Term Paper

Precision Agriculture Based on GIS

For

CRP 514: Introduction to GIS

Term (112)

BY

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Abstract

Historically, there were many farmers and their fields were large and each farmer would know a great amount of information about every corner of each of their fields. With the use of Precision Agriculture (PA) which allow the farmers to know more about their fields and may be they can in control of thousands of acres and making detailed knowledge of each filed using maps provided on computer monitor. One of the tools of PA is the use of Geographic Information Systems (GIS). GIS can be used to analysis, interpret and evaluate the yields and make it is very easy to control large farm just from your PC. This helps the farmers to make good solution to reduce the cost and improve their yields. This paper presents the use of GIS in PA and how this can help the farmers. The paper contents the definition of PA, Yield Mapping and Monitoring; Soil sampling and Variable Rate Application and finally concluded with conclusion and Recommendations.

Key Words: Precision Agriculture (PA), Geographic Information Systems (GIS), Risk Index (RI) and Site-Specific Weed Management (SSWM).

1. Introduction:

Precision Agriculture becomes the new technique in farming in the last ten years. Along with GIS and GPS there have appeared some range of sensors, monitors and controllers for agricultural equipment such as shaft monitors, pressure transducers and servo motors, this will enable farmers to use electronic stuff to direct equipment movements more accurately, provide precise positioning for all equipment actions and chemical applications and, analyse all of that data in association with other sources of data. Precision agriculture allows a producer to gain detailed information on specific portions of the fields. Using the Global Positioning System (GPS) in combination with machine mounted computers and sensors, a farmer can now see variations in each field on a computer monitor whenever they want. This makes it easier to understand the management requirements of each zone in a field once again. This allows an increase in production potential, decreases in agricultural fertilizers, and decreases in harmful environmental effects of over applied herbicides and fertilizers.

2. Study aim:

The aims of this paper is to illustrate how GIS can contribute in Precision Agriculture to reduce the cost of agriculture inputs which plays very important role in whole cost of agriculture and which play important role to pollute the environment as well.

I am motivated by the fact that by using the Precision Agriculture we can make a significant improvement on yield and I take a case study to see how the yield can be improved.

3. Literature review:

The use of Geographical Information Systems gives more facility to farmers to analysis the data of soil types, nutrient contents, seeding rates, fertilizer rates, and herbicide rates that can be taken from fields to be used in order to manage inputs and outputs of their land. Mapping yield information allows a better understanding of where and why yields vary across fields (Seelan et al, 2003). The Global Positioning System and the geographical information systems allow data to be analyzed on a sub-field level allowing precise knowledge of field variability and precise management of crop inputs to adjust the variability. The latest technology currently being added to the site specific capabilities of the precision agriculture arsenal is remote sensing. Remote sensing images are beginning to be used to monitor and manage crop conditions on a field scale by detecting many levels of light reflectance from the plants which then relates to the type of crop or weed that is growing there (Backes et al,2006). Variable rate application is another technology that can modify the rate of input flow or switch input sources (e.g. between seed or fertilizer types) in response to GIS records that guide a GPS system. The system is an onboard computer which signals the variable-rate piece of farm equipment to vary the input flow as it moves through a field (Bullock et al., 2002). Site-Specific Weed Management (SSWM) is one part of precision agriculture that can use the knowledge that weeds usually grow in patches that are random in size and location throughout a field, and usually exist in the same general area over time (Clay et al,2006)**.**High resolution satellites such as QuickBird and IKONOS are gradually being implemented for the detection of weeds for Site-Specific Weed Management and can be introduced in agricultural production, but there is still a need for cost benefit analyses before widespread use will occur (Seelan et al, 2003). These satellites are capable of producing high resolution imagery that detects different categories or bands of light reflectance in the electromagnetic spectrum.

There are studies that show how GIS can play an important role to analysis and cooperate of some disease that may affects field plants like the case study used a GIS-based map to evaluate Moko disease in in banana growing farms in Colombia (Oscar et al,2010).

4. Methodology:

Overall this term paper investigates what information can be gained from a whole farm precision agriculture case study that can be passed on to farmers in the process of adopting GIS based-map technology. The concept of GIS can found in (Al-ramadan, 2005).

