Successful integration of soil nutrient testing and regional acidity monitoring highlights the opportunities for soil condition assessment and natural resource management

Joel Andrew[1], Chris Gazey[2], Stephen Carr[1] and David York[1]

[1] Precision SoilTech, www.precisionsoiltech.com.au Email joel@aglime.com.au
[2] Department of Agriculture and Food, Western Australia. Email cgazey@agric.wa.gov.au

Abstract

Soil acidity, and in particular subsurface acidity, is seen as being one of the main constraints to production and sustainable agriculture in Western Australia. Past techniques of estimating the extent of soil acidity in Western Australia, such as the 2001 National Land and Water Audit, have had limitations in identifying meaningful small scale spatial variation and subsurface acidity levels. This paper discusses a novel approach to determine the extent and severity of topsoil (0-10 cm) and subsurface (10-30 cm) soil acidity in the Avon River Basin (ARB) of Western Australia's Wheatbelt. In a joint project between the Department of Agriculture and Food, Western Australia and soil sampling company Precision SoilTech, pH (1: 5 0.01 M $CaCl_2$) sampling and analysis was conducted on the 10-20 cm and 20-30 cm soil layers of over 17,000 geo-referenced sites when the growers conducted 0-10 cm soil fertility analysis. Contemporary soil pH data for all major soil groups in the ARB is now available to growers and NRM groups. This data can be used to examine soil acidity at various scales (site, paddock, farm, region, river basin) and creates a more accurate assessment of soil acidity in the ARB. Initial results have shown that over 80% of the topsoil and around 50% of the subsurface samples fall below the Avon Catchment Council's 2020 soil pH targets of pH 5.5 or more in the topsoil and 4.8 or more in the subsurface soil. However, other aspects of this project suggest that these targets are attainable in approximately 80% of the ARB with appropriate lime use. This project highlights the opportunities available for both growers and NRM organisations to receive information otherwise unavailable without public and private sector co-operation and data sharing.

Key Words

Acidity, Monitoring, Soil pH, Lime, Avon River Basin

Introduction

Soil acidity affects over one third of the agricultural region of Western Australia (Davies et al. 2006) and is a threat to agricultural sustainability. Monitoring and management of soil acidity have historically been the responsibility of the land holder, as impacts (i.e. loss of yield, decreased rotational flexibility and profit) were considered to be on farm. Recently, soil acidity has been considered a Natural Resource Management (NRM) issue and has been linked to salinity, erosion and clay mineral particle degradation (National Land and Water Resources Audit 2001). Acknowledgement of these issues has prompted organisations such as the Avon Catchment Council to set long term targets that 'All low buffered soils should exceed pH 5.5 in the topsoil and pH 4.8 in the subsurface soil by the year 2020' (Avon Catchment Council 2006). This has created the need for improved spatial and temporal estimates of soil acidity to be produced to facilitate appropriate management options.

This paper examines a novel approach used to collect geo-referenced soil pH data from within the Avon River Basin of Western Australia, integrating grower topsoil fertility analysis with a soil acidity survey. Collaboration between the public and private sectors enabled very large numbers of midsoil (10-20 cm) and subsoil (20-30 cm) samples to be collected and analysed (pH) when growers engaged a commercial contractor to collect topsoil (0-10 cm) samples for nutrient analysis. This joint project between the Department of Agriculture and Food Western Australia and Precision SoilTech will allow soil pH data to be provided at relevant scales to both Natural Resource Management organisations (i.e. Avon Catchment Council & local Landcare groups) and growers. Although this project was focussed on soil pH, the approach could be similarly applied to collect data on a large number of soil condition parameters.

Methods

Integration of grower soil fertility sampling and regional acidity survey

Growers who operate within the Avon River Basin (ARB) and conducted soil nutrient testing using Precision SoilTech were provided with a subsidy which paid for sample collection and pH analysis of the midsoil (10-20 cm) and subsoil (20-30 cm). This offer was made on the understanding that the topsoil pH data, paid for by the grower, would be available for use in the project and the subsurface soil pH data, paid for by the project, would be provided back to the grower. This approach has proved to be successful not only in its capacity to collect large numbers of samples but also in providing benefits to growers who can use the more detailed soil pH profile data for liming and rotational decisions.

Soil samples were collected using Precision SoilTech during the summers of 2005/06, 2006/07 and 2007/08 when soil conditions were dry and warm. Five identical machines were used during the collection and were operated by Precision SoilTech regional operators. The sampling machine consists of a Ute mounted air compressor which is used to drive a pneumatic drill and vacuum system which lifts samples from the soil profile into buckets on the Ute tray. All samples were collected using the same sampling method of bulking 10 cores over a 3 m x 10 m area at each sampling location. Each sampling location was recorded using a Rinex Saturn H Box guidance computer using datum GDA94.

