Knowledge is power in soil acidity management

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Abstract
Soil acidity affects around half of the agricultural land in Australia. Soils in Western Australia (WA) are commonly acidic with pH below recommend targets of pH_{Ca} 5.5 for topsoil and pH_{Ca} 4.8 for subsurface soil in an estimated 80% and 50% of cases respectively. Use of agricultural lime in WA has increased in the past 20 years, but annual rates of application remain well below the level that has been estimated as required to remediate the problem. Previous focus group workshops with farmers have indicated that economic factors such as costs, returns and cash-flow are the main limitations to farmers' ability to apply sufficient lime. It was hypothesised that approaches to better target lime applications would enable management of soil acidity within the realities of budgetary constraints.

One hundred and ninety-two farmers from grower groups in the Northern and South West agricultural regions of WA were surveyed regarding their current knowledge and practices as part of an interactive project involving the collection of background information, cost-shared soil sampling to depth and follow-up discussion of liming strategies and intended practice. Sixty eight per cent considered that soil acidity is a moderate or greater problem on their farm, while 74% felt that it was manageable. The most common liming practice was a blanket application of 1–1.5 t/ha. Intended soil sampling of farmers from the only grower group to have completed the first two stages of the project, changed significantly with 78% intending to sample both topsoil and subsurface soil, compared with 20% at the preliminary workshop ($P< 0.05$). All reported that additional soil pH information would assist in prioritising liming. These results indicate the benefits of increased soil pH information to target the most important areas for applying lime, and thus address economic limitations, within current financial settings.

Key Words
Soil acidity, pH, agricultural lime, survey

Introduction
Soil acidity is a constraint that affects around half of the agricultural land in Australia. In Western Australia (WA) alone, the impact of lost agricultural production due to acidification has been estimated to cost $400–500 million per annum (Herbert 2009). While the use of agricultural lime in WA has been steadily increasing for the past 20 years, it remains well below the estimated 2.5 million tonnes per annum that are required over the next 10 years to increase soil pH and maintain it at recommended targets (Andrew and Gazey 2010). This short-fall is evidenced by recent analyses of soil samples taken from 39 480 locations on farmers' paddocks across the central WA wheatbelt, which indicated that approximately 80 per cent of topsoil samples and 50 per cent of subsurface soil samples were below recommended soil pH targets of pH_{Ca} 5.5 and pH_{Ca} 4.8 respectively.

Preliminary focus group workshops, involving 24 farmers, conducted in the central and eastern wheatbelt in 2009 highlighted the chief importance of economic factors (costs, returns and cash-flow) in limiting farmers' ability to apply sufficient lime to address the problem (Fisher *et al.* 2010). These findings have been supported by subsequent focus groups workshops, involving a further 37 farmers, in which economic factors (cash-flow, cost of lime, freight) were again identified and ranked as the main limitations to their management of soil acidity through liming. It was hypothesised that approaches to better target lime applications would enable management of soil acidity within the realities of budgetary constraints.

Methods
Survey of farmers
Farmers from the Northern and South West agricultural regions of WA were surveyed regarding their current knowledge of soil acidity and their management of it. Questions were asked regarding the farmers' soil sampling in the past three years, previous use of agricultural liming products, and assessment of soil acidity

as a problem on their farms. Responses from participating farmers were recorded using a mix of media. Questionnaires using the Turning Point Audience Response System, whereby responses to questions are obtained using electronic numeric keypads, were utilised at three focus group workshops. Responses at field days were collected using questionnaires delivered on either iPads or printed sheets of paper. The questions were consistent across the three media types.

The surveys were the first stage of a three-step project involving the collection of baseline information (through the questionnaires), sampling to depth and review of results and intentions and lastly an assessment of impact through any changes to practice. In the second stage soil samples collected from three, ten-centimetre depths (to 30 cm) from a minimum of 30 sites on farm paddocks were analysed for pH. The results of this soil sampling were used to produce individual recommendations for the management of each paddock. These results were presented and discussed with the participating farmers at a second workshop. The farmers were again asked about their intentions regarding soil sampling and to assess the usefulness of the information provided.

The third stage of the project, assessment of any changes in practice, will be conducted in early 2013.

