Precision Agriculture (PA): A Useful Tool for Farmers

- Why use so few farmers Precision Agriculture? -

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ABSTRACT: **In agriculture, even small-scale site differences can lead to great differences in yield and quality. Today, it is technically possible to take such small-scale differences into consideration. This is called precision agriculture or site-specific-farming. With the help of this tool farmers can save resources, will have a more efficient production and will transform their crop production into an integrative management system.**

KEY WORDS: *precision agriculture, heterogeneous fields, site quality differences, crop production, GIS*

Introduction and problem definition

For centuries it is known, that the properties and qualities of soils differ considerably even within a small area. For example, in moraine landscapes, alluvial areas or low mountain ranges the growth factors can show great differences within a few metres. Soil maps demonstrate this in a graphical way (see figure 1). These locally varying site properties are additionally influenced to different extents both by natural features such as hollows, slopes, ridges as well as by cultivation-related impacts like compaction or erosion.

Figure 1: *Soil map from the years between 1930 – 1940 of a 90 ha field*

These local variations, in special the soil quality, have a great influence on the yield (see figure 2). The current agricultural practice does not consider these site differences within fields. To arrange these fields by dividing into almost uniform parts is mostly not possible. Therefore farmers adjust soil tillage, sowing, fertilization and plant protection to an average site quality of their field. As a result, on plots with a high yield potential this potential is not exploited whereas areas of low fertility are over fertilized.

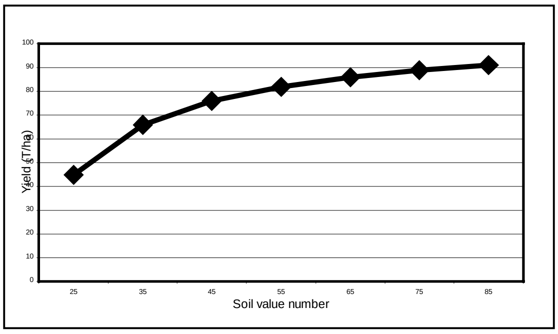

Figure 2: *Theoretical correlation between soil quality (expressed by a soil value number ranging between 8 and 100, a soil fertility index) and yield.*

The dimension of this site related yield differences became visual, when the agricultural engineering industry developed the first time GPS based (global positioning system) yield mapping systems (see figure 3).

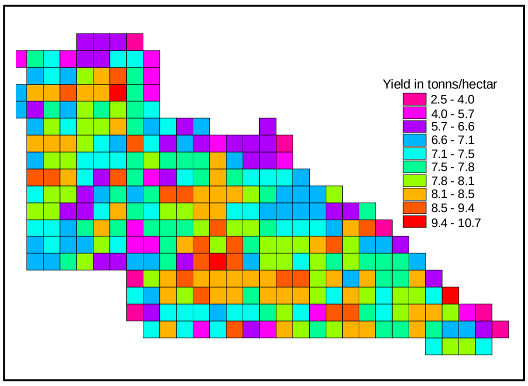

Figure 3: *Yield-map of the field from figure 1 with a yield-variation of about 8.2 t/ha*

The technical development provides satellite navigation as a tool, which establishes the important condition to consider the spatially varying site differences within fields while cultivating them. Adopting these methods and systems precision agriculture can significantly increase economic and also ecological efficiency of arable crop production.

In addition to this, new methods for the characterisation of the site variations where developed. Beside the soil grid sampling, witch is one of the most expensive methods several other techniques exist. For example identifying soil quality variations by the measurement of the "electromagnetic soil conductivity" (s. figure 4) or for the description of the crop biomass a near infrared remote sensing method (s. figure 5).

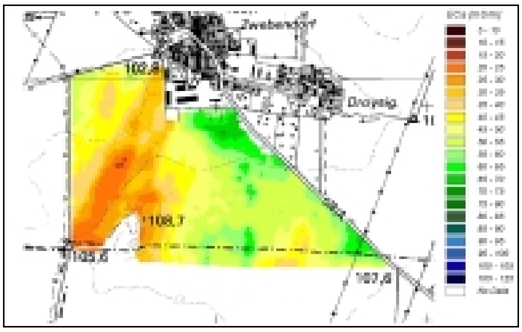

Figure 4: *Electromagnetic soil conductivity (EM38) of the field from figure 1.*

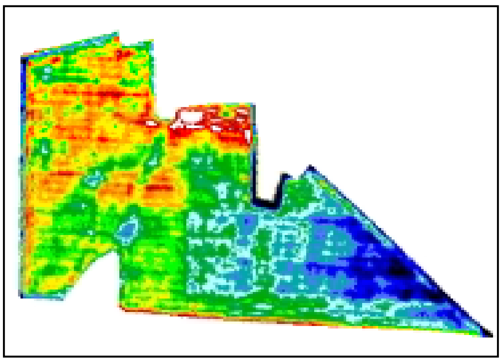

Figure 5: *Near infrared remote sensing picture of winter wheat (picture taken on: 27.4.00) of the field from figure 1*
Blue = low biomass; red = high biomass

All this different site information have to be combined in a GIS (Geographic Information System) with expert knowledge (s. figure 6). The rule based combination of the various information will end in application maps. With them it is possible to control the specific equipment like fertilizer, sowing machine etc. in crop management.

