20 years of soil acidity RD and E in Western Australia—what have we learnt?

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Key messages

The severity and extent of soil acidity, including subsurface acidity, has been mapped across the south-west of WA and the current condition and trend are rated as poor.

Growers' understanding of their soil's pH profile is contributing to an increase in the rate of lime applied per hectare and they intend to increase total lime use further. However, the amount will need to be substantially more than their intended 2 t/ha to achieve appropriate pH profiles.

Twenty years of soil acidity research in WA has shown a large range in yield benefits to liming which varied due to severity and depth of soil acidity and the extent to which liming ameliorated the constraint.

An alternative approach is needed by economists, consultants and advisors to promote lime as an essential input because in many cases much more than 2 t/ha is needed to recover the soil profile.

Introduction

The management of soil acidity in south-west Western Australia has been a topic of research, development and extension for more than 20 years. The most recent assessment of the current condition of the soil resource demonstrates that soil pH has continued to decline; more than 70% of surface (0–10 cm) and almost half of subsurface (10–20 and 20–30 cm) samples have pH_{Ca} below the appropriate level of 5.5 (surface) and 4.8 (subsurface) (Gazey et al. 2013). The ongoing acidification of agricultural land is the result of productive farming practices (product removal and leaching of nitrate) in combination with insufficient use of agricultural lime.

This paper presents three complementary pieces of evidence providing confidence to consultants and advisors that managing acidity is a contemporary issue for WA growers and makes economic sense in terms of profitability as well as environmental sense in terms of recovering and protecting the soil resource.

The evidence: i) surveys and workshop evaluations show that practice change is happening, soil sampling and lime use are increasing; ii) analysis of more than 69 long-term lime trials demonstrate long-term responses of 10% greater yield are common; iii) a case study examining response to the application of lime at Mingenew in 1994 shows that rates of lime, previously considered to be adequate, do not ameliorate soil pH to depth.

This information provides compelling evidence that farmers, consultants and other stakeholders need to remain focused on managing this problem, which costs WA agriculture in excess of $500 million per annum in lost productivity.

Method

Grower surveys and workshops

Grower surveys and workshops were conducted 2010–2013 as part of the Caring of our Country 'Improving Soil Acidity Management of >1000 Growers in south-west WA Agriculture' project. A total of 539 people were surveyed from across the WA wheatbelt over half of all respondents were aged between 31 and 50 years and 74% were grain growers. The growers surveyed manage an estimated 1.6 million ha or approximately 15% of the WA wheatbelt. Since 2006, over 600 growers have participated in soil testing to 30 cm in 10 cm increments with costs shared between growers, State and Federal governments. Each participating grower received a soil acidity management plan tailored to their circumstance and group data were used at workshops with the 22 participating grower and agribusiness groups. Amalgamated data were used for state-wide mapping (Gazey et al. 2013).

Analysis of response to liming

A DAFWA database of 69 small plot and large scale lime trials from across the wheatbelt, which includes lime rates and re-liming, lime sources, ripping and lime rates with nutrients, was investigated to determine factors affecting crop response to liming. Soil information and yield were collected over the period 1991–2012 for trials of varying duration and with different start and finish times. Data were organised so that there were 232 data points for which yield at zero lime, minimum yield, maximum yield, pH at zero lime and pH at maximum lime were directly compared. Soil was generally measured at 0–10, 10–20, 20–30 and 30–40 cm which were classified as acidic if pH_{Ca}<4.5.

Long-term response to liming – Mingenew trial 2013

A DAFWA small-plot lime trial was established in 1994 in a paddock near Mingenew, WA. Agricultural limesand was applied at 0, 0.5, 1, 2 and 4 t/ha to plots 1.8 m wide and 30 m long. There were four replicates. The location of the trial was recorded and marked by burying large pieces of metal at a depth of 40 cm at each of the four corners. The trial was relocated using a metal detector in 2013 in a farmer-sown paddock of wheat following aerial observation of significant growth response to the treatments applied 20 years previously. Subsequent to the initial treatments, the farmer applied 1 t lime in 1998, 1999, 2003 and 2012 (total 4 t lime) to the whole trial as part of normal paddock operations. In 2013, the trial plot yields were measured using a small plot harvester and soil samples collected to a depth of 50 cm.

