Remote and in-crop sensing: Adapting to change

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Key Findings/Take Home Messages:

In crops and pastures:

1. Active optical sensors (AOS) are sensors that contain their own light source; they can be used under any conditions (day, night, cloud etc). Note that water on the surface of leaves (eg heavy dew, rain) has been reported to influence sensor response. AOS are currently limited to a maximum sensor-target distance of < 5 m.
2. AOS are an effective photosynthetically-active biomass (PAB) assessment tool (cereal crops: emergence – head fill; pastures: 0 - ~3000 kg DM/Ha).
3. Users are unlikely to get an absolute calibration applicable between sensor response and biomass for all times and all plants but AOS are good for day-by-day calibration and/or extending a few point measures to extensive surveys.
4. AOS as point-sensors can be used to calibrate remotely-sensed imagery allowing users to convert an NDVI (or PCD- simple ratio) image to a map of PAB.
5. AOS can be used with GPS/dataloggers to conduct field surveys of PAB in crops and pastures. Recent tests have been completed with sensors mounted in a low-level aircraft.
6. Pasture PAB maps can be augmented to get an insight into pasture quality by using 3rd-party indicators- eg GPS livestock tracking, EM38.
7. GPS cattle tracking in pastures shows a diurnal variation in grazing behaviour- with peak morning and afternoon grazing windows that can be linked to digestibility and be a valuable tool in understanding biomass and nutrient pathways during grazing.

Introduction/Background:

Airborne and satellite images offer a synoptic view of agricultural fields and can be readily converted into maps depicting indices (eg NDVI or PCD/simple ratio) that are related to PAB. However acquisition of satellite and airborne imagery is limited by cloud cover and/or availability of platform when suitable operational windows occur (eg crop stage, availability of ground staff to coordinate calibration, plant cuts etc). Moreover, the data are un-calibrated, and application of imagery to change detection is limited to qualitative assessment. AOS can, by their definition, be operated irrespective of illumination conditions (including day/night). They can be used as hand-held optical sensors for PAB assessment or collection of calibration data for remotely-sensed imagery, or can be integrated with other on-ground sensors (eg EM38) configured with GPS/dataloggers to measure and map PAB in their own right.

This presentation summarises a number of applications of AOS, as well as other sensors currently being investigated by the Precision Agriculture Research Group at UNE.

Presentation Content:

<u>General- AOS</u>

- AOS are 'active' because they emit their own light and use detectors to sense the reflected radiation from this light.
- AOS generally use pulsed light sources and 'synchronous detection' to allow them to select out the reflected light from their integrated source against the background light (Figure 1a). This enables them to be used under any (including varying) light conditions.
- The AOS' radiation reflecting back off a plant will vary with distance to plant (inverse square law) hence the AOS rely on band ratios (eg NDVI) which (over a fixed range) will be invariant. However, accessing the raw, single-band reflectance data provides an opportunity to employ AOS as a proximity, as well as PAB sensor.

- AOS' can be used for manual sensing, or mounted on ATV's and even low-level aircraft (Figure 1b-d)

(a) Photograph of the CropCircle (red) AOS showing pulsing LED's located in the top of the detector head (note, only *red* radiation emitted by the LEDs is visible) and dual photodetectors below.

(b) Manual deployment of an AOS for estimating biomass

(c) ATV-mounted AOS (with GPS and datalogger) for on-the-go surveying.

(d) AOS deployed on low-level aircraft for mapping PAB

Figure 1.

Application to Pastures

- AOS are being trialed to calibrate CSIRO's Pastures From Space (PFS) pasture growth rate (PGR) algorithms for perennial pasture systems on the Northern Tablelands of New South Wales as well as for generating high definition biomass maps in their own right.
- The relationship between pasture biomass in kilograms of dry matter per hectare and CropCircle generated NDVI shows the NDVI 'saturates' for values greater than ~0.45, corresponding to dry matter values in excess of 3000 kg/ha- effectively setting an upper limit on biomass estimates. From 0-3000 kg/Ha, the measured dry matter explains in excess of 70% of the variance observed in the optical response.
- We are also augmenting the basic AOS PAB data using the diurnal grazing behavior extracted from GPS cattle tracking collars to see if we can infer indicators of pasture quality. GPS tracking logs show a clear diurnal trend with peak morning and afternoon travel cycles

(PMG, PAG) (Figure 2). Other researchers have indicated (based on manual observational work) 'unforced' travel distances > 250 m/hour correlate with grazing behaviour.

