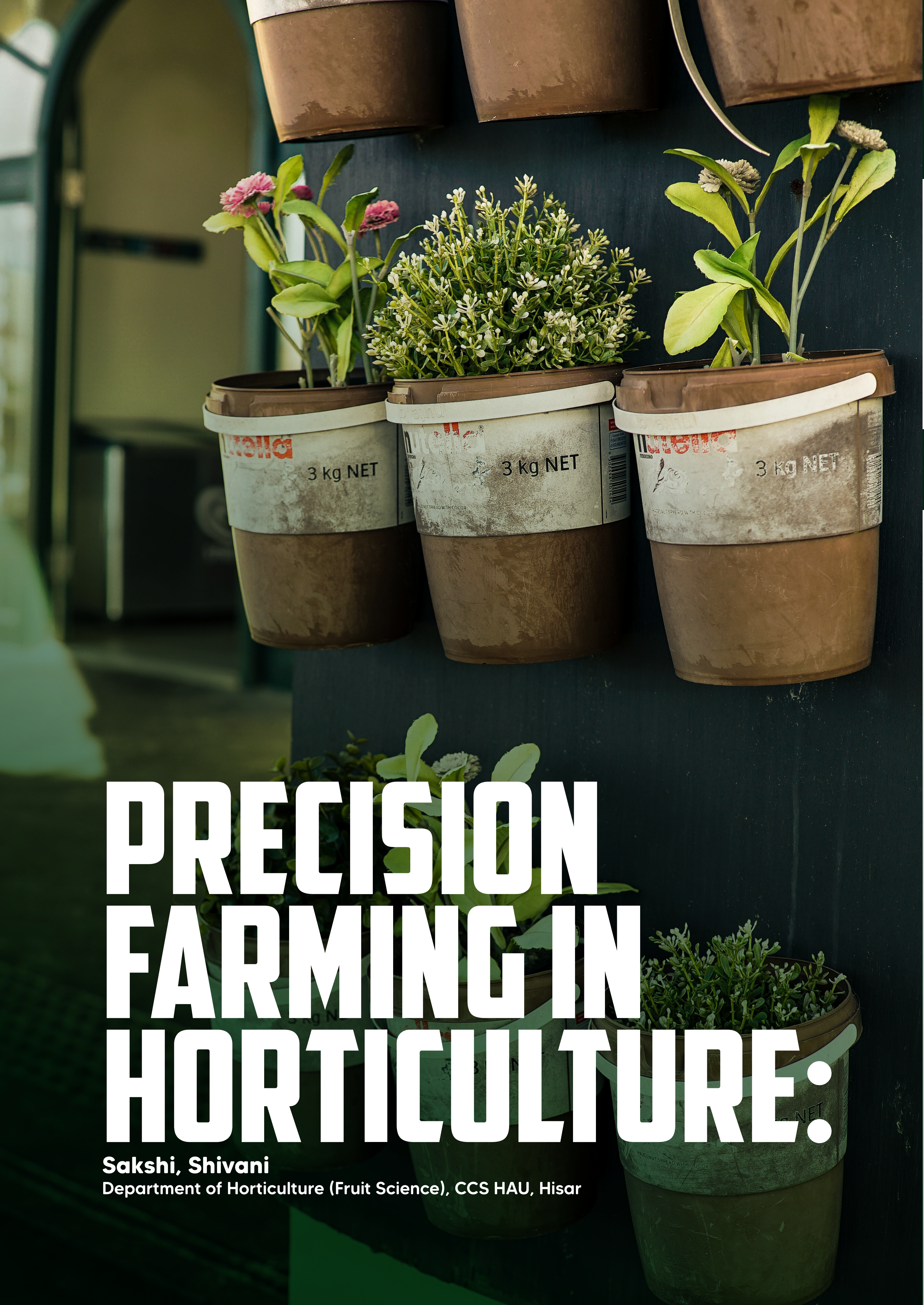

PRECISION FARMING IN HORTICULTURE:

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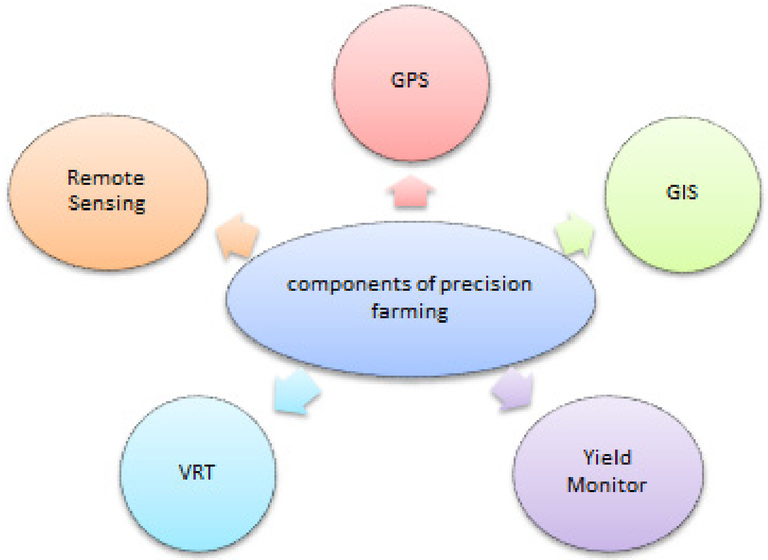
INTRODUCTION

In the past crop production has most frequently assumed that fields are nearly uniform. The uniform treatment over the field results in non-optimal fertilizer levels over the entire field. An overdose means an extra cost with no additional yield while creating problems in the quality of the surface waters. In orchards, the conditions of the trees can be very much different from place to place, depending on the topography or the local soil properties. At harvest time this may result in the very uneven quality of fruit. Technological developments in electronics and sensors create the possibilities for a more precise production system that takes into account the natural variability of biological production and its environment. It leads to a horticultural production technology that enables to deliver products with a precisely specified quality using accurate and precise cultural practices.

PRECISION FARMING:

Precision farming is an art and science of utilizing site-specific, innovative techniques, for the management of spatial and temporal variability that is designed to increase whole farm production efficiency, profitability, and productivity while minimizing unintended impacts on wildlife and the environment.
Components of precision farming:
Timely collection and analysis of variation can be done by using different techniques like –

- ✓ Geographic Information System (GIS)
- ✓ Global Positioning System (GPS)
- ✓ Variable Rate Technology (VRT)
- ✓ Yield Monitor
- ✓ Remote Sensing



Global Positioning System in precision farming

APPLICATIONS OF PRECISION FARMING IN HORTICULTURAL CROPS:

1. Yield monitoring

Spatial information on the yield is a prerequisite for analysis in precision horticulture. Yield mapping can be carried out easily in mechanized crops with sensors added to the harvesting machine. During manual harvesting, each worker gets picking bags to collect fruits. After filling, bags were emptied into nearby pallet bins placed between trees. Bins are removed by hydraulic lift, which used load cells for weighing, and GPS to record the position of the bin. It is assumed that each bin represents the yield of surrounding trees. A reasonable assumption since workers would empty their bags into the nearest bin. The yield was estimated by dividing weight by the area covered by each bin. Position and yield were used to prepare yield maps.

Yield monitoring and mapping help farmers identify low and high-production areas of the field. This information can be used to make decisions about:

I. Soil tillage
II. Fertilizer recommendation
III. Irrigation requirement
IV. Crop rotation

Remote sensing applications

Remote sensing is a group of techniques that can collect field data without being in contact with the object (plant or soil) using reflectance or emission of light from the plant or soil.

2. Predicting yield

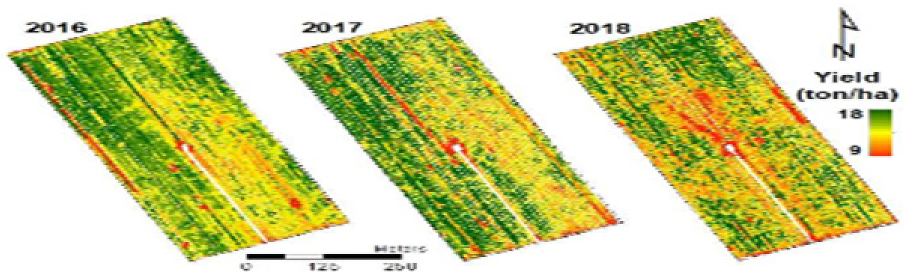
Mathematical models had been developed to predict the yield of citrus trees several months ahead of the harvesting season from their canopy features obtained from hyperspectral imagery recorded.

