Airborne video imagery - a potential tool for monitoring irrigated cotton

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Summary. Video images collected from a light aircraft offer the potential to improve farm management decisions through timely monitoring of crop vigour. In cotton crops imagery is able to map entire fields and show the within field variation of crop vigour and stress. The availability of imagery in near real time offers advantages over traditional satellite and photographic methods. The method enables farmers and agronomists to understand the current status of the entire field and facilitates crop checks in more representative areas when making management decisions. Using video image data with current ground based crop monitoring techniques for irrigated cotton is discussed as a potential crop monitoring tool of the future.

Introduction

Efficient water management is fundamental for Australian cotton *(Gossypium hirustum)* growers to achieve high cotton yields. Cotton production is expected to contribute $742 million to Australia's gross value product this year (1). One of the greatest constraints to the industries expansion and sustainability is the availability of water in climatic regions which arc suited to cotton production. The cotton industry constantly finds itself under the environmental microscope with most of the attention being focused on agricultural chemicals and fertilisers. Whilst these issues may attract most media attention, there arc other important issues which are vital to the long term sustainability of the cotton industry. Crop water use is one of these factors. For any particular cotton field, improved crop agronomy and plant breeding have resulted in increased yields per hectare, however the yield per megalitre of water in any particular field is possibly decreasing due to a decline in soil structure and reduced availability of soil water. An example can be found in (6) which highlights the importance of careful crop monitoring for irrigation scheduling to avoid soil compaction. More accurate crop monitoring techniques are critical to the long term sustainability of the cotton industry. It is therefore important that cotton growers aim to maximise water use efficiency through timely irrigation decisions.

Crop monitoring from satellite image data - looking back

The launch of the first satellite of the Landsat series in 1972 marked the start of an era of change for agricultural information gathering. Early Landsat imagery research was focused on crop identification, estimating crop acreages and yield forecasting (4). These data are now used by governments and marketing bodies to gain information for commodity markets on crop inventory. However, the most common applications of remote sensing in Australia are in resource monitoring, not agricultural production (5). Whilst the information is of interest to farmers and agronomists, they have a very different need for operational management. They do not need imagery to identify the crop type and estimated acreage. A farmers question may be; 'of the 500 hectares that need to be irrigated, which fields should be irrigated next?' These farmers therefore have a need for information in real time if they are going to use imagery of their fields in day-to-day management decisions. Satellite and infrared photographic imagery cannot do this, but airborne video imagery has been proposed as an image source which can be used in real time.

Crop monitoring - and the role of remote sensing

In Australia, farmers and agronomists have had to learn to make decisions in an extremely variable environment. Historically, the decisions were based on subjective information learnt by experience. The introduction of quantitative crop monitoring techniques has enabled the decision making process to become quantitative. These techniques to measure physiological parameters include; the monitoring of soil moisture status using a neutron probe, and soil, leaf and petiole nutrient testing.

One of the problems with current monitoring techniques is that they involve a few point measurements (usually 3 points in 100 ha) of typically large and variable fields. Practicalities will always limit the sample size; however, by addressing the issue of spatial variability within fields, current monitoring techniques can be improved by monitoring crops in more representative areas. Research agronomists also constantly face the problem of spatial variability and plot location and the remote sensing techniques offer the opportunity of selecting representative sites.

Airborne video data - for monitoring cotton

Airborne video remote sensing involves the acquisition of imagery using a light aircraft and commercially available video cameras and recorders. The system devised by Button and Cull (2) uses three black and white video cameras, each filtered in different wavebands of the electromagnetic spectrum (ie. green, red, and near infrared bands) mounted on the door of a Cessna 182 aircraft. In addition to these cameras a thermal infrared camera measures the canopy temperature in degrees celsius. The plane is flown over the cotton fields to collect imagery at a height of approximately 1770 metres AGL giving the system a ground resolution of 1-5 metres. Data are recorded onto four separate super VHS video recorders inside the aircraft cabin. Upon landing the images are viewed on a monitor and any particular field of interest can then be transferred to a computer using a video frame grabber and stored for image processing. The images presented in this paper are single channel grey scale which can be pseudo coloured for ease of viewing. A review of airborne video systems can be found in (3).

Airborne video imagery offers several advantages over the use of satellite imagery. The most important being the availability of imagery in real time. Other advantages include; finer spatial resolution and the operators ability to determine the day and time of image collection which is important for crop stress detection.

