AIRBORNE MULTISPECTRAL IMAGING AND PRECISION FARMING - THE SOUTH EASTERN AUSTRALIAN EXPERIENCE

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Abstract

Since 1994 Charles Sturt University's multispectral airborne video system has acquired over a thousand images of dryland cereal crops in the Riverina region and across three states of Australia. Metre-resolution colour-infrared images of crops, taken at appropriate stages of crop development, can be an important tool in assisting crop managers with the strategic management of within-paddock variability. With the recent introduction of precision farming technologies into Australia, crop managers are requiring information within a single growing season to supplement annual yield data to improve the yield profile of paddocks. Colour-infrared imagery is a useful indicator of plant vigour, and enhances contrast between plants and the background of soil or stubble. Imagery has proven useful in directing soil sampling and crop monitoring, and in evaluating the pressure of weeds. This paper summarises our experiences to date of using multispectral imagery of dryland crops to monitor variability at various stages of crop development.

Key words: Airborne multispectral imaging, remote sensing, crop variability, precision farming.

With the introduction of precision farming technology, crop managers can quantify and consider crop variability both within a single growing season and in the longer term. Yield maps help guide a farmer when sampling paddocks after harvest to ascertain causes of yield variability. Accurate profiles of paddock perform-ance will come from yield data, acquired over many years to account for seasonal variations and crop rotat-ion. However, near-real-time monitoring of "transient" crop variability particular to a given season requires more timely information.

Healthy vegetation reflects approximately five to eight times more sunlight in the near-infrared portion of the electromagnetic spectrum than in the visible wave-bands. Near-infrared imagery of vegetation is ideal for monitoring plant vigour. Often small spatial variations in crop vigour can be observed in near-infrared wavebands and not in the visible wavebands. Further-more, plants exhibit signs of stress sooner in the near-infrared wavebands than in the visible.

Airborne near-infrared imaging of crops at various stages of crop development can provide important spatial information concerning the establishment and development of crop plants. In most cases this spatial variability is mimicked in the yield profile of the crop. Like yield maps, colour-infrared imagery will only indicate symptoms and their location, but this informat-ion can be acquired at any time or frequency and, most importantly, it can be cost effective.

Material and methods

Charles Sturt University's four-camera airborne video system (ABVS) acquires digital images in four wavebands (blue, green, red and near-infrared) (3). Carried in a light aircraft, the ABVS provides an image coverage of between 24 and 200 ha, depending on aircraft altitude, with a corresponding ground resolution of between 0.7 and 2.0 m respectively. The composite digital imagery is processed using the same range of computer image processing hardware and software typically available for analysing satellite imagery.

Results and discussion

Since 1994 the ABVS has acquired over a thousand images of dryland cereal crops for use by researchers, farmers and agronomists. Our experiences with imagery of these crops have shown imagery to be useful: (i) between sowing and two-leaf; and, (ii) two-leaf and flowering.

Sowing ? two-leaf

Immediately after sowing, and providing stubble is not a significant ground cover, imagery of fields will often indicate regions of differing soil type or condition. For example regions of heavy clay can usually be discriminated from those of lighter soils. Dalal and Henry (1) have demonstrated the potential of using multispectral information to estimate soil organic matter content. In a season where soil characteristics are a significant influence on the yield profile, soil variability information can be "subtracted" from the canopy variability in the search for other causes of variability.

It is not possible to see the crop plants from the air until approximately 4-5 weeks after crop emergence. Any weed patches, which often appear in the row spacings, are discernible against the soil or stubble background. This allows for the detection of weed patches as small as one-half the spatial resolution of the sensor (in this case as small as 0.13 m^2). Accurate maps showing the extent and distribution of weeds in a crop or fallow field are useful for managers assessing the efficiency of current weed management strategies or the spray requirements of a crop. Maps are also essential for studying weed population dynamics, and more recently for the control of GPS-equipped automated weed spraying systems (4). Lamb and Weedon (2) have assessed the accuracy of weed maps generated against a soil or stubble background using multispectral imaging.

Variability in crop establishment is detectable approximately 4-5 weeks after sowing, unless stubble is a confounding factor. This information provides a useful early indication of the poorer performing sections of a paddock for follow-up soil-sampling (nutrition and moisture).

Two-leaf ? flowering

Because near-infrared imaging provides improved contrast between vegetation and soil or stubble, it is an important aid in delineating relative amounts of plant biomass in an established crop. Generally, the influence of plant disease, pests, nutrition and available moisture will all effect plant biomass, leaf spectral characteristics, or a combination of the two. These symptoms are detectable in colour-infrared imagery and specific examples have included using the ABVS to assess rodent and hail damage, the effectiveness of top-dressing, and evaluating liming, nutrient, tillage and seeding trials.

The conditions for weed detection change once crop canopy begins to obscure the soil or stubble background; weed detection now requires a spectral difference to exist between the weed and crop. Our experience has shown this to occur to a greater extent with weeds of vastly differing physical characteristics compared to the background crop. This includes detection of broad-leaf weeds in cereal crops, grass weeds in broadleaf crops, and weeds that are flowering.

Conclusion

A multispectral colour-infrared imaging system is being successfully employed over dryland crops to assist researchers, farmers and agronomists in monitor-ing crop variability in near-real-time. Imagery has proven useful in delineating variability in crops during establishment and throughout their development; it is a useful aid in smart sampling and targeted management.

References

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