The International Society of Precision Agriculture presents the
15th International Conference on Precision Agriculture
26–29 JUNE 2022
Minneapolis Marriott City Center | Minneapolis, Minnesota USA

Utilization of UASs to Predict Sugarcane Yields in Louisiana Prior to Harvest

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A paper from the Proceedings of the
15th International Conference on Precision Agriculture
June 26-29, 2022
Minneapolis, Minnesota, United States

Abstract. *One of the most difficult tasks that both sugarcane producers and processors face every year is estimating the yields of sugarcane fields prior to the start of harvest. This information is needed by processors to determine when the harvest season is to be initiated each year and by producers to decide when each field should be harvested. This is particularly important in Louisiana because the end of the harvest season is often affected by freeze events. These events can severely damage the crop and result in decreased or negligible sucrose extraction at the sugar mill. Current methods to estimate crop yields rely on visual yield estimates and trend analysis of the yield histories of the fields in question. These methods are both subject to a high degree of variability. The objective of this research project was to determine if imagery obtained with UASs could accurately predict sugarcane yields prior to harvest. UAV imagery of a first-ratoon field of L 01-299 was acquired in August and November 2018. Imagery was also obtained in November from the same field in 2019 from the second-ratoon crop. The site for the study was located on a commercial sugarcane farm in Paincourtville, LA. Imagery was collected using a Sony Alpha 7R, 36-megapixel true color/Infrared (IR) camera and a MicaSense, RedEdge multispectral sensor. The UAV platform utilized in these experiments was a Trimble UX5 fixed wing drone. Yield estimates were obtained in November 2018 and 2019 by harvesting selected rows from the field in 30-m sections utilizing a chopper harvester and field wagon equipped with load cells. Sugarcane stalk samples collected during harvest were used to determine TRS at the USDA juice quality lab. Variogram analysis and block kriging were used to create yield maps obtained from the weigh wagon yield estimates. Orthomosaics of the acquired images were created using Pix4D and selected vegetation indices were derived from the orthomosaics. The image data was then correlated with field measurements of both cane and sugar yields. The image data was also compared to estimates obtained from a yield monitor mounted on the chopper harvester. Data from these evaluations suggest that UASs appear to have potential as an alternative to estimate sugarcane yields prior to harvest; however, additional research is needed to refine yield estimate procedures and increase the area covered by each flight.*

Keywords. Unmanned Aerial Systems, Multispectral, Orthomosaic, Yield monitor, Digital Surface Model (DSM).

Introduction

The goal of sugarcane producers is to maximize yields, while minimizing the cost of production, thereby insuring a profitable venture. This goal, while straight-forward for annual crops, is much more complicated for perennial crops that are harvested over several years. Sugarcane yield is determined by multiplying two different yield components, the biomass (cane) yield (Mg ha^{-1}) and the sugar yield of the stalks (kg sugar Mg^{-1}), These two different yield components depend on a wide variety of factors including crop age, variety, soil type, soil fertility, water availability, pest and diseases and climate factors. In addition, sugarcane is harvested over a time frame ranging from 3-5 months in Louisiana. Yield variation can be significant over this extended time frame. Also, in many industries, an artificial chemical ripener must be applied to increase sucrose concentration in the stalk, because the harvest campaign begins before the crop is physiological mature.

These combined factors increase the grower's uncertainty as to the potential yield of a given field. A field may be harvested when yields are not yet at optimum levels, thereby decreasing not only yields, but wasting resources. If accurate yield estimates were available for the two yield components of interest (cane and sugar yields) the growers could develop harvest schedules that could maximize yields and production efficiency. The main objective of this project is to utilize emerging UAS technology with multispectral sensing capabilities to obtain yield estimates that is accurate and obtained in a timely manner for sugarcane growers. The secondary objective was to determine whether photo derived digital surface model (DSM) will be useful in characterizing the crop structure which is directly related to biomass density and yield.

Materials and Methods

The site for the study was located on a commercial sugarcane farm in Paincourtville, LA. Ground control points were monumented near the site using survey grade Trimble R10 GNSS receiver for proper project control. The sUAS deployed in this study is a Trimble UX5 fixed wing aircraft mounted with a 36-megapixel Sony Alpha 7R true color/IR camera and MicaSense RedEdge multispectral sensor.

Mission plans created in the lab can be loaded on to the rugged tablet or the plans could be manipulated in the field based on prevailing conditions. Our missions had the following parameters namely: 119 m flying height, 90 percent endlap and sidelap, with a desired GSD of 2 cm to a pixel. Each mission is flown once with a true color sensor and then with a NIR sensor. This was followed by flying UX5 with a MicaSense RedEdge sensor with a desired GSD of 4 cm to a pixel (per band).

Images were post processed utilizing Trimble Business Center and Pix4d software to obtain True color and Infrared Orthomosaics, Normalized Difference Vegetation Index (NDVI), Point cloud and DSM were derived from true color orthomosaic. The spectral indices and individual band data (Red and IR) were corelated with yield monitor mounted on the chopper harvester. A 2D yield model was developed in a GIS environment.

Results and Discussion

True color orthomosaic imagery and the corresponding point cloud of the study site is presented in Figure 1. The point clouds generated before canopy closure have shown promise in modeling the biomass variability. The individual peak band sensitivity of our multispectral sensor is depicted in Figure 2. These bands were used to generate and test the efficacy of several vegetation indices. An example for NDVI generation is shown in Figure 3. These data were then used to correlate with yield data taken at the study site. The yield results for theoretically recoverable sugar (TRS) are included in Figure 4.

