Increasing Productivity of Southern High Rainfall Cropping Systems

**Summary**

A 'Best bet' production package was published, launched and distributed in 2002 ahead of research conducted in collaboration with the Department of Agriculture Western Australia (DAWA), Landmark, grower representatives and CSIRO. Trials in 2001/2002 identified major soil constraints to crop production as low and/or unavailable soil nutrition. In 2003, results showed waterlogging, which resulted in nutrient losses, is also a production constraint in this environment. 2003/2004 trials showed that crop yields can be increased by 60% by applying nitrogen (N) to match the high rainfall received and address the effects of waterlogging. Factors with major impact on crop yields and farm viability are contained in 'Production package for high rainfall cropping systems', published 2005.

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Conclusions
The project successfully integrated researchers, extension officers and growers into a local working group that made well-informed decisions on gaps in knowledge about cropping systems in the high rainfall zone (HRZ) and research needed to fill those knowledge gaps. Much of the research was undertaken as farm-scale trials with grower implements but new concepts were first tested as small plot research trials. The project identified major gaps in knowledge relating to subsoil constraints and soil fertility and their impact on crop yields. Variety evaluation, disease (root and foliar) and insect management, crop canopy management, moisture conservation tools and wide-row spacing for lupins were also investigated. The project had success in demonstrating yield increases in cereals. Yields of lupin and canola proved less predictable.

In 2001, increasing crop nutrition increased barley yields by 10% over grower yields. In 2002 similar results were achieved in farm-scale trials, with wheat yield potential achieved, resulting in grain yield increases of up to 60%. In 2003, including deep ripping and lime application in farm-scale trials improved barley yields by 68% over the grower practice. In the period 2001 to 2003, applying N ‘tactically’ after major rainfall and waterlogging increased wheat yields by 60% compared with up-front application of N. Applying the same principle in farm-scale trials in 2004 increased crop yields by up to 75% over the grower practice and 100% over controls. The detail of this research and the yield increases achieved are included in the booklet ‘Successful cropping in the High Rainfall Zone of Western Australia’. This is a summary of all research undertaken during the project and provides a valuable reference for anyone interested in agronomy including growers, farm advisers, extension officers and research officers.

Yield improvements through the use of findings from projects like these will continue as cropping in the HRZ gathers momentum. Higher-input management options need to be accepted and used by growers, as evidenced by 2005 plant analysis results from fertiliser company CSBP showing the Kojonup and West Arthur shires have the lowest levels of in-crop N in WA. Uptake of improved fertiliser management based on our findings is widespread in these two shires. There is scope for cropping in the HRZ to increase in the future providing grain prices do not drop more than 27% and returns from animal enterprises continue to be low. Economic and risk analyses indicate that for a range of grain and wool prices, profitability is maximised if 20% to 40% of the farm is cropped in rotation with annual and perennial pastures. This equates to 2.1 million hectares (ha) that can potentially be profitably cropped: an increase of more than 50% over the 864,000ha that is presently sown to annual grain crops in this zone each year. If changes in climate continue the HRZ will become more significant as a cropping area and research to improve crop yield and grain quality in this zone must continue. The reliable rainfall has seen land values increase by 26% in one year in the Kojonup shire.

Recommendations
Knowledge and planning are pivotal to ensuring viable cropping in the HRZ. The likelihood of high yields should be maximised through adoption of a ‘package’ that includes selection of well-drained soils with at least 50cm rooting depth, increased nutrition and management of root diseases through grass weed control prior to the crop and crop rotations,
control of leaf and root diseases and selection of crops and varieties with tolerance and/or resistance to diseases and appropriate phenologies. However, this project has identified that more than this 'package' is required to approach potential yields, with the principal constraints of transient surface and subsurface waterlogging, limited availability of nutrients, soil acidity and limited root penetration into clay subsoil all needing investigation. Along with CSP302, this project has identified that transient sub-surface waterlogging may reduce wheat yield by 2t/ha in 50% of seasons. This project has identified that the detrimental effect of waterlogging can be partially eliminated by tactical management of nitrogen. Wheat yields can be 60% greater in crops in which N is applied according to soil and weather conditions than in crops receiving the same amount of N but with all of it applied ‘up front’ at seeding.