Results and discussion

Grower surveys and workshops

Seventy-four per cent of respondents (n=334) considered that soil acidity is a moderate or greater problem on their farm/farms in the area. On a positive note 90% of respondents (n=319) considered soil acidity to be manageable on their farm. The principal barriers to applying sufficient lime to all paddocks immediately were economic constraints/limitations (e.g. cash flow (seasonal condition), cost of transport).

Responses regarding past and intended soil sampling practices showed a clear increase in the amount of subsurface sampling that growers intend to conduct. This was most pronounced for those who were part of groups that had been involved in the project (soil sampling, soil acidity management plan and initial and follow-up workshops).

In the last three years lime was applied as a single rate across paddocks more than 75% of the time. In the future, growers (n=115) intend to increase the proportion of split rate or variable rate applications to around 50%. Growers indicated that the most common rates of application of lime would increase from 1–1.5 t/ha to 1.5–2 t/ha.

Analysis of response to liming

The average gain from liming considering all years and all crops in the database was 0.18 t/ha or 10% increase in yield (n=232). If the first year of lime and the first year after liming are removed from the data (on the understanding that lime takes time to react in the soil and responses in the first two years are not expected) there is an average 0.25 t/ha or 12% increase in yield (n=119). The data are similar to most other trials around Australia, although higher responses were found in trials that include the combined effect of lime and ripping/tillage (e.g. Coventry et al. 1987, 1989)).

Yield and yield gains from liming will depend on the relationship between paddock yield and yield potential. If the paddock yield is low relative to the yield potential there may be little gain from liming (likely to be additional constraints present). Also, if the paddock yield is already close to potential there may also be little immediate gain from liming (pH is not likely to be a constraint). However, for most situations the yield gains to liming appear to be relatively constant. Examination of the yield difference curves for all crops and all years indicate that there is a 10% chance of getting a 40% yield increase and a 30% chance of a 10% yield increase, while almost 100% chance of a 3% yield increase.

By knowing more information about individual circumstances, such as soil pH to depth, the sensitivity of the crop and pasture species being grown to low pH conditions, and the relative yields compared to yield potential, better estimates of the likely response to managing acidity can be made.

Long-term response to liming – Mingenew trial 2013

The cumulative application of 1 t/ha lime by the farmer in 1998, 1999, 2003 and 2012 (4 t/ha total) increased or maintained the topsoil (0–10 cm) pH_{Ca} above 5.5–6 for all initial lime treatments. Only the plots that received the initial 4 t/ha lime application and the subsequent farmer-application of a further 4 t/ha had subsurface pH that is close to target (≥ pH_{Ca} 4.8). The soil pH below 20 cm has continued to acidify from the initial pH as measured in 1994 for all treatments that initially received 2 t/ha lime or less. Not only has the soil continued to acidify but the depth to the lowest pH is deeper, meaning that it will now require more lime and take longer to recover.

Wheat grain yield was 10% higher in the treatment that had received a total of 8 t/ha lime (initial trial 4 t/ha plus 4 t/ha in farmer applications) and 6% higher for the treatment that had received a total of 6 t/ha lime (initial trial 2 t/ha plus 4 t/ha in farmer applications) over the treatment that had received a total of 4 t/ha lime (nil in trial and 4 t/ha in farmer applications) (Table 1).

Table 1 2013 grain yield response to 1994 lime treatments at a trial near Mingenew, WA. Subsequently each treatment received 4 t/ha farmer-applied lime.