5. Applications of GIS in Precision Agriculture:

Figure below show the use of GIS in precision agriculture:

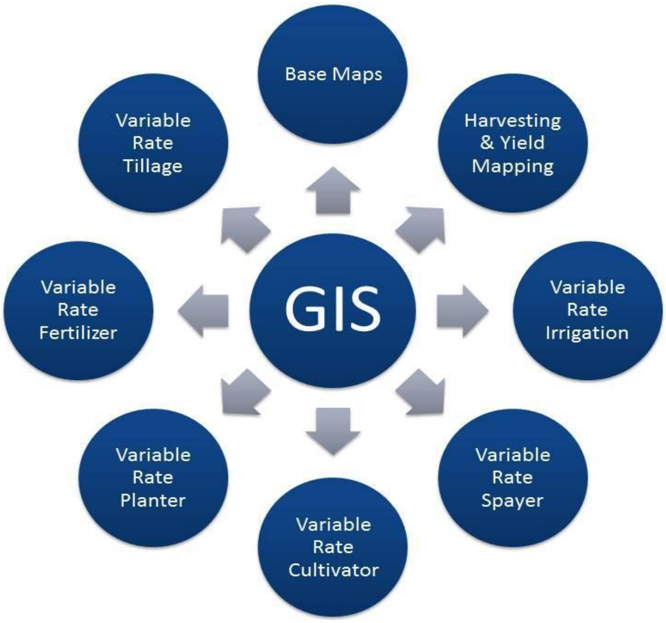

Figure 1 GIS Application in Agriculture

5.1 Precision Agriculture Overview:

Precision Agriculture or sometimes called Precision Farming (FA) is conceptualized by a system approach to re-organize the total system of agriculture towards a low-input, high-efficiency, sustainable agriculture (Shibusawa, 1998).

Currently, the precision agricultural process can be divided up into several events or agricultural tasks as shown in fig 5.2:

• Field and spatial feature mapping

• Soil sampling

• Swath guidance for agrochemical applications

• Application logging and automated record keeping

• Variable rate applications based on prescription maps

• Geographic Information Systems (GIS) to store, manipulate, analyses and interpret the spatio-temporal data collected over the farm and to generate prescription maps for an agrochemical application to a field

Each of these steps uses a combination of one or both of the following technologies of GIS or GPS (Buick, 1997).