Outcomes

The findings from this research have helped raise the overall productivity of farming enterprises in the HRZ by encouraging the incorporation of a profitable cropping enterprise into farm businesses that had previously produced mainly animal products.

Economic and risk analyses indicate that for a range of grain and wool prices, profitability of farming enterprises in the HRZ is maximised if 20% to 40% of the farm is cropped. This allows up to one third of the farm to be cropped in rotation with annual and perennial pastures, suggesting that in the HRZ, 1.2 million ha can be cropped annually. This represents about a 50% increase in the area of annual crops.

Transient sub-surface waterlogging may reduce wheat yield by 2t/ha in 50% of seasons as a result of reductions in the number of fertile ears. The detrimental effect of waterlogging can be partially eliminated by tactical management of N. When N is timed according to soil and weather conditions, wheat yields can be 60% greater than in crops receiving the same amount of N but with all of it applied ‘up front’ at seeding.

A baseline study undertaken as part of this project showed that growers in the HRZ applied 50-70kg/ha of N for wheat, canola and barley. This is only about half the N requirement for a targeted yield of 6t/ha of wheat or 3.5t/ha of canola. Barley yields were increased by 68% over grower practice by application of a ‘package’ comprising increased nutrition, deep ripping and lime application.

High crop yields are possible but need higher inputs. If crop yield potentials are reached, the high-input packages are very profitable.

Achievements/Benefits

The HRZ covers about 4.8 million ha of land, approximately 3.7 million ha of which is freehold land used for agriculture. At present, about 864,000ha - about 18% of the total land base or 22% of the cleared area - is sown to annual grain crops in the HRZ each year. It is estimated that about 50% of land in the western half and 70% in the eastern half of the HRZ is potentially suitable for annual cropping. This is equivalent to 2.1 million ha. Economic and risk analyses indicate that, for a range of grain and wool prices, profitability is maximised if 20% to 40% of the farm is cropped in rotation with annual and perennial pastures, suggesting that in the HRZ, 1.2 million ha can be cropped annually. This represents an increase of about 50% in the area for annual cropping.

This project was designed to raise overall farm productivity by assisting the incorporation of profitable cropping enterprises into farm businesses that had been predominantly producing animal products. Growers in the HRZ have an advantage over their counterparts in traditional cropping areas because the higher rainfall (450-700mm) and longer growing season mean they have potential for higher crop yields than growers in low and medium-rainfall zones. Estimated potential yields in the HRZ are between 4.5t/ha and 8t/ha for cereals and 3-4t/ha for canola. Unfortunately, current crop yields are only about half that potential, averaging 2.7t/ha for wheat, 2.4t/ha for barley and 1.4t/ha for canola from 1996 to 2001. This shows there are good opportunities to lift crop yields in the HRZ.

In nearly all cases this yield potential is not realised for several reasons including poor soil drainage, inappropriate management of rotations, inadequate weed control, poor nutrition, insects and diseases, sowing time, seeding rate and poorly-adapted varieties. Interest in cropping in the HRZ has increased dramatically over the past decade so it is more important than ever to get the most out of the resources of land, labour and capital applied to cropping in this high-potential environment. The key is to develop a sound knowledge of the cropping systems that fit into the zone, their limitations and the most sustainable long term practices.
Major achievements of this project include a published report of previous work carried out by grower groups and research organisations in the western region. The review on which the report is based identified that the appropriate combination of high yielding crop varieties and good management can maximise potential yield in the HRZ. This review, plus local working group meetings, identified major gaps in knowledge about subsoil constraints and soil fertility and their impact on crop yields. For example, although nutrition had been previously investigated, the availability of nutrients in no-tillage and/or deep-banding fertiliser situations needed investigating. The report showed that in the HRZ, growers applied 50 to 70kg/ha of N for wheat, canola and barley. This is only about half the N requirement for a targeted yield of 6t/ha of wheat or 3.5t/ha of canola.

