
Summary

Since the early 1960s, global agricultural output has increased at rates and to levels that are unprecedented in human history. Much of the productivity increase is attributed to the breeding of high-yielding crop varieties, intensive use of inorganic fertilisers and pesticides, expansion of irrigation and capital-intensive farm management. However, over the last few decades the euphoria surrounding this 'Green Revolution' has subsided, due to a growing community awareness of the long-term environmental consequences of these practices. Since then, agricultural research has expanded its scope to include sustainable and resource-efficient cropping systems and farm management practices.

A major issue facing the cotton industry in Australia is the potential for surface and groundwater contamination from the inefficient application of nitrogenous fertilisers. This dissertation appraises the merits of applying site-specific nitrogen management to irrigated cotton in Australia, as this system has been hypothesised as being economically and environmentally more sustainable than the traditional 'blanket' approach to the application of crop production inputs. Site-specific crop management (SSCM) utilises new technologies such as the Global Positioning System (GPS), yield monitors, orbital-satellites and variable-rate crop applicators to identify within-field crop and soil variability as well as their causes. The rationale behind SSCM is 'by identifying within-field variability in crop and soil attributes and their origin', it then becomes possible to optimise crop production inputs such as pesticides and fertilisers on a point-by-point basis. Implicitly, this lowers the potential for their over- and under-application.

A review of the scientific literature in Chapter 2 discusses how existing cotton nitrogen recommendations have been derived using field experimentation. It identifies a number of variables that impact on the nitrogen requirement of the cotton plant and highlights a number of inadequacies with the current recommendations due to their failure to consider spatial variability. The different scientific techniques that are required to derive site-specific nitrogen recommendations are reviewed as well as the progress that has been made in introducing site-specific nitrogen management to other cropping systems around the world.

Chapter 3 reviews the scientific literature on the use of model-based decision-support to aid in the nitrogen management of cotton. Field-scale empirical and

mechanistic simulations models which have been developed in Australia and around the world specifically for cotton are described. The strengths and weaknesses of each model are assessed. A number of issues regarding the future application of these models as a tool for the derivation of site-specific fertiliser rates are raised.

Chapter 4 provides an introduction to the data sets at each of the research sites and describes the methods employed to collect them. Classical statistical techniques are utilised to determine the extent of yield and soil variability in uniformly managed cotton fields. This study indicated that there is substantial variation within irrigated cotton fields and consequentially, current uniform nitrogen applications are highly inefficient.

Chapter 5 examines the creation of soil fertility maps for the continuous spatial application of nitrogen fertiliser. Archetypal spatial interpolation techniques, such as inverse-distance weighting and kriging, are compared to stochastic simulation for the spatial interpolation of the soil nitrate data sets. The prediction errors were found to be similar for each of the methods tested and were too high for site-specific fertilisation purposes. Stochastic simulation does offer an opportunity to deal with this error by providing a realistic representation of the spatial uncertainty.

Chapter 6 investigates the suitability of using multi-spectral satellite data, as a quick and cost-effective method, for identifying management zones for the variable-rate application of agricultural inputs. There is statistical and agro-economic evidence presented that this technology is suitable for differentiating soil types within Australian cotton fields. Soil testing demonstrated that these zones represented suites of different soil characteristics that would more than likely be amenable to some form of variable-rate management.

Field-scale on-farm experimentation is used in Chapter 7 to compare two methods for applying variable-rate nitrogen fertiliser with the current uniform management systems. These experiments identified some clear deficiencies with the current advisory methods used to estimate uniform nitrogen application rates. Although yield increases were not detected by either variable-rate strategy, there was considerable evidence to suggest that site-specific fertilisation will bring economic and environmental benefits over conventional management once appropriate recommendations have been derived.

Chapter 8 examines the attunement of the OZCOT model for site-specific nitrogen management. The testing of this model at two of the research sites produced disappointing results. In both fields the model displayed very little sensitivity. A number

of problems are identified that require addressing before the model can be applied at the with-field scale. Most notably, deficiencies were identified with the current nitrogen model in OZCOT, as it is too simplistic, and concerns are raised about the model's failure to consider soil water movement above and below the root-zone.

Chapter 9 is a brief general discussion that reiterates the main points that were discussed at the end of each of the research chapters. Conclusions to the project aims are also given as well as the future work that should be undertaken based on these findings.