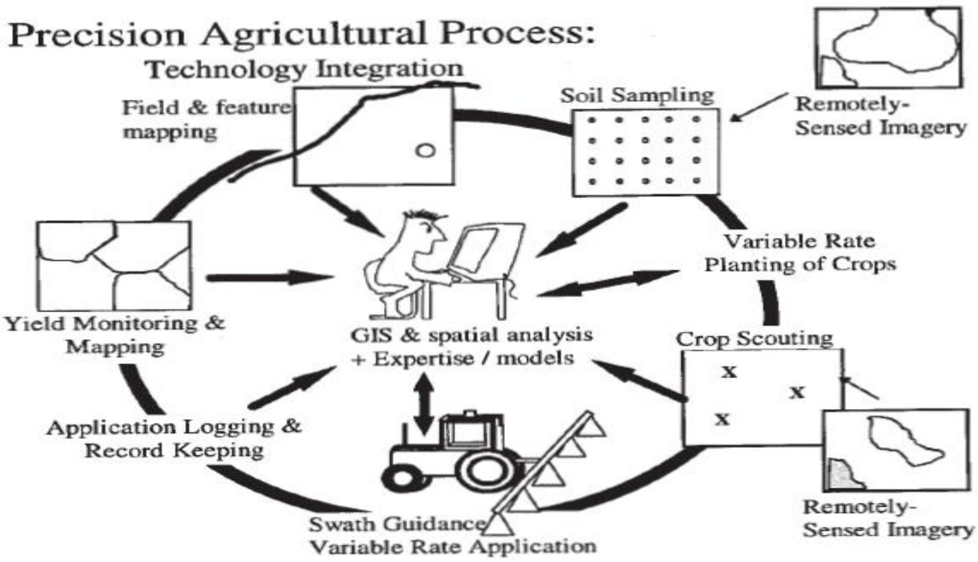

Figure 2 Precision Agriculture Process

5.1 Yield Mapping and Monitoring:

Yield monitoring and mapping is one step in precision agriculture which is often recommended as a first step to carry out in precision agriculture (Krill, 1996).Yield Monitoring is the most direct method to assess the field production and how it should be better managed. Yield monitors use a Differential Global Position System (DGPS) receiver, a computer or user interface, and sensors to accurately measure the amount of crop harvested at a specific location and time. Yield monitors are installed on harvesting equipment and are available for a variety of crops including grain (corn, wheat, soybeans, etc.) and cotton. In addition to measuring yield, these systems often provide other useful features such as collecting grain moisture content and elevation data along with the ability to spatially mark points or areas of interest (e.g. pest and weed infestations) during harvest. Yield data is typically recorded to a storage device (e.g. data storage card or USB drive) which can then be transferred to a desktop AgGIS package for processing, viewing, and analyses (Fulton, 2010). Using the yield monitor and mapping the farmers can evaluate their yield year by year.

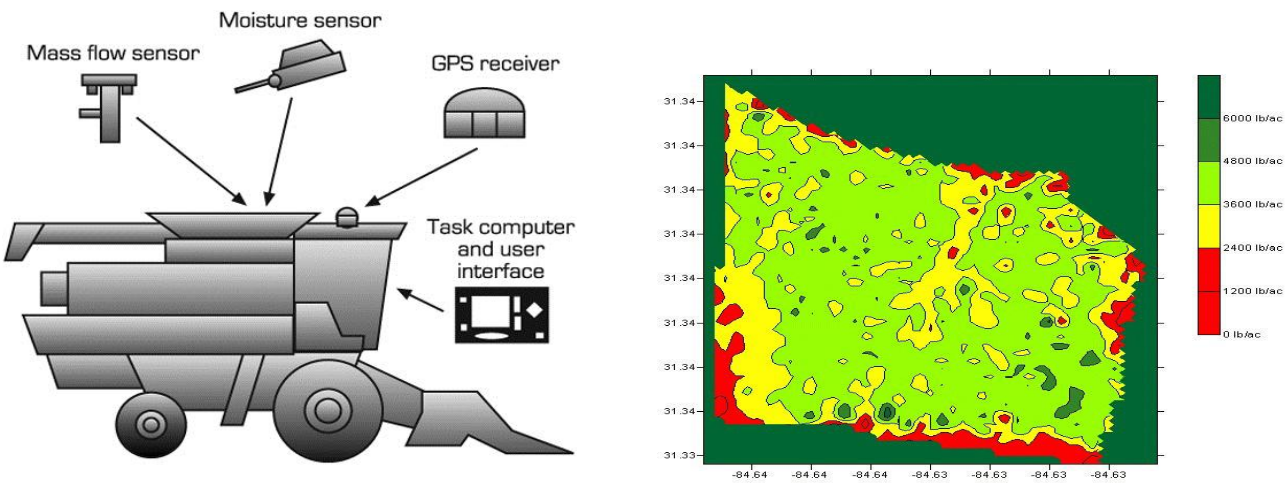

Figure 3 (Lift) Machines of Yield monitoring (Right) Yield map

5.3 Soil sampling:

Soil sampling used to provide an index for the nutrient availability in soil and is a critical step in nutrient management planning. Samples from soil have been taken either as traditionally way by taking samples to the laboratory or using on-the-go sensors with remote sensing technique. Also, laboratory analysis is still the most trusted and reliable method for determining most soil and plant properties.

Dividing the field into 2 ½ acre grids and collecting a sample for each cell, the grid lines help ensure a good spatial representation of the field that can be used to develop a nutrient map. Again, 5 cores should be collected, but they should be within a 10-foot radius of the center point for the sample. This provides nutrient information for the point, and the collection of data for all points in the field provides the basis of nutrient variability maps. Several different interpolation schemes are used to estimate the nutrient levels across the field based upon the sample points. The more points, the more accurate the map, but there is a practical and economic limit to the sample density---which appears to be about 2 ½ acres per sample.