Small plot and farm-scale trials in 2001 and 2002 showed that yields can be increased with increased nutrition in no-tillage, deep banded situations. A small plot nutrition trial using Gairdner barley in 2001 at Arthur River showed that increased nutrition - 103.8kg/ha of N, 23.5kg/ha of phosphorus (P), 37.1kg/ha of potassium (K), 8.8kg/ha of sulphur (S), 0.58 kg/ha of copper (Cu), 2.73kg/ha of zinc (Zn) and 0.522kg/ha of manganese (Mn) - increased grain yields to the rainfall-limited yield potential of 5.6t/ha (growing season rainfall of 292mm). In 2002, results from six farm-scale nutrition trials showed that, for wheat, the highest profits were achieved with a complete fertiliser strategy (I47 N, 49 P, 50 K, 23 S, 42 calcium (Ca), 1.5 Cu, 1 Zn, 4 Mn, 0.7 molybdenum (Mo)), with yields reaching 5.2t/ha at Boyup Brook (Hill et. al. 2005b).

The subsoil constraints of pH and compaction on grain yield revealed were also investigated in a farm-scale trial in 2003. A combination of increased nutrition (95 N, 45 P, 90 K, 22 S plus trace elements), deep ripping (to 40cm depth) and lime (2.5t/ha) increased Gairdner barley grain yields from 2.8t/ha for grower practice to 4.7t/ha, an increase of 68%.

Waterlogging has been regarded as a major limitation to crop production in the HRZ, results from research by the Kojonup Crop Research group before this project began challenge this proposition. The Kojonup group monitored 14 cereal crops on eight farms within the Kojonup area in 1995/96 and found that waterlogging had an insignificant effect on crop yield even though rainfall was near the long term average for both years. However, results from this project (DAW673) show that transient sub-surface waterlogging and/or leaching may reduce wheat yield. CSIRO, as part of a parallel project, found that waterlogging reduced yields by 2t/ha in 50% of seasons as a result of reduced fertile ear numbers. This was investigated further as part of this project, demonstrating that the detrimental effect of waterlogging can be partially eliminated by tactical management of N. A small plot trial in 2003 on a sandy, leaching duplex soil at Cranbrook showed that timing N according to soil and weather conditions can increase wheat yield by 60% over crops in which all the N is applied at seeding (3.5t/ha versus 2.2t/ha). Based on this, subsequent extension activities were aimed at encouraging growers to monitor the amount of water in the root zone (to a depth of 30cm). Grower groups (JRL Hall and Co. farm consultant group and North Kojonup TOPCROP Group) have adopted the practice of using dip wells (open auger holes) to determine how much water they have in the root zone, and most growers are aware that they may be losing water and therefore nutrients out of the root zone (a result of extension activities including field days, Crop Update presentations, AgMemo, Ground Cover and CRIST magazine articles and guest speakers at various grower meetings). Adoption of tactical N will depend on a grower’s ability to incorporate this approach into his existing post-seeding management program, with a capability for tactical application of liquid N (e.g. Flexi N) an advantage. The cost of N has risen by 30% in the past two years, so it is important to understand N in agronomy and to use it effectively.

These are some of the achievements over the duration of this project. A full list of project achievements can be found in our final publication, ‘Successful cropping in the High rainfall zone of Western Australia’, which was published in collaboration with CSIRO (CSP302).