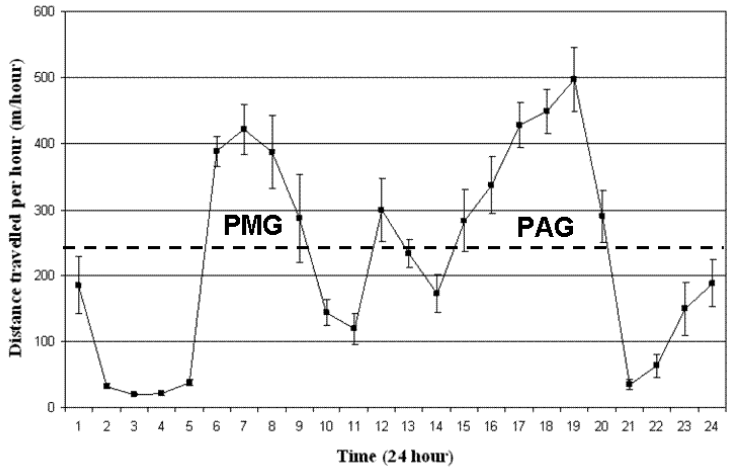

Figure 2. GPS position logs (10 minute sampling interval) converted to travel distance and distances traveled in each hour averaged over 6 collars and 14 consecutive days (error bars ± 1 SD).

Application to crops

- Work is underway to calibrate AOS data (CropCircle) for use in manual crop evaluations (Figure 1b); specifically PAB and crop height up to head-fill stage, and to apply the AOS response versus PAB or crop height to calibrate airborne/satellite imagery.
- An example of crop height calibration data for Triticale at late-tillering and grain-fill is given in Figure 3.
- The AOS response varies with phenological stage (especially during senescence) however at any given time, the underlying plant height explains >80% of the variance observed in the AOS response.

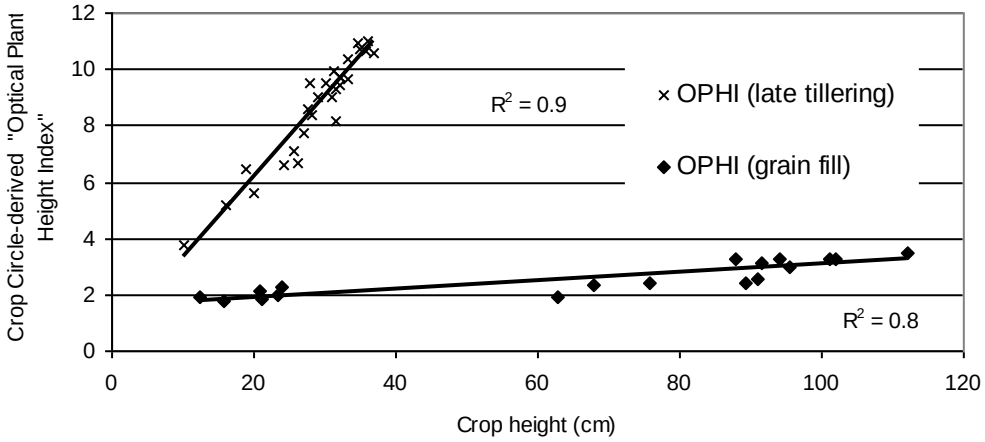

Figure 3. AOS (CropCircle)-derived plant height for Triticale at 2 stages of development.

- Calibrated biomass maps (at anthesis), coupled with yield monitor maps provide harvest-index maps.
- Work is now in progress to test an AOS on a low-flying fixed-wing aircraft (Figure 1d) to generate full-field maps of PAB.

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NOTE: use of commercial product trade names, for example CropCircle as an example of an AOS, does constitute an endorsement of these particular products.

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