COMPARING SENSING PLATFORMS FOR CROP REMOTE SENSING

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ABSTRACT

Remote sensing of Normalized Difference Vegetative Index (NDVI) can be used to predict crop biomass, which is a good indicator of crop health status and nitrogen deficiency. Different platforms can be used to measure NDVI, notably ground based active sensing, airborne and satellite borne imagery. Each of these sensing platforms has pros and cons but few studies have been implemented to compare their potential to predict spatial pattern of crop biomass. In this study three sensing platforms were used to quantify and predict crop biomass and compared to actual crop biomass obtained via crop sampling at the V7 growth stage of maize (*Zea Mays* L). Our results indicate that ground based active sensor NDVI readings as well as airborne imagery based NDVI readings successfully detect spatial patterns in crop biomass while satellite based NDVI readings failed to detect it.

KEYWORDS: Remote sensing, maize biomass, normalized difference vegetation index

It is widely documented that crop productivity varies spatially and temporally within crop fields (Inman et al. 2005). A precise and accurate measurement of crop's green biomass across a field enables site-specific nutrient management, particularly nitrogen and thus potential for improvement in nutrient use efficiency (Cassman et al. 2002). The Normalized Difference Vegetation Index (NDVI) has often been cited as a simple and good indicator of crop status related to crop biomass, leaf area index and yield (Pinter et al. 2003). The NDVI can be measured using different sensing platforms notably satellite, airborne sensors and ground based crop sensing.

Gitelson et al. 2003 found that satellite imagery providing NDVI on a large scale was strongly related to green leaf biomass. This source of data can be obtained seamlessly from various commercial satellite service providers. However, the resolution is somewhat coarse (i.e. around 5 m), acquisition may be impeded by cloud cover and the acquisition can be expensive for small areas. The NDVI can also be acquired using airborne camera arrays by scheduling a flight above the region of interest; it covers a fairly wide area (e.g. tens of hectares) and provides a high resolution data (e.g. 0.25 m pixels). As it was the case for satellite imagery, airborne imagery can also be impeded by weather conditions and is relatively expensive on a per flight basis. The other possibility is ground based sensing. As opposed to the two other platforms, ground based sensing often use active sensors which enables sensing in any light conditions. This last technique is relatively inexpensive, can be obtained under most weather conditions and at a very high resolution with sensors providing readings up to 10 Hz. However, the data acquisition requires scanning the crop physically through the field which can be time consuming.

Each sensing platform have their unique pros and cons for their operation but few studies have been undertaken to compare them for their potential to detect pattern in field. The objective of this study was to assess the precision of each of these three NDVI sensing platforms for quantifying in-field pattern of maize (*Zea Mays* L) biomass across productivity potential management zones.

This study was implemented in Fort Collins, Colorado at the Colorado State University research farm in an irrigated maize field. An area of about 14 acres was divided into three site-specific productivity potential management zones using color based technique (Khosla et al., 2002). The NDVI values were acquired using three platforms. Satellite imagery was acquired by RapidEye (Germany) 55 days after planting (DAP), or V7 growth stage of maize, with a spatial resolution of 5 m. Airborne imagery was acquired at 47 DAP by Geovantage Inc. (MA, USA) with a spatial resolution of 0.25 m to 1 m pixels. Ground based NDVI was acquired at 48 DAP, using a GreenSeeker (Trimble, Ukiah, CA, USA) mounted on an all-terrain vehicle, at every six rows with a frequency of 10 Hz. Geocoding was done by distributing the data along the sensed transects and maps were created by kriging with 0.55 m pixels.

A total of 93 biomass samples 1-meter long (i.e. all maize plants within 1 m row length were cut, dried and weighed) were acquired at 51 DAP over the sensed area in a systematically unaligned sampling pattern. Map of biomass was created using kriging.

Data analysis consisted of fitting a linear model between the biomass and each of the three NDVI data layers sampled at each of the 93 locations. The parameters of the linear model were then used to predict the biomass on the whole surface. Actual biomass (i.e. from biomass samples) and predicted biomass (i.e. predicted from each of the three NDVI data layers with linear models) were then grouped within each zone. Differences were assessed using ANOVA and Tukey's test. Precision was assessed by verifying if predicted values followed the same pattern as the actual biomass values.

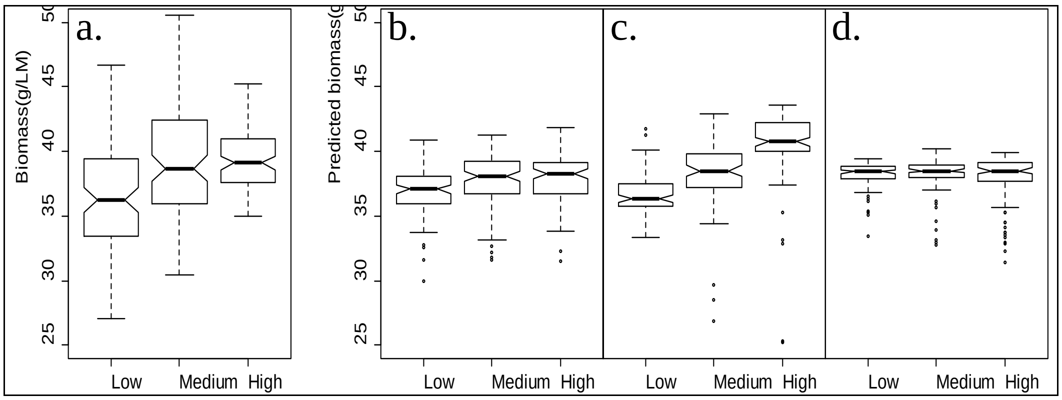

Fig. 1. Boxplots of the actual (a) and predicted biomass values in grams per linear meter (LM) from ground based (b), airborne (c) and satellite (d) based NDVI distributed across low, medium and high management zones. Non-overlapping notches indicate a median significantly different (α= 0.05).

Actual biomass increased from low to high management zone, showing significant difference between low and high zones but not between medium and high zones (Fig. 1a). This is consistent with the fact that medium zone is often a buffer between low and high zones and thus can contain high as well as low productivity areas. Predicted biomass using ground based NDVI active sensing yielded the same pattern as the actual biomass sampling (Fig. 1b). This demonstrates the potential of ground based NDVI as a tool to predict maize biomass. Predicted biomass using NDVI from airborne imagery increased from low to high zone with all three groups being significantly different (Fig. 1c). This is a logical pattern expected from the management zones grouping and thus demonstrates the effectiveness of airborne to detect spatial patterns in maize biomass. Census acquisition of airborne NDVI values as opposed to only 93 biomass samples may potentially explain the higher sensibility of airborne NDVI predicted biomass to pick up the expected zones pattern. Predicted biomass using NDVI from satellite imagery did not show significant difference among the zones while showing relatively low variance in the data set (Fig. 1d). This may be attributed to the large pixel area (i.e. 5 m) covering both soil and crop vegetation and at the V7 growth stage soil background noise may still be too high as compared to signal coming from the vegetation.

In conclusion, at the V7 growth stage of maize, ground based and airborne imagery based NDVI showed high potential for the prediction of maize biomass, while satellite imagery based NDVI failed to detect actual biomass pattern.

References available upon request from louis.longchamps@colostate.edu