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A REVIEW ON YIELD MAPPING: A DETAILED INTROSPECTION

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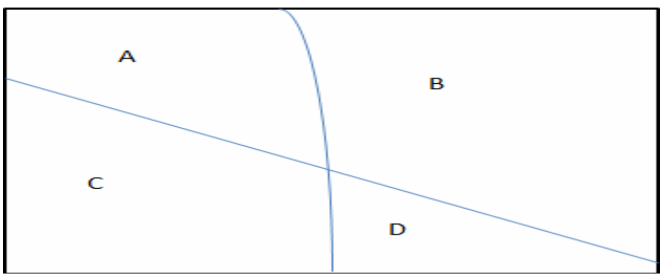
Abstract

In this present scenario when site specific farming and precision agriculture are more talked over due to the ill effects of climate change and over use of chemical fertilizers in the past due to which soil toxicity have sky rocketed, producing and learning methods of yield mapping has been the need of the hour. This paper gives an insight of the process which are followed in producing a yield map and then using it for further processes. Infect this yield monitoring strategies have been prevalent in the scientific world form the last decade of the 20^{th} Century and seen as a common practice in the modern agriculture. The eminent experts have already come up with yield history data with analysis which has helped the farmers of the developed countries a lot to understand more about their farms. But when seen from Indian agriculture point of view we have little access to it, although recently a lot of work has been done in site specific farming and remote sensing. Thus, the aim of this publication is to review several common and easy way of yield data analysis.
Keywords: Yield mapping, Precision Agriculture, Site Specific farming

Introduction

The process of collecting georeferenced or GPS data of crop yield and characteristics such as moisture content, while the crop is being harvested, is known as yield mapping. For this a wide range of sensors can be used for the various methods that is developed. The first research paper published regarding yield mapping was 'A yield map primer', (Blackmore, 1998) which was then first presented in Japan. Later on this paper was used as a practical set of guidelines The second paper 'Yield mapping; errors and algorithms', (Blackmore and Marshall,1996) dealt with issues which caused significant problems in understanding the spatial and temporal variability in the early 1990s as then scientist could not distinguish between spatial variability[1] and spatial errors[2] in the underlying data.

Hence 6 main errors were identified. The errors were unknown crop width entering the header during harvest, varying time lag of grain through the threshing mechanism, the inherent 'wandering' error from the GPS (now reduced as Selective Availability was turned off in May 2000), surging grain through the combine transport system, grain losses from the combine, sensor accuracy and calibration. The errors of unknown crop with entering the header during harvest and the varying time lag of grain through the threshing mechanism was managed by potential mapping (Doerge, 1999).



Types of Yield maps:

The yield maps can be of mainly four different types. They are as follows with their detailed descriptions.

Inference maps: These are the maps which are made by involving yield estimates with existing maps delineations[3] which are not changed on a base map.

Suppose, if we associate the yield goal[4] with a soil map of a country soil survey (Colorado State University, 2018).

For example: Suppose we have a field. Now there are four blocks in the field namely A,B,C,D each of which have a different yield goal as stated below:(adjacent figure)

Name of blocks	Yield goal (in kg/ha)
A	150
B	100
C	120
D	200

Thus, we can see here that with each existing line delineations there is a yield estimate, which describes the inference maps.

Prediction Maps: In these types of maps a prediction function model is used wherein the yield component is predicted but not measured by using spatial data.

For example: Predicting the crop yield in terms of soil/weather properties for a region or field. (Colorado State University, 2018)

Interpolation maps

In this type of maps yield measurements are made at specific locations wherein yield values In this type of maps interpolation techniques are used wherein yield is measured at a specific site locations. The yield values between two data points are estimated with this interpolation technique. This

1. Spatial variability: It happens when a measured quantity at different spatial locations exhibit different values at different locations. This can be assessed with the help of using spatial descriptive statistics such as range.
2. Spatial error: It can be defined as the error in one observation which affects the other observations. In other words it can also be called as 'nuisance dependence in the error'.
3 Delineation: It can be described as the art of describing something with precision.
4. Yield Goal: It can be defined as the pre-planting metric used for making the best agronomical and economical decisions throughout the growing season.

estimated data is much inclined towards the coarser scale rather than the estimation scale (similar to grid sampling[5]).

(Colorado State University , 2018)

Aggregation maps:

In aggregation maps, it is derived from data measured which is either the original data or some accumulation of the data mapped. Here once yield measurements are decided, there is no estimation, no prediction etc., as the data collected is on a very high scale.

