LOCATING AND ASSESSING ON-FARM LIME SOURCES

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

WESTERN

A REGIONAL CROPPING SOLUTIONS NETWORK INITIATIVE

grdc.com.au

Title: Locating and assessing on-farm lime sources

GRDC Contract Code: LIE1803-002SAX

Acknowledgements

Grateful acknowledgement is made for the information and time committed by the following growers featured in the case study booklet: Bob Nixon, Nick Gillett and Clint Della Bosca. Acknowledgement also extends to Caroline Peek from the Department of Primary Industries and Regional Development.

ISBN: 978-1-921779-82-4 (online)

GRDC contact details:

Ms Maureen Cribb
Integrated Publications Manager
PO Box 5367
KINGSTON ACT 2604

Email: Maureen.Cribb@grdc.com.au

Design and production: Coretext, www.coretext.com.au

Cover photo: Spreading of on-farm Morrel lime near Merredin, WA. Photo: Map IQ

Published February 2019

Table of contents

Locating and assessing on-farm lime sources

Key points

- Soil containing carbonates (on-farm lime) can be used to treat soil acidity if it can be found, extracted and applied in a cost-effective manner
- Deposits of on-farm lime are found where:
  - heavy loam soils have a pH 7.0 or higher;
  - soil potassium (Colwell) levels are 500mg/kg or higher;
  - white carbonate nodules are near to or on the soil surface; and
  - Black Morrel (*E. melanoxylon*) native vegetation is growing
- The neutralising value is a measure of how much carbonate a lime source contains and will be the main factor in determining if it is economical to use the on-farm lime
- Viable sources are likely to need a neutralising value greater than 25 per cent; however, viability will also depend on the cost of extraction, transport and spreading

PHOTO: MAP IQ

Morrel soil from an excavated pit near Bencubbin.

Introduction

The high cost of managing acidity using coastal lime in Western Australia's eastern wheatbelt has prompted a number of growers to look for an alternative and economically viable lime source. On-farm lime is being successfully located, extracted and spread on-farm at a lower overall cost than coastal lime, while also achieving the same soil pH increases. Improved soil acidity management is the result for these growers, as larger areas of their farms are being limed each year and higher rates of lime-equivalent are being applied.

Soil acidity

Soil acidity is the costliest soil constraint to Western Australian agriculture, with an average opportunity cost of $498 million each year (Herbert, 2009). Soil acidification is a natural process, however it is accelerated in all farming systems and occurs when hydrogen ions (H^+) accumulate in the plant root zone, which is measured by a decrease in the soil pH. Changes in soil chemistry occur as the soil pH decreases, with elements such as phosphorus becoming less plant available and aluminium more plant available, both of which reduce plant biomass and crop yields.

Soil acidification can be effectively managed with the application of lime, the cost of which is made up of the cost for product, transport and spreading. Product and spreading costs are usually static charges per tonne or hectare. Transport costs increase with the distance between the source of lime and the farm where it is needed and generally make up the largest component of the overall bill. As most sources of lime are found on the coast in Western Australia, eastern wheatbelt growers have some of the highest liming costs while also having soils that have high lime rate requirements.

Soil acidity management

Soil acidity management effectively comes down to keeping soil pH above levels that are known to reduce crop and pasture production. Acidic soils have traditionally been treated through the application of products such as dolomite, limesand and limestone. These products have relatively high amounts of carbonate (CO_3^{2-}), which is the component of lime that will react with the accumulated hydrogen ions and increase soil pH. For this reason, it is not the type of lime (sand, stone or dolomite) but the amount and size of carbonate particles that is important to ameliorate soil acidity.

Neutralising value (NV) is a measure of the per cent carbonate content of a product and its overall ability to increase soil pH. Particle size will determine how fast the soil pH will change. Fine particles will increase pH much faster than larger particles. **The effective neutralising value (see ENV calculation, Tables 2 and 3)** combines both these two parameters and allows different sources of lime to be directly compared. The cost, in relation to the ENV of each product, can then be used to assess how much carbonate is supplied per dollar and therefore which product is most economical.

PHOTO: THE LIEBE GROUP

Stockpiles of on-farm lime near Kalannie, WA.

Lime sources and on-farm alternatives

Dolomite, limesand and limestone have traditionally been used to treat acidic soils because they have relatively high NV (Table 1). However when product, transport and spreading costs are combined it can become very expensive.