Experiments conducted as part of this project show that the high crop yield potentials can be achieved. Economic and risk analyses included in ‘Successful cropping in the High Rainfall Zone of Western Australia’ indicate that grain prices would need to drop by 27% and 31% to reduce returns from the high-input methods used in these research trials to the level of income from current grower practice. At these levels the grain price would be $110/t and $103/t on-farm, respectively, which are very low grain prices. If 6t/ha can be achieved using the high-input package rather than 3t/ha previously achieved by most growers, the gross margin can be increased by $142/ha - from $200/ha up to $342/ha. There is some uncertainty as to whether 6t/ha can be achieved consistently, but a yield of 5.5t/ha with high inputs would provide the same gross margin as a grower aiming to produce 4.5t/ha using district practice. Growers need to assess or test the likelihood of achieving an average yield in excess of 5.5t/ha when considering the high input packages. At the same time, research needs to continue to determine the probabilities of achieving these yields consistently.

It is assumed that project trial results are being observed and applied by growers and researchers in the other HRZ cropping
zones in Australia. Evidence of the importance of this work can be found in an article in the ‘Countryman’ newspaper (25th August, P 9) in which it is reported that analyses by CSBP Nu logic showed that a large proportion of crop samples taken this season were N deficient. These results show there are areas with more than 75% of plant samples analysed deficient in N. Of all the shires in the cereal growing zones of WA, the Kojonup and West Arthur Shires have the lowest N deficiency in plants, tested at 0-25% deficient; clearly a testament to this research. The fact that 'Tactical N' management is becoming a 'buzz' word, with trials throughout all zones using this method as their management practice, is evidence that researchers are implementing this research.

Other research
Soils in south-west WA are inherently low in pH (4.5 to 5.5 in top 0 to 10cm) and the implications of different rates and timing of lime application on soils in this environment need investigating. What is the optimal time to apply lime in these high-rainfall environments to maximise sustainability? What are the implications of applying lime, particularly with increased rates of N, P and K fertiliser? What will ‘tactical’ application of high rates of N fertiliser do to lime requirement and availability of other nutrients like Cu? Will increasing N for greater yield potentials lead to further reduction in soil pH?
Seeding rates required to optimise light penetration into the crop canopy, ensure adequate root growth and adequate crop competition with weeds without creating excessive canopy need investigation.
Long term trials on the most sustainable and economic rotation are required.
High yielding wheat varieties with appropriate phenologies for the noodle, soft wheat and feed grain markets need investigating.
High value pulse options for niche markets are required for tighter rotations. Species with increased tolerance to waterlogging, salt, frost and acid soil conditions need to be identified and tested for root growth and proliferation and increased grain yield and quality.
Lower average temperatures and higher rainfall than other cropping zones ensure fertiliser requirements in the south-west HRZ are larger, so there is a need for research into stubble management to enhance nutrient release and availability (particularly N) in this environment and under more intense cropping systems.
The performance of foliar application of liquid N formulations compared to granular N under waterlogged conditions and in ‘tactical N’ management needs research. Are nutrient uptake and crop responses different at different growth stages? How much leaf area is required for foliar N uptake? Root health and measures of denitrification and ammonium volatilisation need investigation. Liquid fertiliser application allows more flexibility, greater accuracy in application and placement and reduces volatilisation. In high-yielding crops, late fertiliser application may enable the grower to achieve protein bonuses.
What ameliorants – such as minimum tillage, gypsum application, ‘tactical N’ management, green manuring, raised beds, lime and deep cultivation - can be used to address subsoil constraints in intensive rotations? When should these amelioration packages be applied? For example, when can deep cultivation be performed to maximise crop yields without disrupting the management system? What soil types and topography are most suited to drainage or raised beds?
N fertiliser is a major part of the cost of cereal and oilseeds production. More research must be directed towards basing inputs on target yields and adjusting rates according to seasonal conditions, particularly matching N supply to crop demands. Exact N losses must be determined with economic analysis for maximum sustainability.
Gravel soils that fix large amounts of P need increased P nutrition and are associated with non-wetting conditions. The impact of wetters and different P rates on crop yields needs research.