E.g. Site-specific instantaneous (on-the-go) yield monitoring system

(Colorado State University , 2018)

Basic Components of the yield mapping system:

The basic components of the yield mapping system comprise of a series of sensors that work to take reading for one or the other parameters. The list of the sensors used along with their functions are listed below:

Sr No.	Name of sensor	Functions
1	Grain flow sensor	It determines the amount of grain harvested (in volume).
2	Grain moisture sensor	It recompense the variability in moisture in grains
3	Clean grain elevator speed sensor	It is used in mapping systems (not all) in order to improve the grain flow accuracy
4	GPS antenna	It has the simplest function to receive the satellite signal.
5	Yield monitor display with a GPS receiver	It is used to geo-reference and record data
6	Header position sensor	simplest function distinguishes measurement logged during turns
7	Travelling speed sensor	It depicts the distance that the combine travels during a certain lodging interval

Source: (Adamchuk, V. I., Dobermann, A., & Ping, J. 2004)

Calibration and Calculations

Every sensor needs to be suitably calibrated in accordance to the operator's handbook available to the farmers. A binary log file is created during harvest time to record the output of all sensors as a function of time, transforming the sensor's signal into physical parameters during calibration. A simple calculation can help us to decide harvested yield in convenient units such as bu/acre[6]. Note in order to get it in accordance to the Indian standards (i.e. t/ha) we need to multiply it with 0.07. (Arslan and Colvin, 2002).

$$\text{Yiedl} = K.\frac{\text{Flow Time}}{\text{Width Length}}$$

(Colorado State University , 2018)

where K is the conversion co efficient for corn or sorghum for soybeans or wheat when calculated in t/ha are 7840.77 and 7318.08 respectively.

The yield obtained can be used then to calculate the variability in the moisture by using the following formula:

Yield compensated = yield ((100-moisture)/(100-moisture reference)) (Colorado State University , 2018)

For Corn the moisture reference is 15.5% whereas for soybeans it is 13% and for wheat is 12%

(Adamchuk *et al.*, 2004)

How yield map is processed

The yield which is calculated at every field location can be exhibited on a map using GIS (Geographic Information System) software. The initial log file which will have points will be recorded during turns and the measurements taken through sensors will be taken. But this does not correspond to the accurate harvest locations since the grain flow through combine is a process which is much delayed. In order to prevent this from taking place real time correction needs to be applied (Adamchuk *et al.*, 2004; Lotz, 1997; Dobermann *et al.*, 2003).

Normalization process

The normalization process can be done in two ways. The field's yield data is divided by the highest yield which results in values between 0 and 1 and the other process is to do normalization at the end of the analysis. The steps for this are as follows:

Steps:

1. Do grid on yield data that makes sense
2. Minimum 40 grids should be there to have a meaning full map when the process ends.
3. Using different soft wares which will help us in importing spatial data and then converting them to estimated values based on a user-specified grid size.
4. With the generation of grids taking in account the yield averages, the data can be saved in a text(.txt) file or exported in a spreadsheet file.
5. Different values are given:

-1 When the average of the grid is less than the field average

0 When average of the grid is within the field average

+1 When average of the grid is more than the field average.

Thus giving +1, 0, -1 value marks the normalization procedure. From here the normalized grids are then exported to a spreadsheet file and then summed up by a grid for each year of data. Similarly, more year's data are calculated like this to come up with a productive multiyear yield map (Doerge, 1999). With the help of present techniques in all agricultural commercial farm sectors, it is a new development for our agricultural ecosystems for yield mapping.

Conclusion

Thus, this paper clearly depicts how we can prepare yield maps. as yield maps are the most important and valuable sources of the spatial data for precision agriculture.

5. Grid sampling: It determines how the nutrients are distributed across a field. Moreover, it helps us to prevent the over application in areas having high level of fertilizers.

6 1bu/ac = 0.07t/ha bu/ac is generally used for measuring land in the USA

Moreover, a long yield history is essential of respective agroecosystem in present scenario to avoid deducing conclusions that are affected by climatic factors like weather or other parameters. When seen from Indian agricultural point of view a lot of work is still yet to be done and this is just a preliminary step in that direction. This type of technology will be helpful in precision agriculture, as yield maps are the most important and valuable source of spatial data for precision agriculture. Hence this paper will be helpful in the present scenario of crop production. Moreover, this preliminary step will facilitate us to understand the fertilizer or pesticide requirements in the fields thereby reducing the overuse which ultimately points at sustainability.

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