Soil management in low rainfall farming systems

Summary
The project aimed to improve soil management and sustainability in farming systems within less than 450mm rainfall in the central and south west of New South Wales (NSW) by
i) determining the effects of conservation farming, rotations and fallowing practices on soil fertility and acidity, in conjunction with the Central West Farming Systems (CWFS) group and other groups.
ii) defining the extent of soil acidity and the response of crop and pasture species to liming in this environment.

An acid soils management guide and soil fertility management guide have been produced from the information gained from the project and distributed within the target area.

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Conclusions
These results indicated that lime application in this area may be of benefit to crop and pasture production by amending the acidic properties of the surface soil layer. Additional use of phosphorus (P) and sulphur (S) fertilisers and agricultural practices which increase or maintain organic carbon (C) may also need to be adopted to benefit pasture and crop production. The use of gypsum and/or lime on sodic soils may also need to be addressed in this area. As a priority the benefits of lime application to crop and pasture yields were further investigated. The application of lime to the 0-10cm soil should ultimately arrest acidification of the subsurface soil (10-20cm depth), which has occurred in other areas as the acidification of surface soils progresses. Sodic and dispersive soils are also of concern in this area and these soils have received little attention or research. Further examination of gypsum application to dispersive sodic soils and the evaluation of sulphur deficiency in the field in pastures and canola are also priority areas of likely agricultural relevance. An increase in the level of awareness of soil acidity and fertility management issues through the grower guides will lead to increased adoption of better management systems, leading to a reduction in the rate of decline of fertility in the low rainfall farming regions.

Outcomes
Soil degradation is likely to impact on all crop and pasture species reducing yields in the short to medium term. In the longer term, soil structure and fertility decline place whole farming systems at risk. Acidification would adversely affect wheat, barley, canola and pulse crops, as well as lucerne and annual medic pastures. If these degradation processes are not addressed, yield will decline slowly at 1-2% per year and subsoils will acidify with amelioration of subsoils expensive and protracted. The target area of this project is primarily the red earth and red brown earth soils of the low rainfall areas (<450mm) of central and southern NSW. The area extends from the Bogan River in the north, through Condobolin, Lake Cargelligo and Hillston to Griffith in the south and is greater than one million hectares. Increased awareness through management of acid soils in low rainfall farming systems and central western NSW and soil fertility management in these low rainfall farming systems will lead to increased adoption of better management systems, leading to a reduction in the rate of decline of fertility in this region.

Adoption of improved soil management practices should grow slowly to 30% of land managed more sustainably by 2010. Experience in other areas with similar technology suggests that adoption will be slow as most changes in farming systems require the development of new expertise, capital expenditure and increased inputs such as the application of lime. However, the direct involvement of growers in the project is expected to aid adoption and the benefits are likely to be long term. Better soil management will reduce off-site effects of farming and benefit the wider community through improved environmental quality.

The project has benefited the grains industry by providing guidelines and information on soil fertility management and options available to maintain long term productivity. The soils of the low rainfall wheatbelt are likely to be acidifying, driven
by product removal, organic matter changes and the management and movement of nitrogen. A wide range of agricultural practices will influence nitrogen and organic matter accumulation and depletion, and some include legume pasture phases, long fallowing, tillage and stubble retention. The ‘do nothing’ approach will result in slowly declining yields, possible adverse off-site effects and subsoil acidification.

Achievements/Benefits

Growers expressed serious concern about the maintenance of soil structure and fertility and about declining pH under both current and increasingly intensive farming systems. Limited evidence from a long term trial at Condobolin has shown that intensive cropping can be detrimental to soil structure, fertility and pH. More detailed soil analysis was required to understand these relationships. With this in mind, the project aimed to determine the effects of conservation farming, rotations and fallowing practices on soil fertility and acidity, in conjunction with CWFS and other groups and define the extent of soil acidity and the response of crop and pasture species to liming in this environment.

Paired site sampling at Condobolin was combined with data from Dubbo and Coonabarabran. These three sets of data were used to determine if there are varying rates of acidification due to location (rainfall and climate largely), intensity of agriculture or soil type. The results are published in a paper addressing acidification rates in central-western New South Wales (Vimpani, I., Freebairn, R., Mullen, C., Scott, B.J. and Evans, C.M. (2002) Investigate soil acidification in central and northern slopes of NSW, ASA Research Update 2002). Sampling of the zero tillage, conventional tillage, reduced tillage and perennial pasture plots at the CWFS major site at Condobolin was completed. The plots were sampled to a depth of 90cm with a total of 380 soil samples collected, ground and stored to await analysis by CWFS. One existing (at Condobolin) and four new lime trials (two at Condobolin Agricultural Research and Advisory Station (ARAS) and two in the Parkes area) were established. Lime was applied at a single rate to examine crop performance after liming and if it was economical for pulse crops. A further two lime trials were established in 2002 at Euabalang and Tullamore to investigate the effects of lime rates on large scale cropping systems. These trials have been permanently marked for future use. Sampling of the long term trial at Condobolin has been completed at varying depths for pH change. These results have been used to develop the soil fertility management guideline for growers. The core site was sampled and stored for CWFS. The pH results indicate variation across the trial (attributed to different paddock histories) and may need to be considered when comparing yield data.

