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Precision Agriculture Techniques for Crop Management in Trinidad and Tobago: Methodology & Field Layout

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Abstract. *Agriculture in Trinidad and Tobago has not advanced at the same rate at which new agricultural technology has been released. This has led to large-scale abandonment of crop lands as challenges posed by labor availability and their agronomic capability could not meet the technological demands for agricultural production, competitiveness and sustainability. There is an urgent need to develop technology-based agriculture models to meet the demands of a modern agricultural sector and to maintain its lead role in food production. This project looks at the development of advanced precision agriculture techniques for crop production, nutrient and water management. The project will utilize a combination of optimization principles (financial, yields, etc), agronomic data, advanced processing of remotely sensed images of agricultural fields and Geographic Information Systems (GIS) technology for the analysis and integration of the spatio-temporal farming data. A decision support system will be built upon the crop spatio-temporal intelligence for effective and efficient farm operations.*

In the first phase of the project, the primary goal is to evaluate the effect of precision agriculture based irrigation and fertilizer technologies on (1) the growth, yield and quality of a corn crop, and (2) the soil nitrogen (N). In this presentation, we describe the replicated split plot Randomized Block Design (RBD) experimental design comprising of four irrigation (I) methods (Main factor) and three N fertilizer (F) rates (sub plot factor). This design will facilitate the assessment of the individual effects of irrigation (I) and N fertilization (F), as well as any I x F interaction effects, on the respective soil and plant parameters monitored through the project. The selection criteria for the Unmanned Aerial Vehicle (UAV) fitted with a Near Infra Red (NIR) Camera to collect multispectral data across the crop field are also discussed. By analyzing the "big data" comprising of the spectral reflectance values of the NIR, Red and Green bands, we will categorize problematic areas within the field. Based on this analysis, zones will be identified for irrigation and N management interventions.

Keywords. *Precision Agriculture, Unmanned Aerial Vehicle (UAV), Multispectral Imagery, Fertigation, Irrigation Efficiency, Nitrogen Use Efficiency, Water Use Efficiency, Big Data*

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Background

This project looks at the development of advanced precision agriculture techniques for crop production, management and risk assessment. The project will utilize a combination of optimization principles (financial, yields, etc), agronomic data, advanced processing of remotely sensed images of agricultural fields and Geographic Information Systems (GIS) technology for the analysis and integration of the spatio-temporal farming data. A decision support system will be built upon the crop spatio-temporal intelligence for effective and efficient management of the farms.

Research and development will be done by Team members from the Department of Agricultural Economics and Extension and Department of Food Production, Faculty of Agriculture and the Geomatics Engineering and Land Management Department of the Faculty of Engineering, UWI, in collaboration with York University, Canada and University of California, Fresno State, USA.
The project will be developed and implemented at the 200-acre University Field Station at Orange Grove, Trinidad, with a 5-acres experimental site dedicated for intense data collection and crop research (Figure 1).

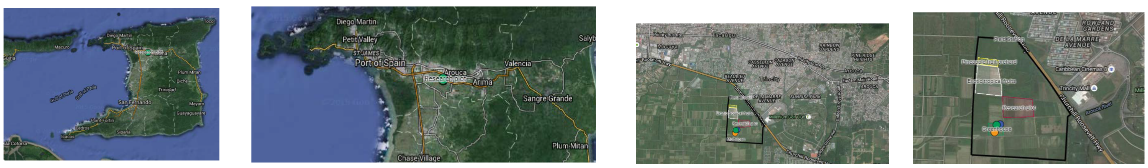

Figure 1: Map & location of the precision ag site at the University of the West Indies (UWI) Orange Grove Estate, Trincity, Trinidad. http://precisionag.seepersad.org/

What is innovative about this project?

1. Application of state of the art irrigation techniques for increasing water use efficiency (WUE);
2. Advanced precision fertigation techniques to optimize Nitrogen (N) uptake by plant and minimize N leaching potential, thereby improving N use efficiency (NUE);
3. Unmanned Aerial Systems (UAS) and GIS as tools for Precision Agriculture; and,
4. Economic Analysis (EA) for evaluation of various Precision Agriculture techniques towards derivation of best management systems, for improving overall crop productivity in response to weather uncertainty associated with climate change and variability.