Analysis of the data indicate that the results for NDVI become saturated, due to the closure of the vegetative canopy, by mid-summer. To improve the potential predictive capacity of this method it will require that additional imagery be acquired earlier in the growing season.

This is supported by a modest improvement in the relation between vegetation indices and yield data at our earlier sampling dates. Based on these observations, we are currently exploring the applicability of hyperspectral sensing combined with Lidar data fusion to improve yield models.

Summary

Data from these evaluations suggest that UASs appear to have potential as an alternative to estimate sugarcane yields prior to harvest; however, additional research is needed to refine yield estimate procedures and increase the area covered by each flight.

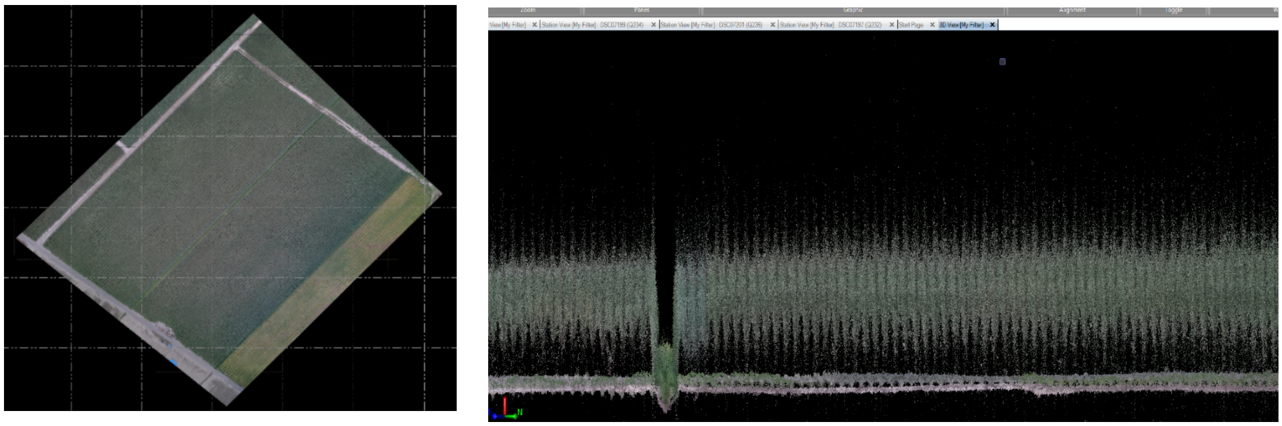
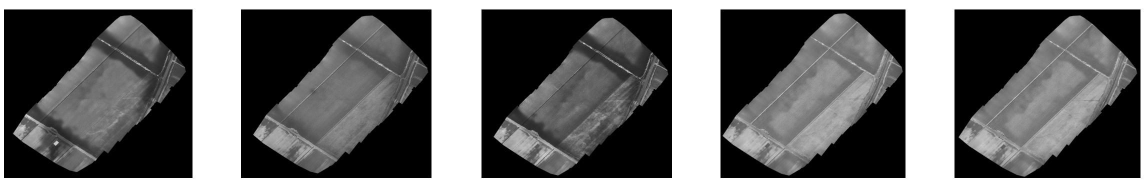


Fig 1. True Color Orthomosaic of the Study Area (2cm / pixel) with corresponding point cloud.



Blue 0.475 um | Green 0.560 µm | Red 0.668 µm | Red Edge 0.717 µm | Near Infrared 0.840 µm

Fig 2. Individual band Orthomosaic from MicaSense RedEdge Sensor

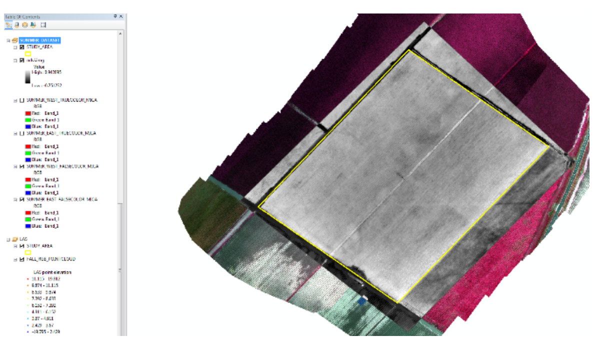


Fig 3. Normalized Difference Vegetation Index-2018

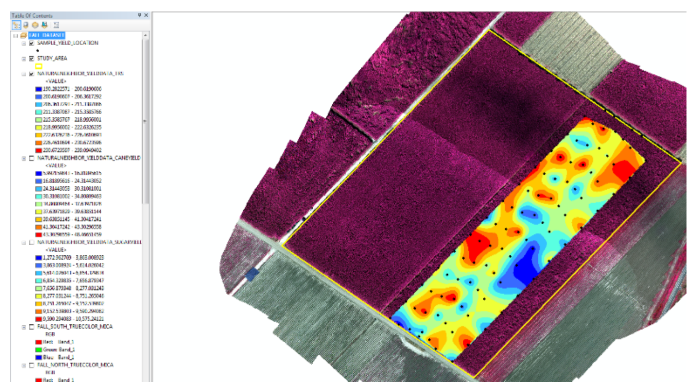


Fig 4 A 2D model depicting TRS in lbs. of sugar per ton of cane