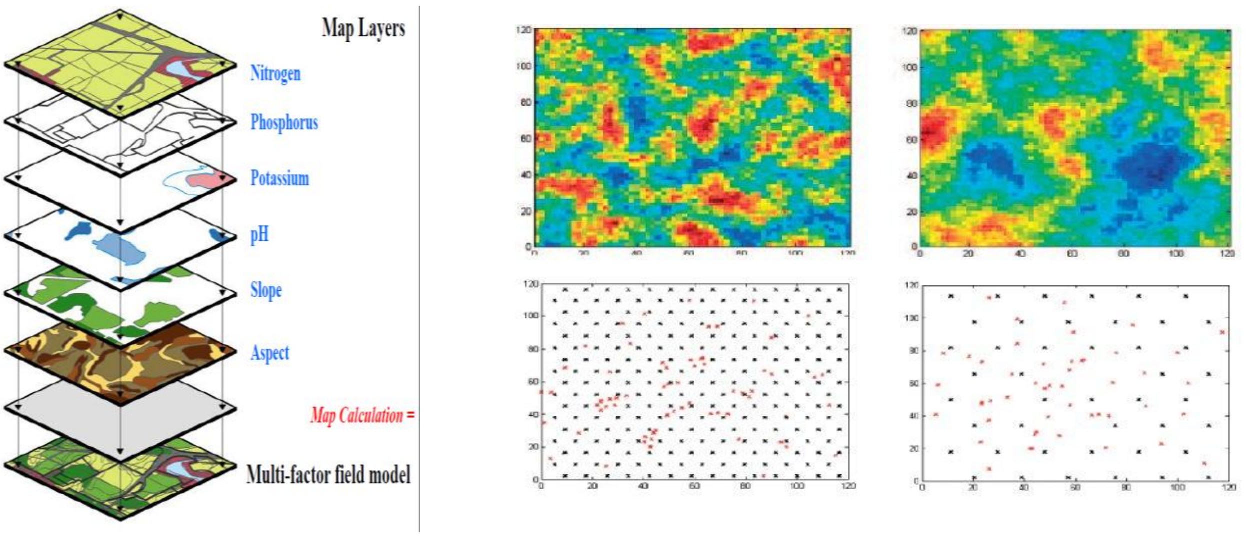

Figure 4 (Lift) Soil layers (Right) Soil sampling

Once field data have been collected and assigned position coordinates (e.g. latitude and longitude), mapping is easily performed using a computer program (usually a geographic information system (GIS) program). Such programs can use mathematical techniques for "smoothing" or interpolating the data between sampling points (Reetz)

5.4 Variable Rate Applications:

VRA is an abbreviation for variable rate application, which is a method of applying varying rates of inputs in appropriate zones throughout a field. The goals of VRA are to maximize profit to its fullest potential, create efficiencies in input application, and ensure sustainability and environmental safety**.**

The inputs are:

– Nutrients / Fertilizer:

N, P, K and Micronutrients

– Pesticides:

Herbicides, Insecticides and Fungicides

– Lime

– Seeding

– Tillage

– Irrigation

There are two methods for VRA can be used:

5.4.1 VRA based on Recommendations maps:

The first site-specific management method is based on the use of maps to represent crop yields, soil properties, pest infestations, and variable-rate application plans. The map based method can be implemented using a number of different strategies. Crop producers and consultants have crafted strategies for varying inputs based on: soil type, color and texture, topography (high ground, low ground), crop yield, field scouting data, remotely sensed images, and a host of other sources. Some strategies are based on a single information source while others involve a combination of sources. Regardless of the actual strategy, the user is in control of the development process.

To develop a plan for variable-rate fertilizer application in a particular field, the map-based method could include the following steps:

• Perform systematic soil sampling (and lab analysis) for the field;

• Generate site-specific maps of the soil nutrient properties of interest;

• Use some algorithm to develop a site-specific fertilizer application map; and

• Use the application map to control a variable-rate fertilizer applicator.

A positioning system is used during the sampling and application steps to continuously know or record vehicle location in the field. Differentially-corrected Global Positioning System (DGPS) receivers are the most commonly used positioning devices. The process of map-based, variable-rate application is illustrated in Fig 5.