Individual growers chose the soil sample locations with each site selected to represent the soil types within a paddock. Soil samples were collected for fertiliser recommendations and acidic soils were not specifically targeted, resulting in a random survey of soil acidity across the Avon River Basin.

All samples were analysed using the methods described by Rayment & Higginson (1992) and are reported in 1:5 0.01 M $CaCl_2$.

Results & Discussion

The number of soil samples collected over the duration of the project are presented in Table 1. A total of 17,021 topsoils and 22,199 (10-20 cm and 20-30 cm) subsurface soils have been collected. Topsoil, midsoil and subsoil sample numbers were lowest in the first year of the project (2005/06) though increased and were similar in the 2006/07 and 2007/08 seasons. Soil sampling in the 2005/06 season was affected by summer rainfall events which resulted in wet soils that were unable to be sampled. The project generated considerable interest in the second and third years via advertising and word of mouth which increased sample numbers in those seasons.

Table 1: Numbers of samples collected in each year of the Avon River Basin Soil Acidity Project.

Season	Topsoil	Midsoil	Subsoil
2005/2006	4544	2718	375
2006/2007	6194	5472	3833
2007/2008	6283	5739	4062
Total	**17,021**	**13,929**	**8,270**

Samples were collected from properties within the Avon River Basin managed by 248 individual growers located in 46 local government areas. Property size averaged 3150 ha and ranged from less than 100 ha to greater than 10,000 ha (Figure 1). Overall, growers participating in this survey manage 840,500 hectares or over 10% of the Avon River Basin's agricultural zone. Samples were collected from all rainfall zones (250-300 mm to 600-800 mm isohyets) and soil groups present in the Avon River Basin. As samples are geo-referenced these parameters can be used in the spatial data analysis.

Differences in the proportion of soil pH below 5.5 in the topsoil and 4.8 in the subsurface were observed across subregions of the ARB (Table 2). The majority of subregions had similar proportions to that of the overall Avon River Basin with around 80% of topsoils and 45% of subsurface soils below the target pH. The Lake Grace subregion had the highest percentage of topsoil below 5.5 (92%) however also had the lowest percentage of subsurface soils (37% and 22% respectively) below pH 4.8. The Cunderdin Subregion had the least amount of topsoils below pH 5.5 (60%) and the second lowest subsurface proportions (39% and 42%) below pH 4.8.

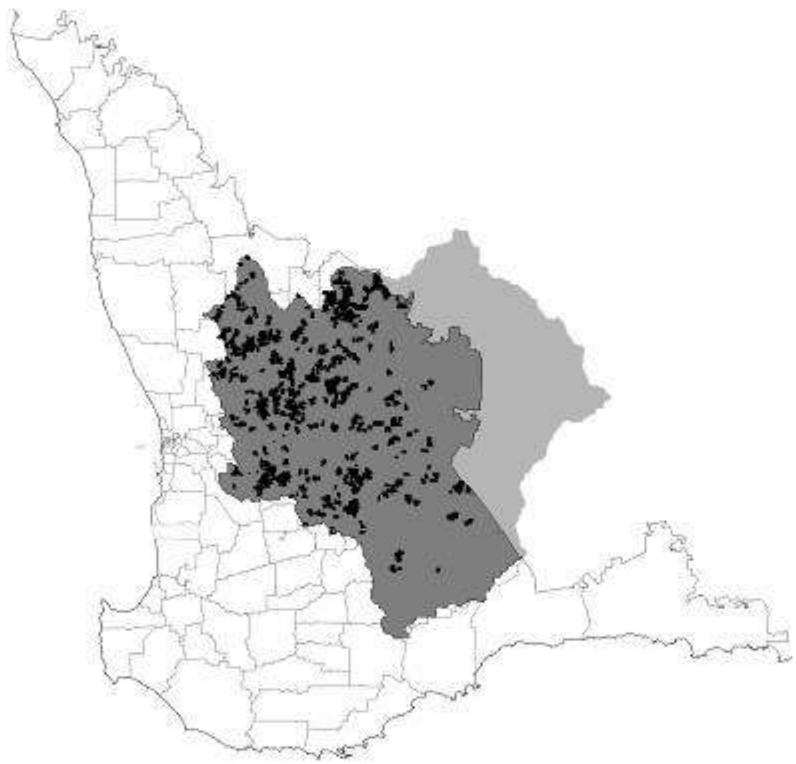

Figure 1: Distribution of soil sample locations across the Avon River Basin. The Avon River Basin covers 12.3 M ha and is made up of the agricultural zone (shown in dark grey ~8.3 M ha) and rangeland (shown in light grey ~2 M ha). Growers that participated in the Soil Acidity Project manage approximately 840,500 ha or over 10% of the agricultural area (shown in black).