The grower guidelines titled ‘Acid soil management in low rainfall farming systems of central western New South Wales’ and ‘Soil fertility management in low rainfall farming systems of central western New South Wales’ have been completed and published as colour brochures. 3,000 copies of each have been produced and distributed to departmental offices throughout central western NSW, mailed out to 1,500 growers in central western NSW and made available at the GRDC Updates at Dubbo, Nyngan and Wagga Wagga in 2004.

General soil results

Surface soil acidity emerged as a substantial problem with 56% of soils having a pHCa less than 5.0. The surface soils of central western NSW have low sulphur (S) (47% of soils had <20 mg P/kg by Colwell method) and sulphur status (70% of soils < 5mgS/kg using KCl-40 analysis) and were low in organic carbon (36% of soils < 1% organic carbon). Most soils had high exchangeable magnesium (Mg) (89% of soils >9% Mg) and potassium (K) (50% of soils >12% K). Approximately 5% of surface soils have an exchangeable sodium percentage (ESP) of 6% (sodic). Salinity of surface soils is of minor significance compared with other soil problems in the area although isolated pockets occur. Only 0.3% of surface soils have salt concentrations where yields of salt sensitive plants may be affected (> 0.1dS/m).

The subsurface soil data indicated that the red soils increased in soil pHCa with depth, generally being acidic at the soil surface and alkaline below 60cm. For the 10-20cm depth interval, 82% of soils had a pHCa less than 6.0 and at the depth interval of more than 80cm, 73% of soils had a pHCa between 7.5 and 9.0. Some soils had an acidic soil profile (pHCa < 5.5) to depth, but these represented only 5% of soils.

The effective cation exchange capacity (ECEC) also increased with increasing soil depth, with Ca, Mg, K, and Na cations contributing to this increase. The Ca:Mg ratio decreased with increasing soil depth which reflected the three-fold increase in Mg and two-fold increase in Ca. At 10-20cm depth, 37% of soils had a ratio of less than two. With each depth interval this proportion increased and at below 80cm depth, 78% of soils had a Ca:Mg ratio less than two. Along with this dispersive trend, sodicity also increased with depth. At 10-20cm, 12% of soils had an ESP more than six. At below 80cm depth, 58% of soils had an ESP greater than six. As there is no well-defined criterion for sodic subsoils, ESP greater than six (used for surface soils) has...
been used as the criterion for sodicity. Using this criterion, over half the subsoils of the red soils of central-western NSW are sodic and dispersive.

Using 0.3dS/m (1:5 soil:water) as the EC where lucerne and phalaris roots may be affected by salinity, less than 1% of soils were above this threshold in the 10-20cm soil. Below 80cm depth, 26% of soils were above this threshold and 19% of soils were above 0.5dS/m.

Liming and pasture/crop responses
Others have established numerous lime trials on the Condobolin Agricultural Research and Advisory Station (ARAS) under both pastures and crops. In the pasture trials, soil pHCa was about 4.8 without lime and up to 6.15 with various lime application rates. There were no increases in dry matter with liming in any pasture mixes containing lucerne, annual ryegrass, various subterranean clover varieties and medics. Cropping trials have examined a variety of crops on similar soils to the pasture trials. Results have shown that in general acid-sensitive species exhibit a response to lime application and this may vary from small yield increases (5%) to large increases (90%) depending upon a combination of species, crop management (e.g. weed control) and the climatic conditions of that year. These yield increases were unexpected as the soils used in the experiments would not be considered to be a ‘problem’ as the Al saturation of the ECEC of these soils was about 1-2% at a pHCa of 4.8. Yield declines in sensitive species are not generally apparent until Al is above 5%.

Long-term effects of liming
A project examining the effect of lime application on pea rhizobia was established in early 1990 at Condobolin ARAS. Varying rates of lime were applied (nil to 4t/ha applied in 1990) and the original study was conducted for three years. The land then lay fallow until 1999 when it was sown to lucerne. In late 2000 this trial was re-sampled within the current project to examine the long term effects of liming rates. Soil pHCa in the unlimed plots in 1990 was pHCa 4.8 and only decreased by 0.05 units in the past 12 years. At the highest lime rate, soil pHCa reached 6.37 in 1990 and had declined to 5.15 by 2001. At the highest rates of lime (3 and 4t/ha) significant soil pHCa effects were still evident 12 years later. At lower rates of lime application there was no significant residual effect of liming.

Agronomic implications
These results indicated that lime application in this area may be of benefit to crop and pasture production by amending the acidic properties of the surface soil layer. Additional use of phosphorus and sulphur fertilisers and agricultural practices which increase or maintain organic carbon may also need to be adopted to benefit pasture and crop production. The use of gypsum and/or lime on sodic soils may also need to be addressed in this area. As a priority the benefits of lime application to crop and pasture yield are being investigated. The application of lime to the 0-10cm soil should ultimately arrest acidification of the subsurface soil (10-20cm depth), which has occurred in other areas as the acidification of surface soils progresses. Sodic and dispersive soils are also of concern in this area and these soils have received little attention or research. Further examination of gypsum application to dispersive sodic soils and the evaluation of sulphur deficiency in the field in pastures and canola are also priority areas of likely agricultural relevance.

Additional information
