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Advances in precise fruit production

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Total number of authors:
15

Published in:
Landtechnik (Muenster)

Publication date:
2012

Document Version
Publisher's PDF, also known as Version of record

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Advances in precise fruit production

The concept of Precision Horticulture follows the knowledge achieved in site-specific farming over the last decades. In fruit production, the target is to optimize production processes by means of adapted treatment of individual trees. Prerequisite to precision horticultural management are spatially organized data that might include soil maps and information on plant growth. Such data are used to produce maps guiding growers to appropriately manage zones within fields. Ultimately, the objective is to promote automation of fruit production and to achieve sustainable production through the site-specific management.

Keywords
Automation, 2D-Image analysis, laser scanner, Precision Horticulture, site-specific, fruit production

Abstract

Landtechnik 67 (2012), no. 5, pp. 338–341, 3 figures, 3 references

Soil mapping methods developed for Precision Agriculture of field crops can be applied in orchards for precise fruit production. However, the established methods may not be sufficient for characterizing management maps in orchards due to more complex root system, individual phenotypes developed over several years in perennial plants, high-value crops, and already highly intensive production systems.

Plant level data - regarding response to environmental and management conditions - are required at high spatial resolution in order to identify zones of similar behavior (hot spots). Data acquisition should be automated throughout the vegetation period. The conditions for acquiring the data need to consider (i) the sensor based measurement of plant parameter itself, (ii) the measuring interval, and (iii) the data transmittance.

Plant parameters can capture the plant growth (leaf, canopy, root or the generative organs: flowers and fruits) as well as temporally occurring physiological responses (flower-, leaf, fruit-drop, leaf gas exchange, fruit water status, xylem sap flow, water potential, xanthophyll cycle, chlorophyll fluorescence kinetic, etc). Measurements need to be carried out accordingly and can be seasonal, daily or even the recording of diurnal courses. The parameter therefore determines the mode of data acquisition – here we can distinguish remote and contact readings. This mode of measurement and the necessary measuring interval determine the options for the sensor platform (autonomous platform, unmanned aerial systems, stationary sensors on the tree) and the related data transmittance (on-board computer or wireless sensor network) to the spatial decision support system.

In the framework of the on-going transnational ICT-AGRI project "3D-Mosaic" (ERA-Net ICT-AGRI, www.atb-potsdam.de/3d-mosaic), the concept of precision horticulture is tested for site-specific management of fruit production. Within the 2-years project two field trials are conducted in subtropical and temperate orchards for evaluating the concept.

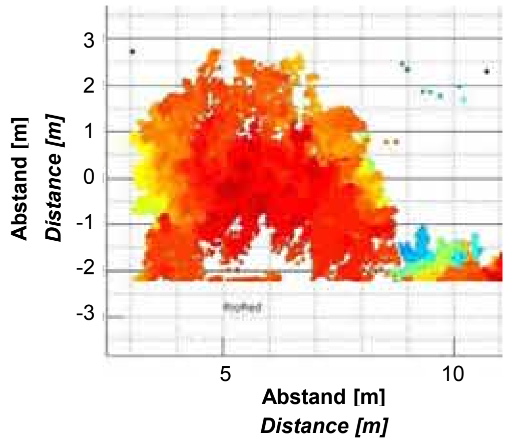
Field trial

During the growing period 2011, measurements were carried out in an orchard, located in a subtropical Mediterranean climate in Adana, Turkey. The orchard consisted of 21 rows from which 9 rows with a total of 207 trees were subjected to intense measurements.

The spatial soil variability was measured with various geoelectrical methods, e.g. four electrodes with 1 m spacing (4-Point Light, LGM, Germany) were placed in the soil for measuring the apparent electric conductivity (ECa). A laser scanner (alasca XT, ibeo, Germany) was applied for analyzing canopy parameters. The scanner was mounted on a tractor in side view to the trees. Laser hits were analyzed as laser hits per tree.

Non-destructive, multispectral fruit sensors were applied to obtain spatially differentiated data regarding the fruit development. The handheld device (DA-Meter, Sintéleia, Italy) used light emitting diodes as light source and measures the diffusively reflected intensities at 545 nm, 640 nm, and 750 nm, where the 750 nm passband serves as the reference on the fruit tissue measured. Fruit counting was done manually during harvest and from RGB camera readings.

