Integrated management of soil and crop in precision agriculture[13]

extended summary of the respective subprojects of *pre agro*, dealing with integrated management of soil and crop

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Introduction

Crop management of integrated farming procedures is adapted to the site specific conditions for growth and yield formation of the very crop. In addition the different measures[14] are created compatible to the other measures within the cropping system to ensure a development and yield that is most suitable to the expected results of the crop production. Such an approach is rather complex already for single, uniformly cultivated field. All measures are planned according the site conditions and linked logically to their specific impacts onto soil and crop. Those measures that aim directly onto the soil are important additions to the crop management measures, because they prepare physical conditions as important prerequisites for the crop development and yield formation.

In precision agriculture these principles for soil and crop management are applied for single sub-units in the heterogeneous fields. According to this, each step in planning and managing the crop is related to the site conditions of the sub-unit, its crop management history and linked with the other measures on that very sub-unit. To ensure the proper use of the site data and deducting feasible activities for cropping measures for each sub-unit in the fields, it is necessary to support the decision making of the farmer. The joint-research project *pre agro* develops such decision support tools as software modules for farmers and extension service. These modules aggregate the appropriate existing knowledge on crop management. The knowledge is stored in mathematical algorithms and logical rules. The algorithms and rules are developed in a general approach and are still site specific. Thus these rules can be applied on most locations in Germany that are suitable for precision agriculture. The modules are programmed in standard software.

Soil cultivation

A prototype of a soil cultivator was developed in *pre agro* that is capable of tiling the soil in different depths. The depth of cultivation can be changed during the soil cultivation according to a set of rules. These rules refer to the site conditions of sub-units, especially the soil aeration due to more or less dense and compacted soil as well as water flow in the soil. Reducing the soil tillage depth can lower the fuel consumption for the tractors up to 60%.

Sowing (module: *pre agro*-sow)

For sowing winter wheat differentially according the site specific conditions of sub-units within field, the prototype of a decision-support module was developed. It was programmed as an ArcView-extension. Sowing winter wheat differentially according site conditions was done on all *pre agro* fields in the last three years. The planned plant densities as well as the

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[13] Reprint from: Werner, Jarfe (2002): Precision Agriculture – Herausforderung an Integrative Forschung, Entwicklung und Anwendung in der Praxis, KTBL Sonderveröffentlichung 038, Darmstadt, pages 222 - 224

[14] Important cropping measures are: soil tillage, seedbed preparation, sowing, Nitrogen-fertilisation (N), weed control, crop protection and fertilisation of Phosphorous (P) and Potassium (K)

planned ear densities were achieved on the fields in some cases rather well. Due to bad weather conditions (drought) the emergence rate was reduced and a much lower plant density was achieved in autumn of 2000. Thus, due to favorable weather conditions later on during the relevant growth period, almost similar yields were harvested in many sub-parts of some of the different fields in the project. On some locations the planned ear densities were far to low compared to the counted results in the fields in the year 2001.

N-fertilization (*pre agro*-N)

A module for N-fertilization in precision agriculture was developed that helps to make decisions in different nitrogen fertilization strategies. The module was programmed as an ArcView-extension. On-Line as well as Off-Line approaches (mapping approach) and combinations (on-line with mapping overlay) were developed. Some of the algorithms were tested with plot experiments as well as with on-farm experiments. The analyzed N-fertilization strategies resulted in similar yields as the usual N-fertilization strategy of the farmers.

P-/K-/Mg-fertilization, liming (*pre agro*-basic fertilization)

Algorithms for site-specific fertilization of P, K, Mg and for site specific liming were developed. New approaches were designed to calculate the demand and to typify the proper soil-nutrient level. The algorithms are specific for whole farms and less for single crops. These rules and balancing algorithms were programmed as prototypes.

Weed control

With a prototype of an optical weed detector the local weed density in row crops can be analyzed. According to the detected weed density the proper amount of herbicide can be adjusted on the sprayer accordingly. With such an approach the necessary herbicide amount could be reduced about 12,7 % in comparison to the standard application rate.

Crop protection

With the use of a mechanical biomass sensor (pendulum-meter) the leaf area of sub-units in heterogeneous crop stands can be determined. With this information the necessary amount of fungicide spray to cover to canopy completely can be adjusted. With this approach the amount of sprayed fungicides could be reduced about 14 % in comparison to the standard application rate. The pendulum-approach was compared with other methods, especially those from non-destructive LAI-measurements as well as from remote sensing.

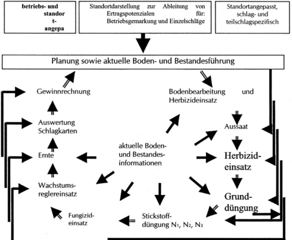

Figure 2. Illustration of the integrated management of soil and crop in precision agriculture.