3. Plant water status analysis

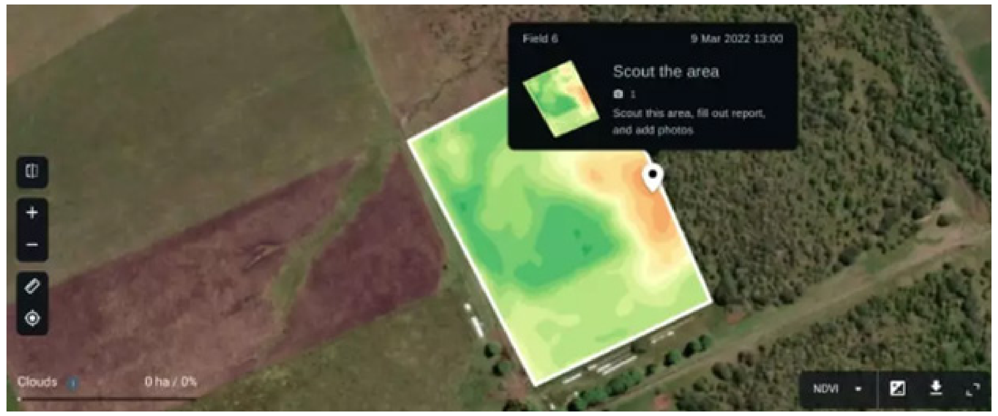
For estimation of water status, high-resolution thermal imagery is used to map tree canopy conductance, and crop water stress index (CWSI), to detect insufficient irrigation rate, water leaks, and malfunctions in subsurface drip irrigation in fruit crops. Thermal imagery successfully managed to produce a protocol for mapping water status variability that could be used for irrigation scheduling.

4. Vegetation indices estimation

Remote sensing has been used in precision horticulture to calculate vegetation indices. The most frequently used vegetation index is the normalized difference vegetation index (NDVI) which is feasible in low-chlorophyll fruits and canopy imaging. NDVI is a simple graphical indicator used to analyze remote sensing measurements, often from a space platform assessing whether or not the target being observed contains live green vegetation. A higher value of NDVI represents healthy plants while values close to zero generally correspond to barren areas of rock, sand, or snow. It detects plants under stress, diseased plants, and plants damaged by insects.



Yield Mapping



Low NDVI in the problem area (orange shades), which may indicate the presence of pests, fungus or low moisture

5. Quality analysis in situ

For non-destructive analyses of internal quality, sensors have been commercialized during the past 15 years. It can be expected that still more sensors will become available soon. Optical properties of fruits and vegetables that may be considered in their non-destructive analyses are wavelength-dependent: absorption coefficient, scattering coefficient, refractive index, fluorescence, chlorophyll fluorescence kinetic, and fluorescence lifetime. Methods are commercially available as hyper or multispectral systems as well as imaging techniques.

TABLE 1. Spectral photometric methods available as portable systems for in situ analysis of fruit.

Measuring principle	Feature
Hyper- and multispectral spectroscopy in the visible range	Anthocyanins, carotenoids, chlorophylls
Near infrared spectroscopy	Dry matter, soluble solids content
Hyper- and multispectral imaging	Same as visible or NIR
Photogrammetry	Size, shape, colour, biospeckle
Fluorescence	Chlorophyll, phenols

6. Variable Rate applications

Variable Rate (VR) application is the major target for PA. All information gathered should result in adapted management of the defined zones. Tree canopy measured by ultrasonic or laser scanner was correlated to yield. This property was used to vary fertilizer applications. In sprayers, sensors can detect missing trees and then stop nozzle output. Other sensors sense the trees' density and height using laser scanners, and ultrasonic or photoelectric sensors and adjust the spraying direction of nozzles to reduce out-of-target spraying.

CONCLUSIONS

Horticultural crops pose an emerging and challenging sector for precision agriculture technology and management. From most research reported, spatial variability of yield was confirmed even in small fields, where the majority of horticultural crops are grown in contrary to arable crops. Variability of growth factors affecting yield is the rationale of precision agriculture, which is by definition the management of variability. Nevertheless, no mainstream technologies or strategies for measuring yield in orchards and vegetable production are yet in place, while this article may inspire new research for other horticultural crops using more automated methods for yield mapping that are needed.

Quality management is one major component of horticultural crops. Methods to estimate fruit status in production are required. Advanced techniques have been introduced in experimental practice for measurements of the fruit level in situ. Operations supported using in situ information on the plant status will be: on/off zone spraying, thinning, irrigation, frost protection, pruning, and harvest. As most fruits are perennial crops, temporal stability is important for establishing permanent blocks or sub-blocks within the fields. However, the temporal stability of quality patterns still needs more studies. Finally, as many horticultural crops are in small fields in the major part of the world, site-specific technologies and strategies should be developed for small fields, which should be economically viable and easy for small farmers to adopt. This, and the huge amount of data obtained, will be major challenges for the application of precision agriculture in horticultural crops.