1994 Lime treatment (t/ha)	Wheat grain yield (t/ha)
0	4.43 a
1	4.56 ab
2	4.69 b
4	4.85 c
Lsd (p=0.05)	0.14

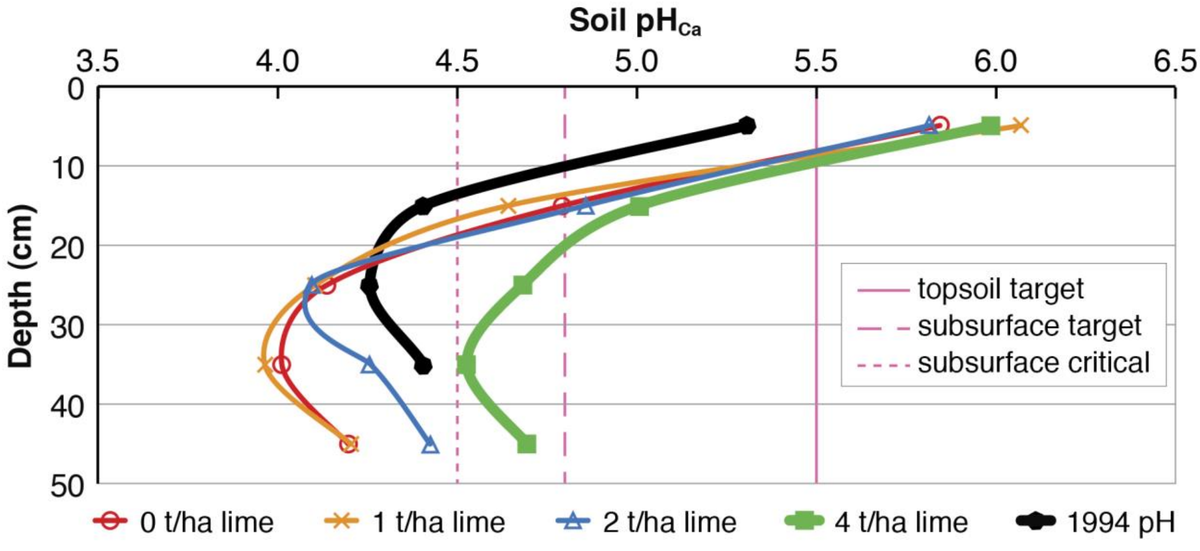

Figure 1 Soil pH profiles in 2013 for different lime treatments compared to the starting pH 20 years ago in a trial near Mingenew, WA.

The soil pH of the plots that received 8 t/ha lime over a 20-year period almost meets the recommended targets. This amount of lime far exceeds most current and intended farming practices. Improvements in farming practices leading to greater productivity have also lead to increased acidification and therefore an increased lime requirement. The treatments receiving lower rates of lime over this time are now so acidic at depth that they will require large amounts of lime and mechanical incorporation by ripping, ploughing or spading to recover the soil pH profile in a reasonable time frame (3–5 years).

Conclusion

Soil acidity continues to be a major constraint to agriculture in WA, with acidity in subsurface soil a problem particularly on good sandplain. Crop and soil measurements and analyses from long-term lime trials clearly demonstrate the benefits of managing soil pH. Liming increases yield where soil pH is below recommended targets and the maintenance of soil at an appropriate pH is needed to maintain yield potential. Farmers are increasing their use of lime and appropriate soil sampling to identify and prioritise lime application. However, the evidence clearly shows that soils are continuing to acidify, so more lime is required—be it higher rates, more paddocks or better targeting within a paddock—as determined by objective assessment. In the absence of appropriate management, soil acidity will continue to cost farmers the opportunity to achieve their rain limited yield potential. Appropriate management of soil acidity should not be viewed as an encumbrance but as an opportunity to improve the yield potential and resilience of many cropping systems beyond their current potential with comparatively little effort or financial strain relative to gradual deterioration. Moreover if the soils are allowed to continue to acidify then we are accepting that it is OK to degrade our non-renewable soil resource for short-term financial imperative. This needs to be taken seriously with a cross-industry approach by economists, consultants and advisors in collaboration with farmers.

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Key words

Soil acidity, pH, lime, liming, soil management, long-term

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