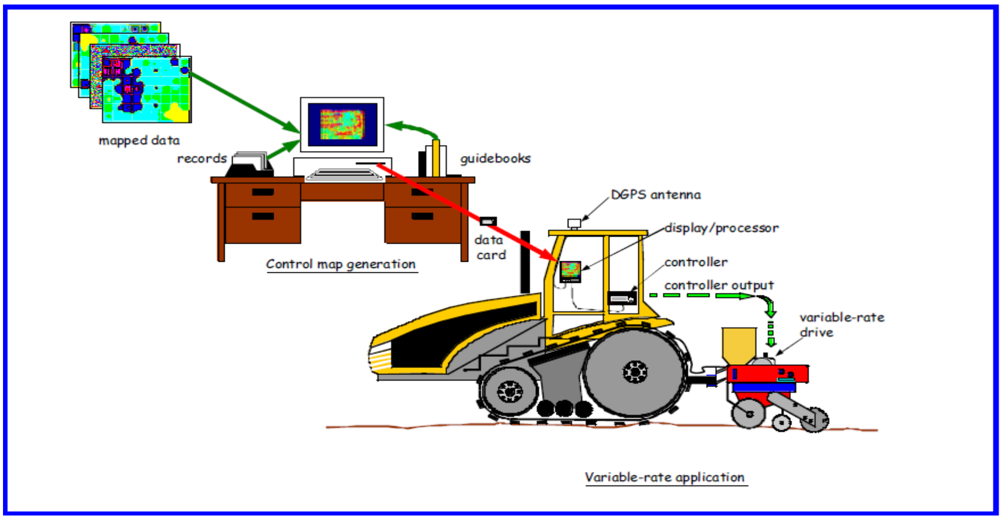

Figure 5 VRA based on Recommendations maps

5.4.2 VRA based on the on-the- go Sensors:

The sensor-based method utilizes sensors to measure the desired properties, usually soil properties or crop characteristics, on the go. Measurements made by such a system are then processed and used immediately to control a variable rate applicator (Fig 6). This second method doesn't necessarily require the use of a DGPS system nor does it require extensive data analysis prior to making variable-rate applications.

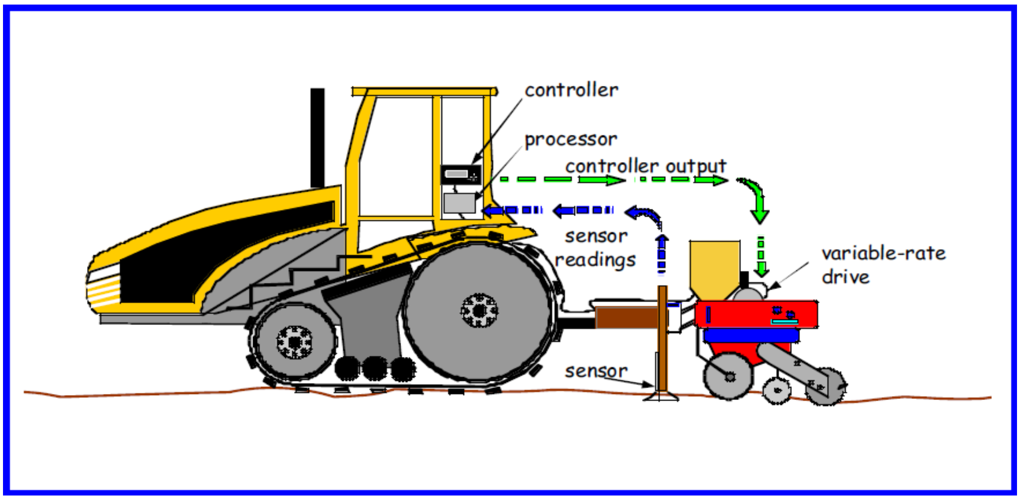

Figure 6 VRA based on Sensors on-the- go

6. Case Study:

In this case study (Oscar et al, 2010) which about the use of integrated information and GIS-based maps to evaluate the Moko disease during three different time periods.