An on-farm lime source can be used as an alternative to these products if it can supply the same overall amount of fine particle carbonate for a lower cost. Finding a potential on-farm lime source and measuring the NV and particle size will allow growers to assess if the source will be an economically viable alternative.

TABLE 1: Typical NV of various lime sources.

Lime source	Neutralising value (typical range)
Coastal limestone	65 to 85%
Coastal limesand	75 to 95%
Dolomite	85 to 95%
On-farm lime	25 to 55%

See Tables 2 and 3 for Effective Neutralising Value.

Locating and assessing sources of on-farm lime

There is no established method for locating sources of on-farm lime and there have not yet been enough sources found to develop fixed guidelines for where these sources occur. There are common soil type and landscape indicators that exist for the sources that are known, and a similar process of locating and assessing was followed by each of the growers who successfully found a source of on-farm lime on their property.

Finding your own on-farm lime source

Where to look

SOIL TYPES AND LANDSCAPE FEATURES

In the eastern wheatbelt of Western Australia, deposits of on-farm lime have been found In heavy loam soil types that are light pink to brown in colour and have a very fine-textured topsoil. These areas tend to turn to bulldust if driven over when dry and become very slippery after rain. All growers have commented that on-farm lime deposits are found on areas that perform poorly in all years except those with well above average rainfall.

White carbonate nodules are found on or near the soil surface and will generally become a fine white powder when crushed. The size and quantity of the nodules, or the presence of white to creamy white soil anomalies, may increase with soil depth.

These soils typically have pH values greater than 7 and potassium (Colwell) values above 500mg/kg, and often up to 1500mg/kg, in the 0 to 10cm layer. Soil pH in the subsurface is higher, usually between 7 and 9.

Many of the on-farm lime sources are found lower in the landscape, some of which are close to, but slightly above, saline soil types. Deposits are found in the calcareous loamy earths as defined by the Department of Primary Industries and Regional Development (DPIRD) soil landscape zone maps (DPIRD, 2018).

Aerial imagery shows the on-farm lime sources are found on the darker, red soil types of the eastern wheatbelt in the vicinity of water courses or salt chains. While there is no correlation between these sources and airborne radiometric data layers, there is visually the same affinity between heavier soil types, landscape position and on-farm lime deposits.

Black Morrel vegetation near Burracoppin, WA. PHOTO: MAP IQ

Morrel soil with carbonate nodules near the surface. This source has an NV near 50 per cent. PHOTO: THE LIEBE GROUP

Carbonate modules near the surface in an on-farm lime source near Moorine Rock, WA. The NV increases between 10 to 150cm then drops off quickly. PHOTO: MAP IQ

VEGETATION

Deposits of on-farm lime are very frequently found near stands of Black Morrel (*Eucalyptus melanoxylon*) or Salmon Gum (*Eucalyptus salmonophloia*).

Assessing likely lime sources

It is recommended that multiple potential sources of on-farm lime are assessed to make sure you find the best available.

SAMPLING

Each area thought to contain on-farm lime should be sampled to quantify the extent and quality of the deposit. Samples should be collected along a transect or in a grid from multiple depths down the soil profile using a soil corer or post-hole borer. These samples can be examined on site and sent for analysis if needed. Digging a trench with a front-end loader, back hoe or excavator lets you assess the depth and length of the deposit, estimate the amount of rock and collect further samples. It is recommended to take six to 12 samples from multiple sites in the stockpile or pit and bulk the sample for analysis.

ANALYSIS

There are several options for testing potential on-farm lime sources, each with varying costs and levels of information provided. It is essential that analysis is carried out prior to using a source on-farm, as some soil types contain clays that look very similar to carbonates but have no neutralising value.

Fizz test

The carbonate within an on-farm lime deposit will fizz when an acid, such as vinegar, is applied to the sample. This method is a very quick and cheap way to assess if the soil contains carbonate and how reactive it may be.

To undertake this test yourself, collect samples of the potential lime source from multiple depths (e.g. 0 to 10cm, 20 to 30cm and 50 to 60cm), then drip vinegar on each sample and observe if the samples fizz or bubble. You can standardise the method by pouring the same amount of vinegar, say 25ml, on each sample and record the duration and vigour of the fizz. The samples with the longest and most energetic fizz are likely to contain the most carbonate.

