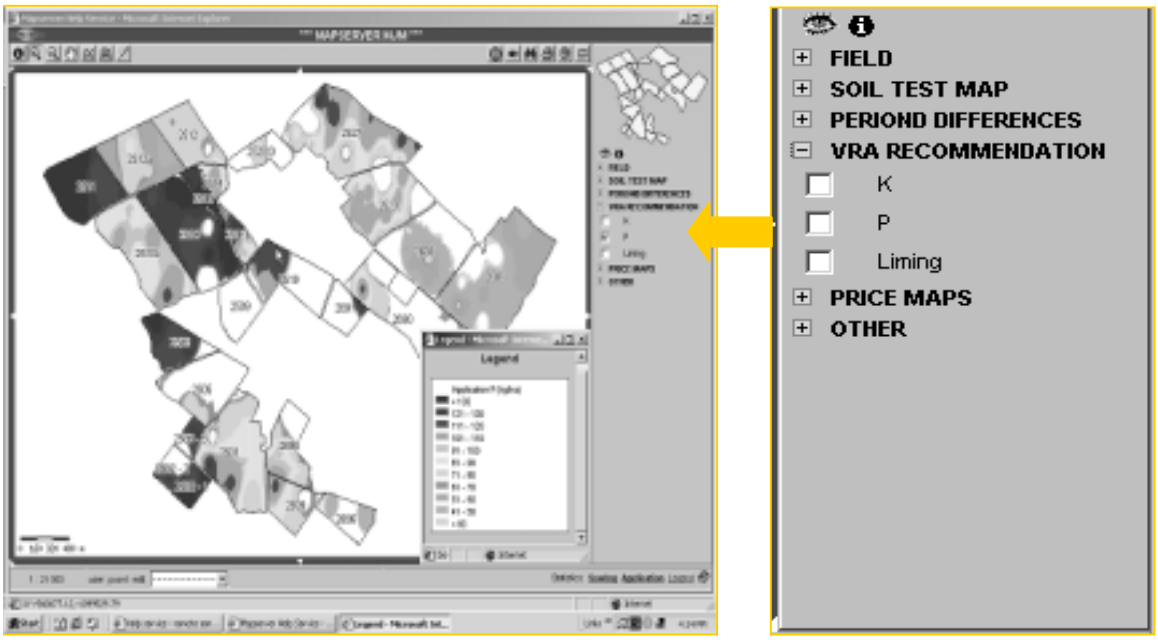

Figure 4. Variable rate application maps

1. Field boundary – 61 fields
   – Field average area is 24.39 hectares
   – Minimum field area is 2.09 hectares
   – Maximum field area is 68.13 hectares
2. 1 964 Soil type maps
3. 374 soil sample control points
4. Soil sample analysis 1998, 2002(P, K, Mg, Ca, soil pH, CEC)
5. 1997 Soil test maps
6. 2002 Soil test maps
7. Crop rotation data – 1997, 1998, 1999, 2000, 2001, 2002
8. Yield maps of winter wheat, spring wheat, barley, rape seed oil, corn, peas: 1999, 2000, 2001
9. Recommendation maps 1999, 2000, 2001, 2002
10. Applications maps for P, K, Ca – 1999, 2000, 2001, 2002
11. N-application data in cereals 2001, 2002
12. As applied data
13. Electro-magnetic data collected by EM-38

