Yield and Quality Mapping: A New Technology of Precision Farming for Horticulture

Animaka Upadhyay, S. Nandi and Umesh Thapa
Department of Vegetable Science, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur

Corresponding author : anamika.upadhyay1994@gmail.com

INTRODUCTION

Spatial variability of yield is an important factor in terms of precision farming. Yield is an ultimate indicator of variation of different agronomical parameters in different parts within a field. Hence, mapping of yield and its interpretation and correlation with the spatial and temporal variability helps in development of next season's crop management strategy. In practice of precision agriculture, most important thing is to realize the spatial and temporal variability of the field conditions, yield, soil fertilizer and crop growing status. Yield map helps in understanding the yield fluctuation inside a field, by analyzing the reasons of variation, and improving management in order to increase the profit. Present day yield monitors measure the volume or mass flow rate to generate time periodic record and quantity of harvested crop. High-value crops like carrots, sweet potatoes, green beans, onions, tomatoes and others, need smart farming technology for promising yield quantity. Representation of these agricultural data through yield and fruit quality maps allows crop management in a precise way which means agricultural operations may also be carried out considering intra-orchard variability, thus resulting in greater efficiency.

Yield mapping/ Yield monitoring:

It is a technique which uses GPS data to analyze variables such as crop yield and moisture content in a given field. It was developed in 1990's and uses a combination of GPS technology and physical sensors.

Data obtained from a yield map can be used to compare yield distribution within the field from year to year, giving farmers a beforehand idea to determine areas of the field that may need to be taken care of which are not yielding properly. It also allows farmers to show the effects of change in field-management techniques, to develop nutrient management strategies for their fields.

Some basics of yield monitoring in Precision Agriculture: Yield mapping helps to provide farmers with adequate information to make right decision for their fields. Yield monitors are recently developed tools in precision agriculture that include farm equipments such as combine harvesters or tractors to gather a huge amount of information, including grain yield, moisture levels, soil properties, and much more. It also helps in assessing things i.e. harvesting time, fertilizer doses, the effects of weather, and other factors.

Working steps of yield monitors: The grain is harvested and fed into the grain elevator which has the sensors that can read moisture content of the grain. After the grain is being delivered to the holding tank, the sensors monitor the grain yield. Then, the information is sent to the driver cab and is displayed on a screen. Further, the information is geo-referenced so it can be mapped on later time.

Benefits of farmers to use yield monitoring technology:

- It helps to give the farmer accurate and often geo-referenced data about their field.
- A farmer can better understand crop yield and crop related information to mitigate potential threats or enhance possible opportunities.
- A yield monitoring system includes the ability for a farmer to export the information onto a personal computer. This information can be available in a variety of different formats.
- In home or office, a farmer can easily use the specialized computer software for better understanding of the recorded information.

Benefits of yield monitoring:

1. Yield data analysis: It is an essential aspect of smart farming. Numerous cultivators underestimate this data since they think it is a misuse of cash and time. A farmer can better understand crop yield and crop related information to mitigate potential threats or enhance possible opportunities by knowing yield data analysis including crop visualizing and crop variability.

2. Moisture content measurement in soil- Water level in the soil gives an overall idea for better farm production. A few crops do well in low-volume water content while others do not. Knowing about the moisture level in the soil gives an idea about which area to add or where to lessen water input.

3. Avoiding excessive fertilizer application- High value crops can be grown by using appropriate fertilizer quantity. Growers are using this technology to assess the yield potentiality of their field. If for instance, in the last few years there are areas in a farm consistently yielding less. In such cases, yield maps are proved to be beneficial by indicating the appropriate amount of fertilizer application required for drawing better results.

4. Saving of money- This technology helps monitoring the top performing section of a given land. Thus, giving an idea to farm in an area that has maximum potential rather than farming a whole block that gives the same yield.

5. Better hybrid choosing capabilty- The money spent on selecting wrong hybrids and application of unwanted fertilizer will result in reduced yields. Through yield mapping, farmers get to know which hybrid goes well with which soil.

6. Choosing the best management strategy according to performance rate of soil- Yield mapping helps to pinpoint the low performing areas and have a map to locate exact areas of concern. It also aids to figure out how to fix those problems/challenges by planning a good management strategy.