These trends may indicate the effect of management practice. The Lake Grace region has experienced a relatively short period of agriculture (30-40 yrs) hence acidity is restricted to the top and midsoil. Lake Grace is also located 400-500 kms from high quality lime deposits resulting in poor adoption of liming or insufficient amounts of low quality liming products being applied. Cunderdin on the other hand has a long history of agriculture (110-120 yrs), is much closer to lime sources and traditionally spreads large amounts of high quality lime products (Australian Bureau of Statistics 2006).

Table 2: Regional comparison of the number of topsoil samples below pH 5.5 and subsurface soil samples below pH 4.8 collected from locations where all three sample depths were collected. * not all subregions have been included.

ARB Sub-region	Total number of complete profiles*	Topsoil % below pH 5.5	Midsoil % below pH 4.8	Subsoil % below pH 4.8
Lake Grace	446	92	37	22
Beverley	1647	80	48	39
Beacon	1351	79	53	51
Narembeen	390	78	64	53
Wongan Hills	816	76	49	43
Cunderdin	610	60	39	42
Avon River Basin	6946	78	48	40

There were 6946 sample locations that had all three profile depths sampled, with 15% of these locations meeting or exceeding the soil targets of pH 5.5 in the topsoil over 4.8 in the subsurface (Figure 2). The majority of soil profiles (59%) had slight or moderate acidic content. These sites represent soil profiles that did not meet the pH targets in the topsoil (though exceeded targets in the midsoil and subsoil) or both topsoil and midsoil did not meet the targets though met the targets in the subsoil. These sites can be rectified through liming over the short to medium term (5-10 yrs). Soil profiles that were acidic to depth made up 26% of the soil profiles sampled. Treating acidity in profiles such as these requires long term management (10-15 yrs) as liming has to treat topsoil acidity before alkalinity can be leached through the profile to increase subsurface pH.

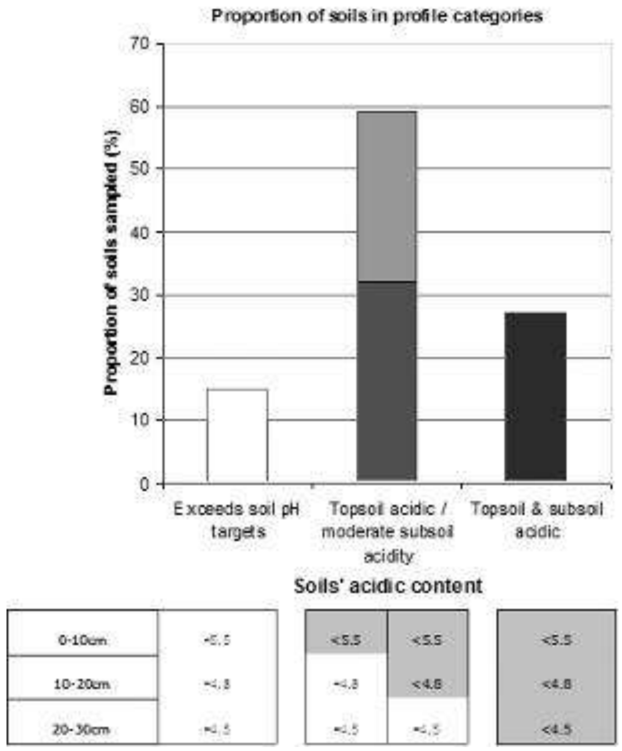

Figure 2: Of the nearly 7000 complete soil profiles collected (0-30 cm), 15% are considered above target, 59% of sites have a slight to moderate acidic content and 26% have severe acidity through out the complete profile. It is recommended that the 59% of soils in the slight to moderate category be targeted with strategic liming applications as it is these sites that will provide the most cost effective responses to pH increases.

Conclusion

Integrating a subsurface soil pH survey with grower soil fertility testing has proved to be highly successful in collecting large numbers of data which can be used to assess the current condition of soil pH across the ARB. Soil acidity has been shown to be a severe and widespread problem in the Avon River Basin with over 80% of the topsoil samples and nearly 50% of subsurface soils collected being below the 2020 soil pH targets of 5.5 and 4.8 respectively.

Integrating soil condition or monitoring surveys with practices that growers conduct as standard operating procedure, such as topsoil fertility testing, has proved to be a cost effective and efficient way of collecting soil data. Though this project specifically focussed on soil pH, the same approach need not be restricted to soil.

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