Fig. 1a



Laser scanner point cloud from a grapefruit tree of the cultivar 'Rio Red' - in false colour the distance of laser hits to the scanner is presented

The fruit data obtained with optical sensors were correlated with the soluble solids content (r = 0.52) and fruit acidity content (r = 0.77) analyzed on harvested fruits in the laboratory. The on-tree measured fruit sensor data indicate a correlation with the patterns of soil properties (**Figure 3**). The optical properties of the fruit were more specifically analyzed by means of laboratory analyses [1] for improving the calibrations in the subsequent field trial. Since the fruit readings require contact with the fruit surface, data transmittance was developed based on wireless sensor network (CP, Germany), which was tested considering the path loss in the orchards [2].

By means of spatial statistics, correlations between soil properties (apparent electrical conductivity) and vegetative growth, yield, and fruit sensor data were revealed. The application of hot spot analysis enabled the characterization of management zones in the orchard. Preliminary readings in the orchard of the second field trial already show enhanced correlations when using the electrical soil conductivity of deeper soil zones [3].

Results

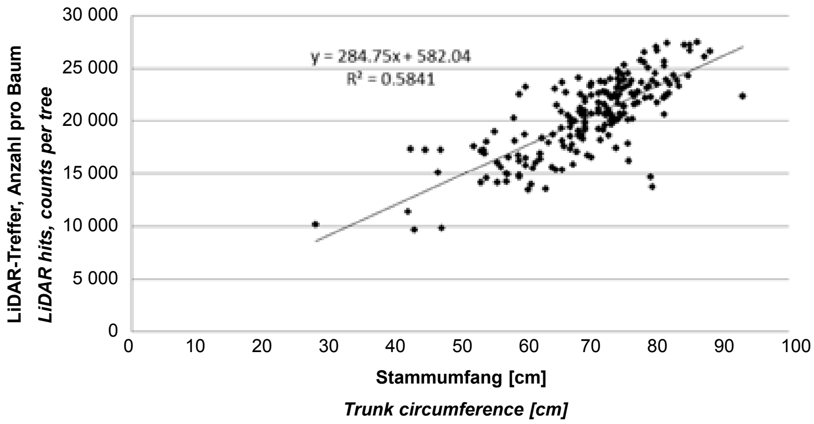
Measurements with the laser scanner were carried out on 207 trees. Results point out high correlation with the stem circumference (**Figure 1**) in the first field trial. In parallel preliminary readings on smaller canopies, when the number of leaves were taken as reference values, high correlations were found between the number of laser hits and e.g. leaf number with r = 0.79. The high correlation was analyzed even in varying weather conditions. The fruit yield was correlated with the vegetative mass in the present experiment, and – therefore - also correlated with the number of laser hits per tree. Plant growth was influenced by the soil characteristics as indicated by the similar pattern of number of laser hits and soil ECa (**Figure 2**). In the next field trial laser scanners and camera systems will be mounted on an autonomous platform for automated readings.

Conclusions

Consistent with findings in precision agriculture of field crops, correlation was found between soil electric conductivity and plant parameters. In preliminary experiments in the subtropics, interactions of soil and vegetative growth, yield, and fruit quality were indicated. The data were supplied by means of adapted sensors, providing the necessary prerequisites for numerous spatially resolved measurements.

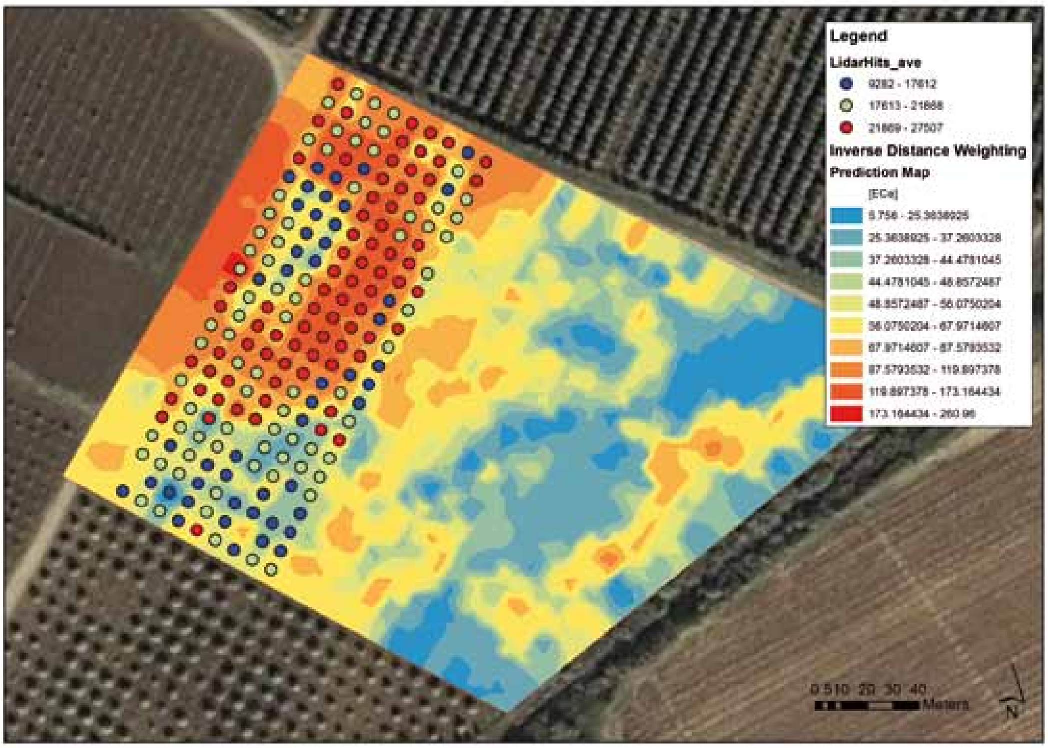
In the next project year, the concept will be further developed and tested in temperate climate. Main targets will be the more robust measurement of plant growth and fruit quality data as well as additional readings considering the plant water status. Adapted methods for delineation of management zones will be tested.