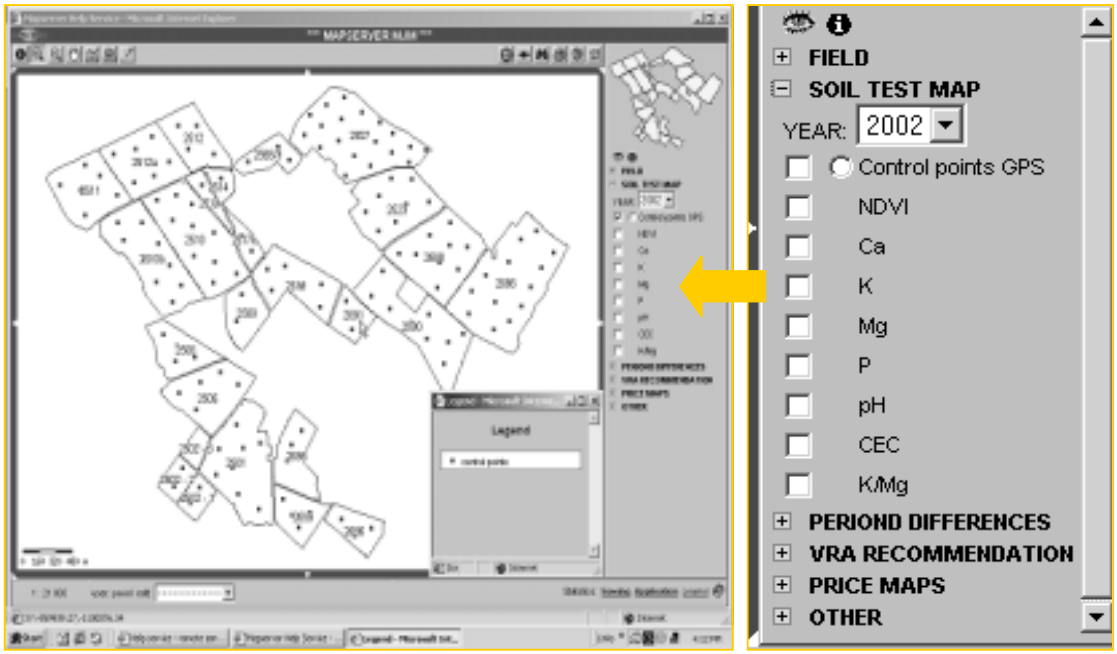

Figure 5. Price maps

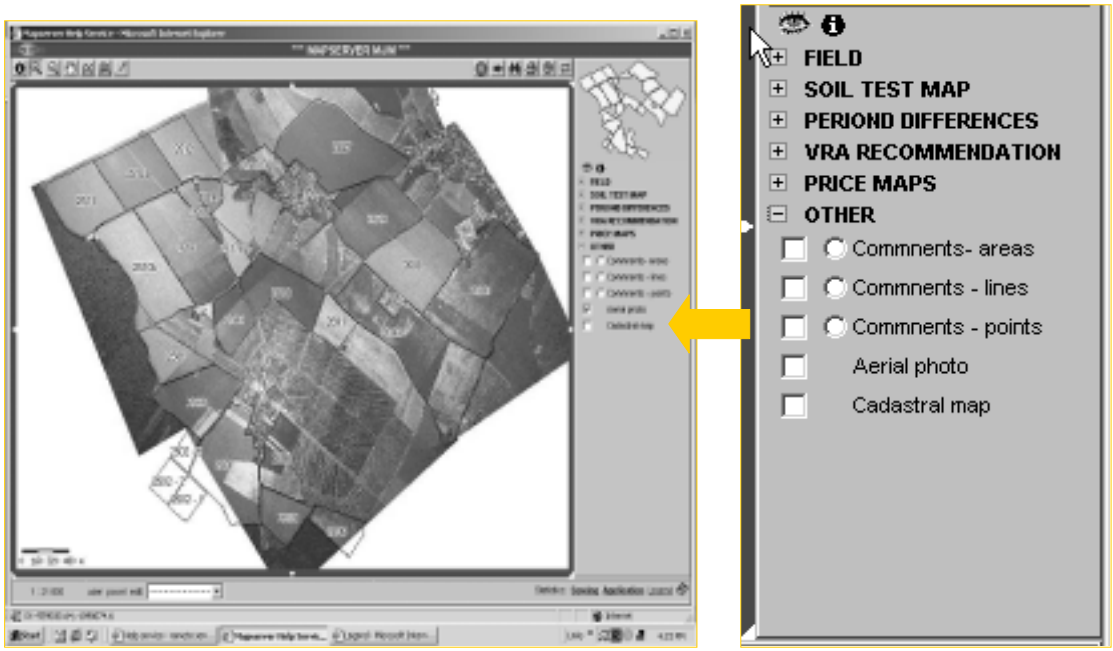

Figure 6. Air borne pictures

14. Remote sensing data (Airborne data 2000, satellite data 1997, 2000, 2002)
15. Statistic data of soil test changes
16. Leaves index data – 1997, 2000, 2002
17. Others (geographic map, notes).

