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Precision Irrigation

A New Irrigation Strategy

Considering the site-specific heterogeneity of the soil, water- and energy requirements are intended to be reduced. Different irrigation depths are to be distributed over the irrigated area in order to compensate for the uneven water storage capacity of the soil. For the irrigators, two different solution strategies have been examined. Differentiated travel speed for mobile irrigators and differentiated control of each nozzle in centre pivot irrigators have been realized.

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Keywords
Irrigation, site-specific irrigation

Literature

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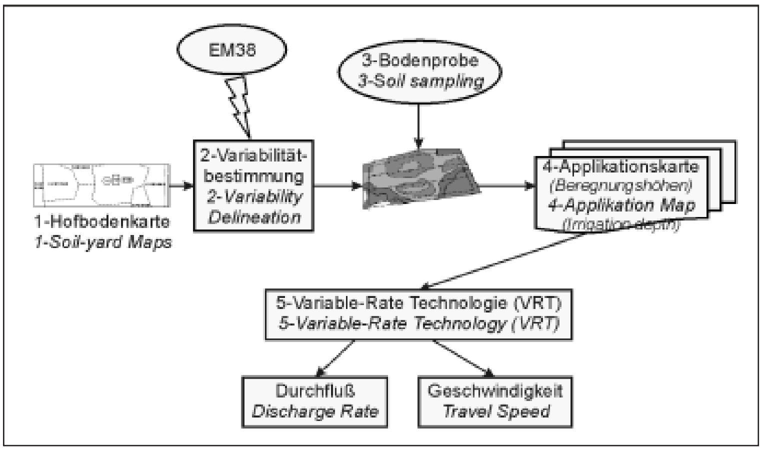

Fig. 1: Suggested strategy for site-specific irrigation

The farmer adapts his measures (irrigation, tillage, fertilizing, plant protection) to the average site quality of the field. Actually, however, many fields show more or less significant differences in soil quality at a small scale. These small-scale differences in site quality as well as additional influences and effects caused by cultivation lead to inhomogeneous crop stands on the fields. Precision management allows site- and crop differences within a field to be taken into account in a differentiated manner.

In the past decades, it was the goal of research and industry to distribute water on the field as evely as possible with the aid of irrigating technology. Given the current knowledge about soil heterogeneity and increasing field sizes (in eastern Germany about 50 ha, which are irrigated by one single irrigator), the demand for precise water distribution becomes obvious. Precision irrigation pursues the goal of reducing product-related expenditures, i.e. in this case water and energy, and to take better account of environmental aims by considering the site-specific heterogeneity of the soil.

Material and Methods

The way to the application map comprises the farm soil map, the measurement of electrical conductivity (EM38), and soil sampling for the determination of the water storage capacity of the soil at certain points (*Fig. 1*). Technical realization is based on mobile irrigators and centre pivot irrigators. Accordingly, two different solution strategies are being applied at the experimental stage. For mobile irrigators, the variation of the travel speed over the field length to be irrigated has been proposed. At a constant flow rate, this results in different irrigation depth. The differentiated setting of the speed per field can be stored in the machine or carried out by the farm manager. For centre pivot irrigators, a special nozzle controller with solenoid valves has been developed.

Measurement of Variability

The special characteristic of precise irrigation as compared with conventional production techniques consists in the very intensive utilization of specific and comprehensive site data. Initial information is contained in the farm soil map. However, these data are too rough for them to be used for a site-specific application map. For the EM38 measurements, the fields were driven over at a track distance of 5 m, and a GPS value was correlated with each EC value (*Fig. 2*). Based on these values, conductivity maps were

Fig. 2: Measuring instrument EM38 and transport vehicle for the measurement of soil heterogeneity