Fig. 1b



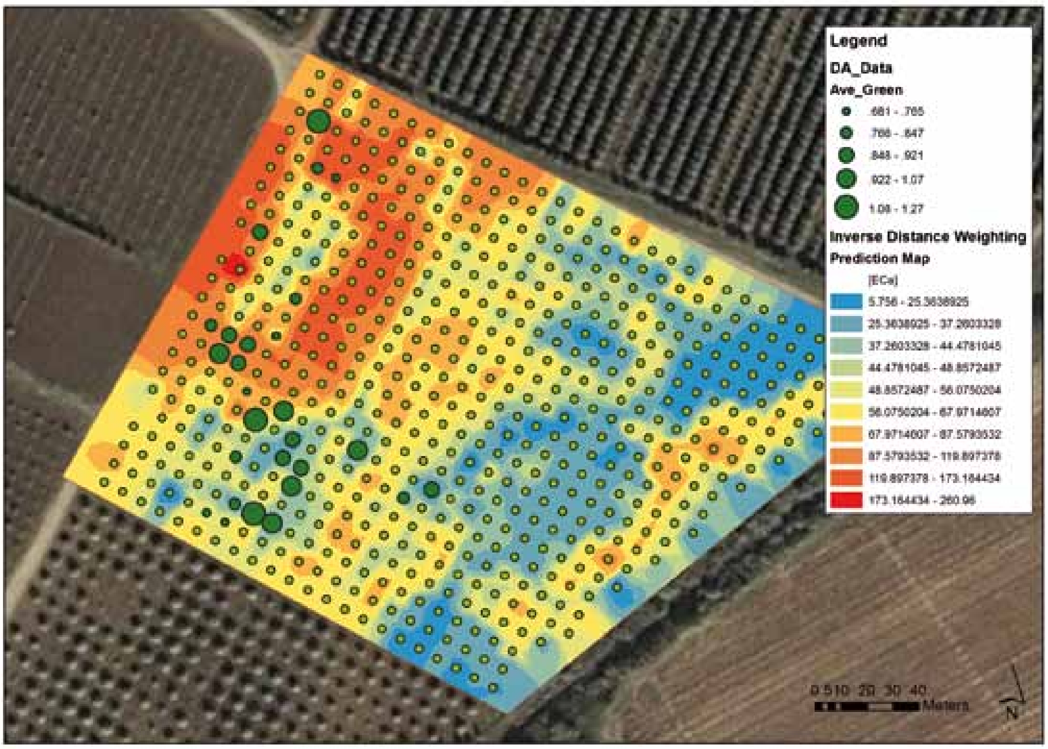
Tree stem circumference data plotted against laser scanner data

Fig. 2



The circles showing the laser scanner hits (average) classified into 3 groups (blue, green and red) based on natural breaks overlaid on electrical conductivity prediction surface (Basemap from ESRI World Map Background, Copyright © 1995 - 2012 ESRI (ESRI 1982))

Fig. 3



DA Data for 27 monitored trees overlaid on apparent electrical conductivity (ECa) prediction surface (Basemap from ESRI World Map Background, Copyright © 1995 - 2012 ESRI (ESRI 1982))

Literature

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Acknowledgement

This work was supported by the ICT-AGRI project “3D-Mosaic – Advanced Monitoring of Tree Crops for Optimized Management – How to Cope with Variability in Soil and Plant Properties?” which is funded by the European Commission’s ERA-NET scheme under the 7th Framework Program for Research.