Tools used for yield monitoring

(a) Mass Flow Sensor : It helps to provide enough information to establish a grain yield measurement. The mass flow sensor works by utilizing a load cell which is fixed to the highest point of a clean grain elevator. At the point when the harvested grain is fed through the combine, it eventually hit up against the heap cell, this is then transformed into an electrical signal and handed-off to the yield monitor.

(b) Moisture Sensor : The moisture content in harvested grain is extremely valuable information for harvesting, drying and storing of crops. The moisture sensor works when the grain moves in-between two conductive surfaces, which measure how much electric charge the grain can store.

(c) GPS Receiver : It is a remote sensor

that measures a variety of different pieces of data, including where the equipment is located, its speed, altitude, etc. It is one of the key components that can assist to transform yield monitoring data from graphs and charts, into tangible maps that the farmer can utilize.

(d) Yield Monitor : Monitor that is located in the cab of the combine or tractors. Its main function is to display the information gathered by the different sensors to allow the operator to know about the different moisture levels and crop yield. These monitors also have the capability to store as well as transfer memory to a laptop or home computer.

Yield monitor for handpicked horticultural crops:

Crop	Method of yield mapping
Citrus	Weighing pallet bins using load cells from neighboring trees on tractor platforms. Estimating yield by tree canopy (ultrasonic sensor, Lidar, multi-spectral camera).
Apples / Pears / Olives	Weighing bins of handpicked fruits of neighboring trees, geo-referenced using DGPS.
Palm / Plum / Pear / Cranberry	Numbering each tree before harvest and measuring the mass of fruits picked manually. Topographic model or local referencing.
Peaches / Kiwis	RFID or barcodes on the bins together with a weighing machine, RFID or barcode reader and DGPS.
Potatoes	Load cells under the conveying chains. 2-D vision system above the conveying belt
Pecan / Broccoli	Load cells and GPS to weigh the volume and position of the platforms transferring the crop in the field on the go.
Onions / Watermelons	Dividing the field into block and weighing the platforms carrying the fruits per block.
Processed tomato	For using load cells under the conveying chains of the machine.

Quality Mapping : Quantity and quality are the two components of the field production. Quality is very important and its variability is the object of relevant research. Several laboratories are working to develop different sensors to measure quality of the products. In high value crops, quality offer premium prices and increased income to the farmers.

Some information about quality mapping

➢ In high value crops, quality is seen as the crucial factor for marketing. In the past, the Organisation for Economic Co-operation and Development (OECD) set standards considering size, colour, and sometimes shape of the produce.

➢ Regional programmes were established targeting fruit quality and the OECD responded by developing guideline aiming at promoting uniform quality control procedures: "Guidance on Objective Tests for Determining the Ripeness of Fruit" (OECD, 1998). Here, the internal properties of produce are recognized, *e.g.*, sweetness, acidity, fruit flesh firmness, internal browning, glassiness.

➢ It is expected that plant growth and soil parameters may be correlated with yield mapping. Nutritional and water issues causing the huge spatial variability. The influence of

spatial variability of chemical soil properties on spatial pattern of fruit diameter was analysed in different fruits grown in continental, temperate climate.

➢ It was found that areas of high yields had lower fruit quality, which can be explained by high crop load and inadequate leaf area per fruit. Consequently, for mapping fruit quality can be done at least every season. Analysis of quality during fruit developmental stages even several measurements per season or continuous monitoring would be beneficial.

Spectral photometric methods for in-situ analysis of fruit.

Measuring Principle	Feature
Hyper- and multispectral spectroscopy	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
Distribution of time of flight	Anthocyanins, carotenoids, chlorophylls, effective path length
Spatially-resolved hyper- and multispectral Imaging	Wavelength-dependent, same as NIR and scattering properties

Conclusions :

Horticultural crops represent an emerging and challenging sector for adopting 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 are the rationale of precision agriculture. Nevertheless, no mainstream technologies or strategies for measuring yield in orchards and vegetable production are yet in place but it is essential for especially horticultural crops using more automated methods for yield mapping.

Quality management is one major component in horticultural crops. As many horticultural crops are growing in small fields but it shares the major part in the world economy. Site-specific technologies and strategies should be developed for small fields, which should be economically viable and easy for small farmers to adopt.

❖❖