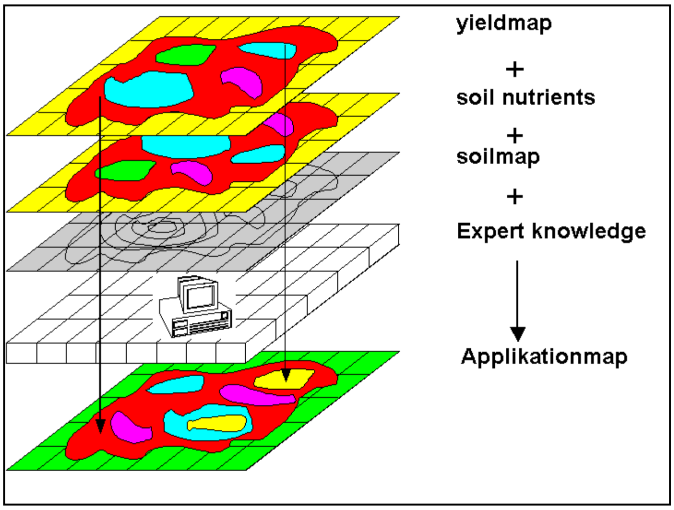

Figure 6: *combination of relevant data for the creation of application maps*

Currently farmers do vary, mostly vary only one crop production measure, generally the soil fertilization. But from the view of crop production it is necessary to consider each crop production measure specifically and in context to the other measures in order to co-ordinate them. Only such integrated measures ensure high economic efficiency and broad ecological benefits (s. figure 7).

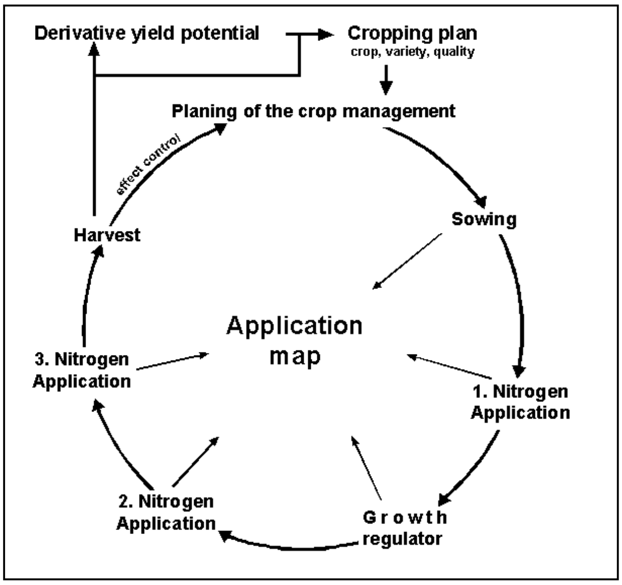

Figure 7: *The practice of precision agriculture has to be an integrated measure*

While in the USA already about 4% of the farmers practice some aspects of precision agriculture, the European farmers hesitate. Some reasons for the unassertive implementation are, that it is not known which meaning can be derived from the basis of the collected data and which in crop management decisions can be derived from the different site information. Practical farming is missing a tool like decision support systems with integrated transferable rules and principles to react with adjusted agronomic measures to the site variations. Beside this, all the different studies never showed what economical results can be obtained through the use of precision agriculture?

Another problem is, that in order to execute precision agriculture, multiple steps in data acquisition and information management are necessary. Some of them cannot be done by the farms on there own. The most important steps are:

- Identification, characterization and delineation of the various site properties.
  This will mostly be done by service companies. The most common offered service is grid based soil sampling. But other methods as remote sensing currently are showing up as services.
- Determination of the respective cultivation potentials corresponding to the various site characteristics.
  The calculation of the yield potential can probably be done by using crop growth models. They have to be part of a general decision support system.
- Development of algorithms for appropriate determination of the cultivation practices according to agronomic and economic criteria.
  The development of algorithms cannot be done by farmers. This is the target of some research projects running at the moment like the *pre agro*-project in Germany.
- Systematic management of the resulting collection of data and information.
  Some data, like soil maps, can be used over several years. Others, for example soil nutrient maps have only a limited value. Yield maps can be used only very carefully because they represent the result of a specific year. These examples show already, that a systematic management of the date is a complex task and very necessary. At present there are still no software products on the market that meet the requirements.
- Analysis of the site specific management effects onto the farms with respect to economic and busines cycles.
  The economic effect of precision agriculture depends on several factors. The cost for the data acquisition, the management of the further production (fertilization level), the heterogeneity of the field, the cost for the technique and the regional climate (water is mostly one of the limiting factors). Therefore it is useful if farmers make there own experiences and probably also own experiments in the fields (on-farm experiments).

With the support of research and development projects the prompt introduction of this innovative agricultural technologies can be improved. The central concept of such projects is to develop principles and to establish rules for crop management, which enable a specific control of cultivation practices by keeping in mind the necessary crop cultivation as well as economic and ecological criteria. With such decision support systems farmers will adopt precision agriculture as a useful tool to increase economic and also ecological efficiency of arable crop production.

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