6.1 What is Moko disease?

It is one kind of Ralstonia solanacearum which is a species complex and is traditionally classified into five races based on differences in host range and into biovars based on biochemical properties. Moko disease, a bacterial wilt of banana, is recognized as Ralstonia solanacearum race 2, biovar 1.

Figure 7 Banana tree infested by Moko disease

6.2 Study Area:

The study carried out in the most important banana growing area in Colombia: Urabá. This area is located in the northwest of Colombia near the border with Panamá. The annual average temperature is 27 C and the annual cumulative precipitation is 2650 mm.

The study included the ten important farms in Urabá which have the highest number of reported Moko foci.

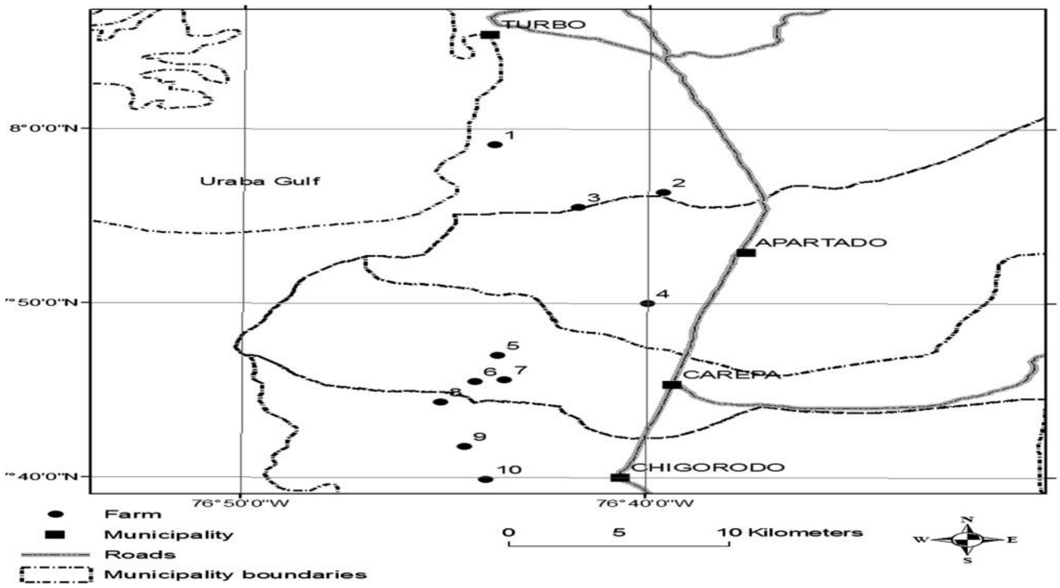

Figure 8 Case study area Urabá, Colombia

6.3 Discussion:

For each farm we performed a detailed planimetric survey using the global positioning system (GPS) which includes the cable-ways which are used to transport fruit and materials inside plantations and drainage channels which are made to evacuate excess soil water. All data was inputted into the GIS. These data consisted in georeferenced points in a system of projected coordinates.

These maps allowed us to relate simple data, such as Moko foci distribution in a farm, with fruit transport cable-ways and the distribution of drainage channels. The information in GIS-based maps was used to calculate the area of polygons for assessing the Risk Index (RI).

RI can be calculated as following:

RI= (Ai/At)*(Li/Lt)

Where:

Ai= the infested area, At= the infested area, Li= the infested lots and Lt= the total lots.

Comparing the RI for contaminated area during the three different times period as shown in figure below:

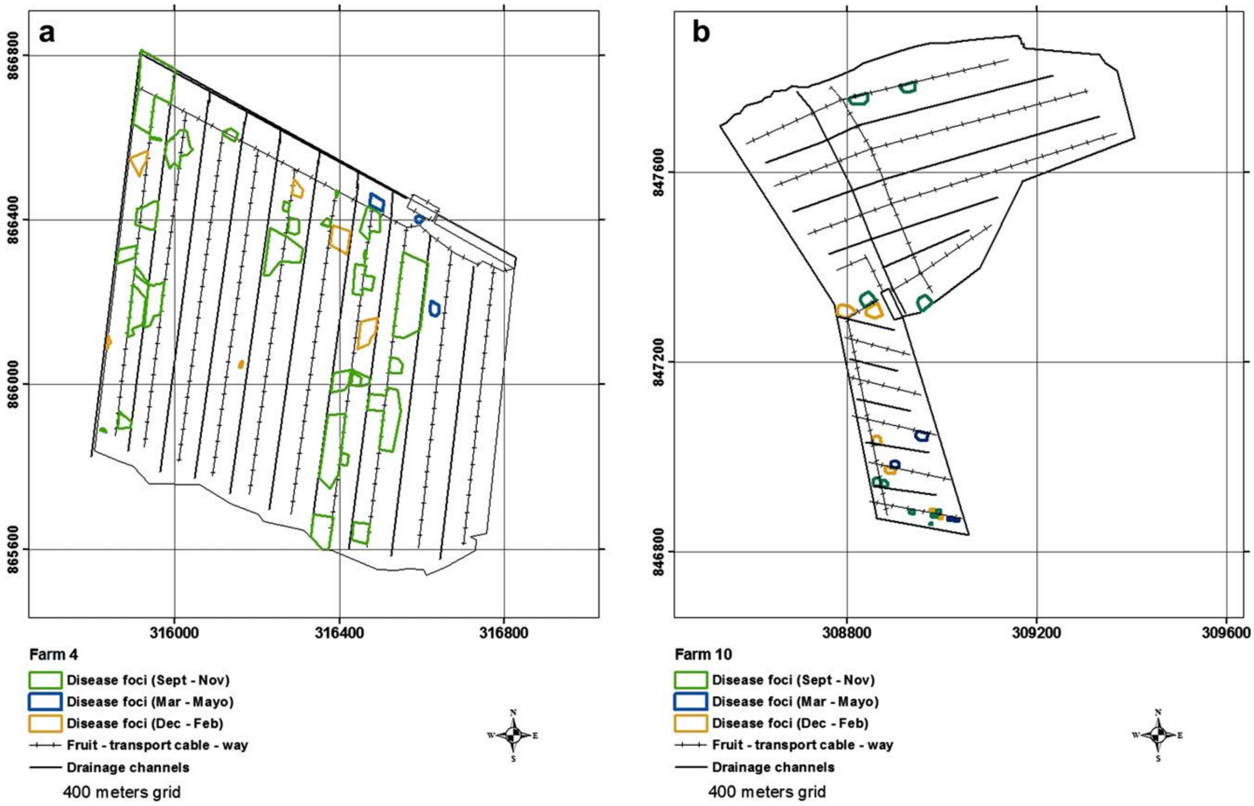

Figure 9 Moko GIS map of the 10 farms

From mapped above they found that the Moko disease located near the cable-ways not near the drainage channels which means the affect coming from cable-ways from human activities within plantations and are also the main footpath for banana workers to access all lots and sub-lots within crop fields. A likely explanation for this pattern of Moko disease distribution in the banana fields is that workers are helping to disseminate the bacteria. Based on this hypothesis, disease disseminationmay be prevented by applying simple measures like footwear and tool sterilization.

7. Summary:

Precision agriculture gives farmers the ability to more effectively use crop inputs including fertilizers, pesticides and irrigation water. More effective use of inputs means greater crop yield and/or quality, without polluting the environment.

Precision agriculture can address both economic and environmental issues that surround production agriculture today. It is clear that many farmers are at a sufficient level of management that they can benefit from precision management. Questions remain about cost-effectiveness and the most effective ways to use the technological tools we now have, but the concept of "doing the right thing in the right place at the right time" has a strong intuitive appeal. Ultimately, the success of precision agriculture depends largely on how well and how quickly the knowledge needed to guide the new technologies can be found.

8. Conclusion and Recommendations:

In conclusion, A Geographical information system (GIS) tool can contribute in precision agriculture by analyzing, interpreting and evaluating the yield which help to improve the yield as we see in the case study. With GIS base-map we can reduce the cost by reducing the inputs of agriculture like (Nutrients / Fertilizer, Pesticides) and the environmental risk will reduce as well.

More effort should be done to train the farmers to use new technology in PA to help them to improve their yields.

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