An airborne video image of one cotton field (60 ha) in the green band (Fig 1.) highlights differences in the colour of the canopy and soil background effects. The red band (Fig 2.) highlights areas of waterlogging. Here the the plants have reduced chlorophyll concentrations in the canopy which the red band is sensitive to. This is indicative of a longer term problem as oppossed to a short term water stress.

Figure 3 shows an image in the near infrared band, therefore it is sensitive to cell structure and percentage cover of the crop canopy. The dark areas represent low canopy coverage (low potential yield) through to the light areas which are areas of high canopy coverage (high potential yield). The most striking characteristic of the image is the amount of variability within the field. Other features of interest evident in the image include; waterlogged areas (dark) and wheeltrack compaction (vertical striping). Figure 4. shows the same field in the thermal infrared band which is sensitive to any factor causing crop stress. Water stressed areas show a higher temperature (dark strips) in the thermal band which are not apparent in Figure 3. This highlights the importance of multiband imagery.

Researchers can locate research plots exactly on the images and it is possible to examine plot location effects and the variability within plots. Therefore images offer to researchers a means to quantify variation spatially to improve experimental design.

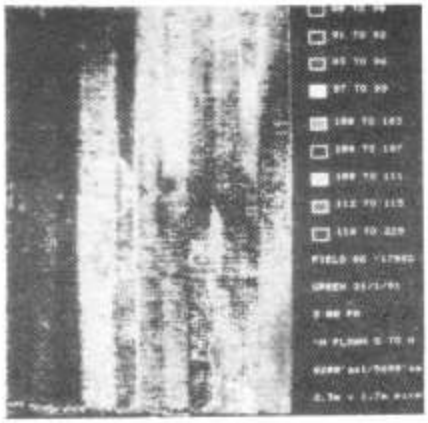

Figure 1. Green

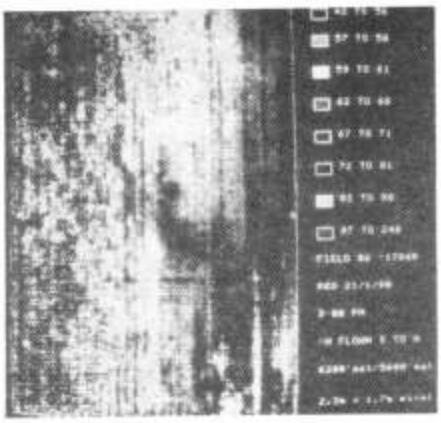

Figure 2. Red

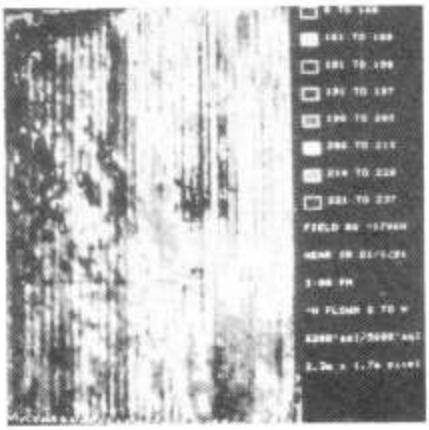

Figure 3. Near Infrared

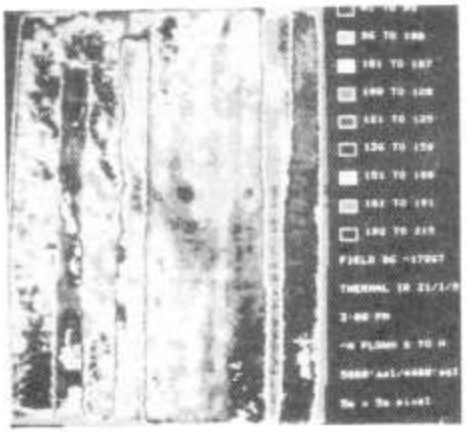

Figure 4. Thermal

Conclusion - towards 2000

Airborne video imagery offers the potential to improve farm management decisions in an operational cropping environment through timely provision of imagery to monitor spatial variability within and between fields. This paper gives an example of the potential use for cotton crops, however the same principles could easily be applied to other high value agricultural crops and agronomic applications.

Planning ahead for the future, a possible crop monitoring service will involve imagery being collected by aircraft over an irrigation valley. Such imagery would be processed and then sent along the phone line to a farmers computer. The manager would look at the imagery on the computer, then go out and check representative areas of fields before making the management decision.

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