SUPPORTING PRECISION AGRICULTURE WITH DUAL-POLARIMETRIC TERRASAR-X – YIELD PREDICTION AND IDENTIFICATION OF IN-FIELD VARIATIONS TO GENERATE FERTILIZER PRESCRIPTION MAPS

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1. ABSTRACT

Precision agriculture can benefit substantially from remote sensing in the early prediction of yield volume and quality and at the early growth stages in the preparation of a fertilizer application map that takes account of infield variability to provide the optimum level of nitrogen for distinct zones of growth patterns[1]. In Southern Australia, the winter crops include cereals, peas, lentils, canola and beans. Precision agriculture in this region is currently using very little remote sensing mainly because of the difficulty of acquiring optical image data for the generation of NDVI due to persistent cloud cover during most of the growing season as well as the comparatively low yield per hectare relative to European conditions.

The utilization of SAR imagery to derive a remotely sensed indication of crop condition is desirable because of the independence of cloud and feasible because of the sensitivity of SAR backscatter to wet biomass. The results presented here utilized satellite SAR data from TerraSAR-X over agricultural test sites at the early growth stage and for yield prediction demonstrating its potential and limitation for precision agriculture applications.

In October – November 2008 an interferometric set of three dual-polarimetric TerraSAR-X scenes were collected over the Roseworthy test site. While no complete interferogram generation was possible due to decorrelation over vegetation using repeat pass acquisition at this wavelength, this mode was seen as desirable to eliminate differences in backscatter due to viewing geometry. Soil moisture was sampled on acquisition dates and yield data was obtained from harvesting records. The data was used to generate an empirical model to relate the SAR backscatter to yield. A significant relationship was obtained between the HV amplitude at the wet ripening stage of wheat and the recorded harvested mass[2]. Later acquisition dates during the season lead to senescence of the wheat crop and reduction in backscatter.

In June-September 2009 an interferometric set two of dual-polarimetric images were collected to estimate the growth in the early growing stages of crops at the Yorke test site. The first acquisition was taken shortly after planting and the second three weeks later. Optical data was acquired at the same time as SAR data and an active NDVI sensor 'Greenseeker' instrument[3] was used to obtain ground based measurements of NDVI at both stages. This difference between returns from the two acquisition times was expected to result in a map showing the growth pattern of the early crop for the extraction of differential fertilizer application prescription maps.

In each individual SAR image the infield variations not sufficiently large to be identified given the SAR speckle characteristics. Numerically however a correlation of 0.6 was obtained between the NDVI values calculated from the optical imagery and the HH backscatter. Backscatter differences are observable between different crop types (peas, lentils and cereals) due to their overall structure and biomass differences. The optical NDVI's from the two dates are highly correlated and not much change is observable (0.74 correlation coefficient), where as the HH SAR backscatter shows a marked change (0.34 correlation coefficient) indicating significant depolarization due to growth of the crop. The stripmap resolution is insufficient to capture variation within the field. The differences observed when the foliage and heads are mature in the earlier experiment are not present here.

This study established working relationships with growers and a data collection regimen to further explore the utility of SAR in precision agriculture since it offers the promise of information availability in time for crucial farming decisions. In particular, the high correlation of SAR backscatter from mature crops at the wet stage is highly promising in yield prediction as shown for wheat and canola. The generation of prescription maps for nitrogen application however is currently limited using X-band SAR and further research is required to isolate plant responses in SAR data at this stage.

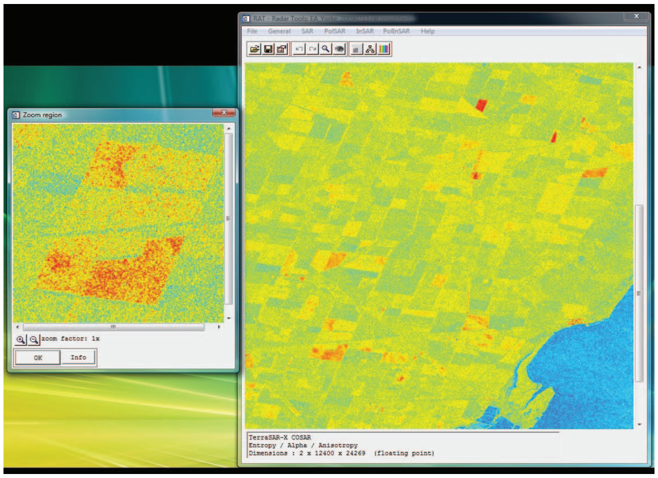

Figure 2: Dual-polarimetric alpha image of the Yorke test site

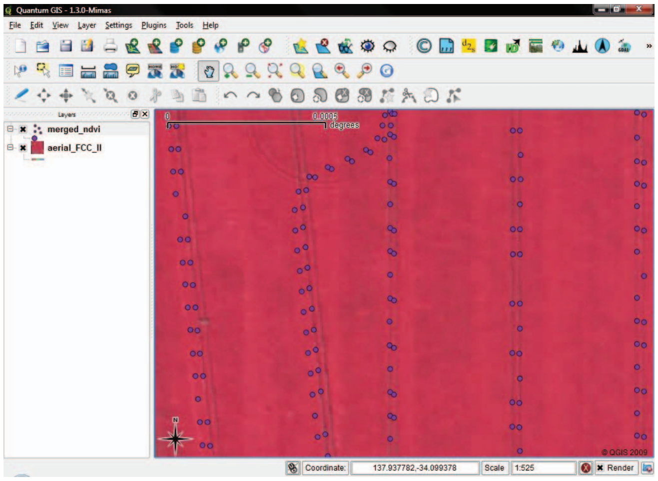

Figure 1: Aerial False Colour Composite with ground NDVI collection points overlaid

Figure 3: Field photograph of beans in flowering stage

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