Results

Survey of farmers

Questionnaire responses were received from a total of 192 farmers. The participating farmers completed the questionnaire at soil acidity workshops (52), field days (57) or regional updates (83). They ranged in age from 21 to over 70 years, with the majority (76%) aged between 31 and 60 years (52% 31–50). The area farmed by the participating farmers ranged from 80 to 13 000 ha, with the majority (52%) farming between 1 500 and 5 000 ha and a quarter farming between 3 200 and 5 000 ha. They were thus broadly representative of farmers in WA who have an average age of 53–57 years and farm 3 500– 4 300 ha (ABARES 2012).

Eighty per cent of the farmers had applied liming products in the past three years. Of those who had applied lime, the most common practice was a single rate applied across a paddock, with 1 t/ha and 1.5 t/ha being the most common rates (Table 1). Sixty eight per cent of farmers considered that soil acidity is a moderate or greater problem on their farm, while 74% felt that it was manageable.

Table 1. The rates of lime applied and method of application reported by 192 WA farmers in surveys conducted in 2011 and 2012. As respondents were asked all rates of lime that had been applied, more than one rate per respondent could be reported.

Rate of lime applied (t/ha)	% of respondents	Method of application	% of respondents
0.5 or less	13	Single rate across paddock	80
1	38	Split/patched out	9
1.5	29	Variable rate by management zone	4
2	23	Single rate and split	6
2.5 or more	6	Split application and variable rate	0
		All three	1
		No answer	1

Ninety-three per cent of growers surveyed had taken samples of topsoil (0–10 cm) in the past three years, but only 49% had previously tested pH in subsurface soil (Table 2). Discussion with survey participants indicated that much of the previous subsurface testing had only involved a small number of samples with insufficient samples taken from each paddock to adequately describe variation. In contrast, 60% indicated an intention to sample both topsoil and subsurface soil in the coming year.

Table 2. Soil testing undertaken in the past three years by 192 WA farmers as reported in surveys conducted in 2011 and 2012.

Soil sampling practice	% of respondents
Topsoil only (0–10 cm)	44
Top and subsurface soil (0–10, 10–20 and 20–30 cm)	49
Not sampled in the past three years	6
Never sampled	1

Soil sampling and review of results

One grower group, the Nyabing Farm Improvement Group, has also completed the second stage of the project; sampling to depth and review of results and intentions. Half of the farmers reported that the soil pH results were as expected, while one-third of them indicated that the results revealed a higher pH than expected. The remaining 17% had no prior expectations. All of the farmers indicated that the soil sampling information would assist in prioritising lime application and that soil sampling to depth had given them a better understanding of variability in pH across their farms.

The intended soil sampling of the farmers had changed significantly with 78% indicating an intention to sample both topsoil and subsurface soil, compared with 20% at the preliminary workshop ($P < 0.05$). Ninety percent of the farmers indicated that the workshop had improved their understanding of soil acidity.

Discussion

The results of the farmer surveys indicate widespread acknowledgement of soil acidity as an important constraint to agricultural production in WA. While application of lime has been common, it has generally been used inefficiently, with few areas receiving sufficient lime to recover and maintain soil pH at the recommended pH_{Ca} targets of 5.5 in the surface and 4.8 in the subsurface (Gazey and Davies 2009). It has been calculated that a blanket application of 1 t/ha lime will only supply the correct amount of lime to increase the pH to achieve these targets in 36% of cases (Andrew *et al.* 2011).

Previous results from focus groups have indicated that economic factors such farm cash-flow, the cost of lime and freight costs are limitations to the application of sufficient lime by farmers. In addition, the survey results show that most growers have inadequate information about the pH of their soil profiles to develop a clear picture of the situation and to devise an appropriate management plan.

This equation can be changed through the provision of adequate soil sampling to depth and the use of this information to target applications of lime. The results of the focus group with farmers around the Nyabing area demonstrate the value of additional information regarding the soil pH of farmer's paddocks to enable the development of a long-term management plan targeting the most important areas with adequate lime. The use information on soil sampling to depth enables farmers to better target available lime, which is determined largely by budgetary constraints to areas of greatest need and/or likely responsiveness. In this manner the economic limitation can be addressed within current financial settings.

Conclusion

Soil acidity can be managed and it is profitable to do so. The provision of adequate information regarding soil pH to depth enables better targeted lime applications that can enable management of soil acidity within the realities of budgetary constraints.

Acknowledgements

Our thanks to all of the farmers who responded to the questionnaire and/or participated in the workshops, particularly the members of the Nyabing Farm Improvement Group. Soil acidity research and extension is funded through the Department of Agriculture and Food, Western Australia, the Australian Government's Caring for our Country, and Precision SoilTech.

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