ABSTRACT

Through a review of the literature it is apparent that many of the generic methods and techniques which will be so valuable to the efficient implementation of precision agriculture farming systems are being developed for other agricultural crops and will be largely transferable with little alterations and applied to cotton management. Foremost amongst these are the engineering processes and tools required to perform such machinations as the variable rate application of fertiliser, seeds and pesticides.

Elements of weakness within a precision agriculture management cycle for Australian cotton farming systems are identified. These primarily included the lack of knowledge of within-field variability of cotton yield upon which an estimation of the typical variability could be based. Were it available, this typical variability would then be used as a measure of the opportunity for potential adoption of precision agricultural management techniques.

As a first stage towards the characterisation of within-field cotton yield variability, the accuracy and precision of proximal cotton yield monitors were evaluated both through a review of literature and field research. Results of this study indicate that the RMSE of proximally sensed yield estimates are relatively large (~10%) for small sample sizes (~5kg) through to samples of around 16kg where it reaches an RMSE of approximately 3%, which is maintained as the sample size increases. This larger variability in the error of the smaller samples is most likely due to sensor precision errors rather than bias errors. Subsequently, a suitable method of reducing this error effect was developed and involved "two dimensional block" averaging of a number of neighbouring instantaneous yield estimates. It was recommended that the ideal block size would be dependant upon cotton yield but would typically measure five metres by five metres for most Australian irrigated cotton (average yield of 8 bales/ha).

Remote sensing, from both a satellite platform and an aerial platform, were investigated as alternative sources of within-field cotton yield estimates. Using Landsat-7 TM data it is possible to generate reliable and relatively accurate yield estimates (plus or minus 1 bale/ha at one sigma). Yield estimates based on aerial NIR chemical film images were of minimal value due to camera calibration problems. Subsequently, it was concluded that the high integrity

reflectance data available from remote sensing satellites such as Landsat-7 TM appears offer a greater opportunity to the cotton industry in the short term than does remote sensing from aerial platforms. The availability of a calibrated and reliable sensor in an aerial platform would however change this situation by delivering a higher spatial resolution and more temporally flexible product than that available from satellites.

A comparative study was conducted between the information contained within datasets generated from proximal yield measurements blocked using Kriging to 25m and 625m and yield estimates generated by transformation of remotely sensed Landsat-TM imagery. The results of this study were that the proximally sensed yield data sets described a greater range in variability of yield (0 to 14 bales/ha) to that predicted from remote sensing (4 to 9 bales/ha) and described larger yield variability (*structure C*) than did remotely sensed yield estimates. Despite this, both methods predicted similar ranges of spatial dependence and produced qualitative yield estimate maps when viewed at an equal resolution of 625m² (0.006 ha).

A study aimed at characterising the variability in a typical cotton field involved the analysis of 273 cotton fields covering ~27,000 ha across three major production valleys. Analysis indicated that for the 1999/2000 cotton season, the average cotton field yielded 6 bales/ha and was likely to vary by as much as ±1.6 bales/ha over a *range* within the field of ~270m. A similar study investigating the temporal stability of spatial structure within the same three fields over an 11-year period concluded that although the magnitude of yield variability between seasons was large, the *range* that this spatial variability occurred over was relatively stable.

Investigations into the spatial variability of lint quality traits and plant establishment and growth structure (plant height) within fields measured significant variability for plant properties and cotton quality traits. In particular the plant height vs. turnout/length parameters indicated that opportunity exists to manage fields differentially based on soil type delineated zones where water holding capacity and yield potential are incorporated into decision making processes such that the local stem elongation growth rates and thus ultimate plant height are managed to maximize yield and quality.

Investigations were made into the spatial variability of soil properties in Australian cotton fields. These involved the sampling of soil to 900 mm depth at numerous locations within a field and subsequent analysis of samples to determine soil physical and chemical properties. Variability was described using both spatial and non-spatial statistical techniques with the soil physical properties such as PSA and the soil chemical properties CEC and pH showing evidence of clear spatial trends. The ability of bare soil surface colour to indicate these soil properties and the potential application of potential management classes derived from the soil surface colour were investigated. Successful results from this method of defining potential management zones included soil texture, pH and CEC. These relationships were analysed to estimate the management gain that would result from soil surface colour based management zones for potential variable rate irrigation and for variable rate fertiliser with both methods producing a theoretical improvement in management efficiency. Analysis of a correlation matrix composed of all measured soil and crop properties identified the greatest correlation between soil texture, CEC, Θg, plant height and cotton lint yield.

The temporal stability of cotton yield shapes within a field was investigated through the analysis of 11 years of consecutive cotton crops for three neighbouring fields in the western Gwydir valley. Analysis indicates that the fields described in this study exhibit a strong degree of temporal stability. Following an assumption that 11 years of consecutive yield estimates, when clustered, will produce temporally stable yield regions, the generation of cluster maps using 6 years or more will generate yield regions which may be expected, with a high degree of confidence, to closely match those of the temporally stable 11-year estimates. Further analysis indicates that water management from year to year (dryland vs. irrigated) will have significant effect on the yield magnitude and spatial pattern of yield within the fields. The improvement on the stability and efficiency of generating potential management zones using data sets comprised of years with exclusively dryland or irrigated management was investigated for each field. These analyses resulted in the number of years required to generate a stable yield map falling from 6 years to 2 or 4 years for dryland and irrigated management types respectively.