The above-mentioned data have got around 20 Mb. This size of database grows up every year. To use this database in farm management and field management needs a good skill of computer and the GIS software using. Every year, data are prepared for field application field by field. After that, a result must be delivered to the end user or service company, which does a variable application on the field (experience in the Czech Republic). One of the limiting factors is time to do this service. Many farmers do a lot of changes in the crop rotation plan and fertiliser for the current year and the prepared plan must be changed several times. Other using of precision farming database than digital form of data used via computer is not possible. In this case, we do not talk about variable soil tillage, variable sowing and so on.

Main factors in data processing by the service company:

1. Complete data collection for agronomic recommendation
2. Short time to process data
3. Short time to deliver data to the end user – farmer, service company doing a spreading
4. Character of data delivered to the end user
5. Seasons condition.

Data processing and final result including agronomic recommendation prepared by service company using a professional GIS software takes for P, K and lime by variable application on the field around 10 hours by one person.

The Map Server and data processing tools allow the service company to cut this time down. The main difference between the traditional data processing and data delivery to the end user is a more often performed communication between the end user and service company through Map Server (Internet) and the technique of data processing.

Collected data are processed as a whole farm and than divided to each field. The time of data processing is the same as the time to process one field in the traditional way. End user can see the results for whole farm as a map or tables in digital form on his/her PC screen.

Data accessibility by end user:

1. Accessible precision farming data any time and almost anywhere
2. Accessible field application data any time
3. Data transport without using floppy disks, PCI MCIA card, or others
4. A quick response to a question.

First experience of using a Map Server

1. End user experience
   – All results can be displayed without any GIS software.
   – Every result is displayed for the whole farm in color map.
   – Easy work with data – using only computer mouth.
   – All data can be printed out by farmers.
   – Application maps can be simply downloaded.
   – Possibility of graphic notes (polygons, lines, points) with legends.
   – Several levels of users.
2. Service company experience
   – Data are processed not as one field but as one farm (number of fields and the area of farm is not really important).
   – Time to prepare a final result for one farm is 30 minutes including the delivery of data to customers.
   – Computer, controlled by person, mainly processes data automatically.
   – Daily capacity of processed and delivered data grows up from 1 farm to ten farms controlled by one person.
   – Service person can spend more time with data collection.

CONCLUSION

Practical testing of the Map Server was done on the test farm by end users from the end of year 2001. Testing is focused on farm management via traditional connection to Internet and also Wireless connection via GSM, HSCSD and GPRS. The focus of testing was on separate components, but also on the functionality of the complex system. Since September 2001, there were done several improvements on the Map Server model. During testing a model was present individually except two presentations. One farm data was presented as training data to simulate any situation. For the spring of 2002, there were prepared 20 farms with true data for using in farm management in the Czech Republic. Currently, is system also practically tested in Germany and Italy.

The system demonstrates completely new solutions of precision farming. It offers a completely new and more economical technology of work. The system was awarded the Grand Prix of TechAgro in April 2003 (the product was offered compared to technologies offered by world agricultural producers like John Deer, Class, etc.). This year, the system is also demonstrated outside Europe (the USA – Precision farming conference in Minneapolis, and there is planned a demonstration in South Africa Pretoria by the end of this year).

REFERENCES

Charvát K. et al. (1998a): Precision Agriculture – European Approach. Proceedings of the First International Conference on Geospatial Information in Agriculture and Forestry, Lake Buena Vista, Florida.

Charvát K. et al. (1998b): Concept of GIS for Precision Agriculture. Proceedings of Conference GIS Brno 98.

Charvát K. et al. (2000): WirelessInfo – Work description for the IST project IST-1999-21056.

Charvát K. et al. (2001a): WirelessInfo – Wireless Communication for Forestry and Agriculture. Agile, Brno.
Charvát K. et al. (2001b): WirelessInfo Technical Implementation plan. Brandýs nad Labem, February.
Holý S. et al. (2001): WirelessInfo Design of system architecture. Benešov, May.
Holý S. et al. (2001): WirelessInfo End user interface. Benešov.
Charvát K. et al. (2001): Mobile data management Book of vision.
INSPIRE (2002a): Infrastructure for Spatial Information in Europe. Reference Data and Metadata Position Paper.
INSPIRE (2002b): Infrastructure for Spatial Information in Europe. Environmental Thematic User Needs Position Paper.

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