Overview of Methodology Used in the Study

Soil samples will be taken at various locations within a designated 5 acres at the University Field Station (UFS) Orange Grove site, referred to as the “experimental site”, for the determination of baseline levels of macronutrients- Nitrogen (N) Phosphorus (P) and Potassium (K). Sample sites will be based on previous knowledge of the soil texture variability along with a random sampling technique across the experimental site. Samples will be analyzed at the UWI testing laboratory for pH, macronutrients (P and K) and some minor nutrient testing. Separate testing will be undertaken for the determination soil N levels.

The 5-acres experimental layout will be a split plot Randomized Block Design (RBD) set up to evaluate the effect of four irrigation (I) methods (Main factor) and three N fertilizer (F) rates (sub plot factor), and a Control (rainfed and no N fertilizers) replicated three times. This design will facilitate the assessment of the individual effects of irrigation (I) and N fertilization (F), as well as any I x F interaction effects on the respective soil and plant parameters monitored throughout the project.

Prior to the implementation of irrigation and fertilizer treatments, the experimental site will be planted with a scavenging corn crop in which no N fertilizers will be applied. After harvest and removal of crop residue, another round of soil sampling will be conducted to assess the nutrient status of the plots, with an emphasis on soil N content. Once the site has been re-planted with the “experimental” corn crop, periodic monitoring using UAS drone technology will be conducted, along with the collection of data for various soil and plant parameters. Brief reviews of the irrigation, fertigation and UAS technologies are given below.

1.*Precision Irrigation Techniques for WUE*
In addition to "fountain surface sprinkler" irrigation method currently in use at the Orange Grove field station, the corn crop will be irrigated with surface and buried drip tapes. The latest advancement in aerating the root zone along with water delivered through the drip tape, referred to as AirJection® Irrigation (refer to: http://mazzei.net/irrigation/) will be incorporated into the one of the buried drip tape treatments. AirJection venturi injectors will be used to assess its impact on plant health and vitality by adding atmospheric air, via a drip irrigation system directly to plant roots.

2.*Precision Fertigation Techniques for NUE*
This experiment will inject chemicals into a pressurized irrigation system (chemigation) using venturi injectors designed for liquid-liquid mixes. Mazzei® pioneered this simple-to-use and easy to install solution more than 30 years ago and the technology will be tested for the first time in Trinidad and Tobago under this project, as a relatively lower cost solution and more efficient approach to N fertilizer application than the method of broadcasting N fertilizer granules. The Mazzei injectors are used worldwide for injecting gases and liquids such as fertilizers and other chemicals into pressurized water systems, and do not require external power to operate but a small booster pump may be used to produce the minimal differential pressure if required.

3. Use Unmanned Aerial Systems (UAS) for Precision Agriculture
The project will seek to employ the use of UAS fitted with a Near Infra Red (NIR) Camera to collect multispectral data across the crop field. By analyzing the spectral reflectance values of the NIR Red and Green bands, the project will seek to identify problematic areas within the established crop. Based on this analysis, management zones will be identified and nutrient, herbicide and pesticide recommendations will be made.

The study will also identify which areas within a crop are underperforming and with supplemental soil and plant tissue analyses, an attempt will made to ascertain the reasons for non-optimal use of water and N fertilizers. This information will help to concentrate efforts on these areas, thus allowing the implementation of agronomic practices that should eventually reduce inputs and increase outputs, thereby increasing the overall efficiency and productivity of the cropping system.

The multispectral imagery will show what the naked eye and traditional cameras cannot. This will allow for the detection of issues that may become problematic at a far earlier stage. In addition, the "real time" data analysis will enable preventative, rather than remedial action be taken when necessary.

Overall, the UAS will serve to improve precision agriculture in the region by collecting larger amounts of data in a shorter period of time; with higher accuracy and lower cost. The equipment allows us to move from sampling a crop to measuring the entire population of plants, thus giving highly accurate assessments of crop health and vigor. A healthy plant will reflect the Near Infra Red and Red portions of the electromagnetic spectrum but will absorb the Green and Blue portions. Using drones as a Precision Agriculture Innovative tool for the acquisition of geospatial information and mapping will potentially allow for scouting for disease, insect, weeds, or any other damages; identifying problems (irrigation, fertilizer) fast and take replanting actions; allow for visual-recorded proof of issues for insurance proposes and record keeping that specified operations were completed. Subsequently, the data will be analyzed as necessary in order to achieve the overall goal of this 1st phase of the project which is to evaluate the effect of precision agriculture based irrigation and fertilizer technologies on (1) the growth, yield and quality of a corn crop, and (2) the soil N and microbial status.

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