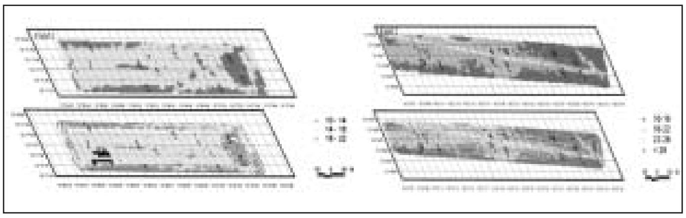

Fig. 3: Differences in electrical conductivity

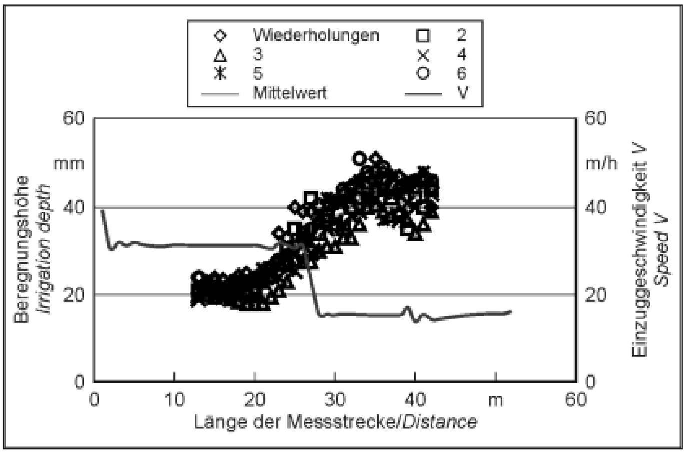

Fig. 4: Change in irrigation depth as a function of travel speed

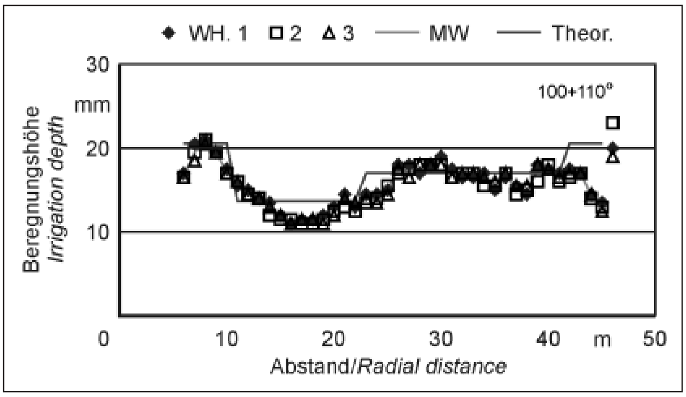

Fig. 5: Change in the irrigation depth of a centre pivot irrigator (measurement in the sector of a machine)

drawn up which served as a basis for the selection of monitoring points. At these points, field capacity (FK) and the wilting point (WP) were determined.

Travel Speed

In order to set and control the travel speed, control systems are available on the market. So far, these devices have mainly been used only for the control of a constant travel speed over the field. For the trials, four speeds (32, 16, 24, 40 m/h) were programmed in the devices. Congruence between the „programmed“ and the „measured“ travel speed was determined over a measuring distance of 100 m in order to answer the question of how irrigation depth changes with the chosen speed. In rain measuring cups, irrigation depth was measured at a grid distance of 1•1 m.

Flow Rate

In centre privot irrigators, every nozzle was controlled at a distance of 3 m. In front of each nozzle, a solenoid valve was installed. The opening and shutting of the individual nozzles is based on the application map. A „Programmable Logic Control (PLC) System“ was developed at the institute in order to store the application map as a file. The position of the irrigator was measured at the centre pivot with the aid of a rotation sensor. The position is established per degree, and the solenoid valves are switched depending on the distance from the centre of the machine. The travel speed of the machine was constant, while the flow rate and, hence, irrigation depth were varied. Irrigation depth is measured in measuring cups usual in trade. For this purpose, the measuring cups are installed radially at a one-degree distance with triple repetition.

Results

Soil Water Differences

The results of electrical conductivity measurements are given in (mS) millisiemens values, which are divided into three classes. *Figure 3* illustrates differences in conductivity. It is shown that the measured differences in conductivity are also reflected by the nFK measurement results. A causal connection cannot be established.

Adaptation of Irrigation Depths through Speed Setting in Mobile Irrigators

After the application map had been determined, different irrigation depths were intended to be distributed over the irrigated surface in order to compensate for the uneven water storage capacity of the soil. In the example shown in Figure 4, a speed change from 32 to 16 m/h has been set. In this case, measured irrigation depth increases from 22 to 45 mm. Trials with other settings were carried out as well, which led to similarly good results. Speed changes within 2 m. For alterations in irrigation depth, however, a transitional range of approximately 16 m was required. This range was measured under a nozzle carriage. If a large-area irrigator were used, this transitional range would become larger. Thus, it is possible to use mobile irrigators to distribute different irrigation depths depending on soil or plants.

Adaptation of Irrigation Depths through Flow Rate Change in Centre Pivot Irrigators

Once again, the application map forms the basis for differentiated irrigation with the aid of a centre pivot irrigator. Irrigation depth, which was calculated theoretically and programmed in the PLC, was examined in the area of a chosen circle sector. *Fig. 5* shows calculated and measured irrigation depth along the pipe of a centre pivot irrigator. These initial trials show that the set and actual values match well. The slow increase and decrease in water distribution must be attributed to the 8 m cast of the nozzles. This course must be evaluated positively because soil differences also exhibit no step function.

Future Prospects

The presented results mark the beginning of precision irrigation. Comprehensive assessment requires additional work steps:

- improved determination of soil data using an on-line technique,
- reliable delimitation of the application map,
- development of a soil-plant-sensor model,
- connection with other site-specific disciplines,
- application of the BUS system,
- development of concepts for precision liquid manure fertilizing and
- determination of the effects of differentiated irrigation on the yield and the quality of plants