A sample of on-farm lime before (left) and after (right) vinegar is applied. The acid in the vinegar reacts with the carbonate in the on-farm lime to form carbon dioxide gas. PHOTOS: MAP IQ

Neutralising value explained

Neutralising value (NV) is a measure of how much carbonate is delivered by a product relative to pure calcium carbonate ($CaCO_3$) at 100 per cent. It allows different sources of lime to be directly compared with the result being the product's ability to increase pH in relation to 100 per cent pure lime and how much of each product is required to deliver the equivalent amount of carbonate. The cost of each product can then be used to figure out which product is most economical.

TABLE 2: Calculating effective neutralising value using wet sieve analysis results of limesand.

Particle size (UM)	% of sample in particle size range	Neutralising value (NV)	Discount factor	Effective neutralising value (ENV)% of sample x NV x discount factor)
0.00 to 0.125	2.7%	92%	100%	2.7% x 92% x 100% = 2.4%
0.125 to 0.250	36.9%	89.3%	100%	36.9% x 89.3% x 100% = 33%
0.250 to 0.500	42.1%	91.3%	70%	42.1% x 91.3% x 70% = 26.9%
0.500 to 1.00	17.8%	73.4%	35%	17.8% x 73.4% x 35% = 4.6%
> 1.00	0.6%	60.1%	20%	0.6% x 60.1% x 20% = 0.1%
				67%

The ENV of limesand calculated in Table 2 is used in Table 3 to compare true cost of limesand versus an on-farm source.

TABLE 3: Using ENV results to compare true cost of each lime source.

Product	Bulk NV	ENV	Amount needed for 100% NV	Cost of 1t of product spread in paddock	Cost of equivalent 100% NV
Limesand	86%	**67%**	100 / 67 = 1.49	$47	1.49 x $47 = $70.03
On-farm lime	35%	25%	100 / 25 = 4	$12	4 x $12 = $48

LABORATORY ANALYSIS

The samples that show the most potential in the fizz test should be further examined through laboratory analysis. The three main tests to consider are:

- bulk neutralising value;
- dry sieve neutralising value; and
- wet sieve neutralising value.

The bulk neutralising value test provides a per cent carbonate amount for the entire sample and does not take into account the particle size of the carbonate. At approximately $55 a sample, this is the cheapest laboratory analysis and gives a good indication of the on-farm lime source quality, although it cannot tell you if the NV is coming from fine or large particles. It is recommended that this test is used when you are first looking for an on-farm lime source, as multiple samples from each potential site can be analysed for a relatively small investment.

The dry sieve neutralising value analysis involves first filtering the on-farm lime samples through different-sized sieves and measuring the NV of each portion of the sample. The wet sieve technique is similar, but uses water to move the particles through the sieves. These techniques allow you to calculate the ENV and compare lime sources.

The wet sieve analysis has been found to be the most appropriate test for Morrel on-farm lime sources. It is recommended that a wet sieve analysis, which costs approximately $450 a sample, is undertaken once the on-farm lime source with the highest potential has been chosen.

In addition to carbonate content, further testing (such as nutrients or trace elements) to better understand the nutrient and salinity levels of these on-farm lime sources is recommended. These tests can indicate if there may be potential benefits from potassium or trace elements, or negative effects if the samples contain high amounts of salt.

On-farm lime product ready for spreading. PHOTO: THE LIEBE GROUP

TABLE 4: Summary of laboratory testing for on-farm lime samples.

Test	Laboratory	Approximate cost/sample**
Bulk neutralising value	■ Agrifood ■ APAL ■ Australian Laboratory Services ■ CSBP	$55
Dry sieve neutralising value	■ Agrifood ■ APAL ■ Australian Laboratory Services ■ CSBP	$250
Wet sieve neutralising value	■ Australian Laboratory Services	$450
Nutrient testing ■ Potassium and phosphorus ■ Sodium ■ Trace elements	■ Agrifood ■ APAL ■ Australian Laboratory Services ■ CSBP ■ Nutri Analytical (Landmark)	$16 to $25

**Costings presented are estimates only and laboratories should be contacted for actual costs prior to testing.

Extracting and spreading on-farm lime

The process of extracting on-farm lime will be determined by the nature of your soil type, if the product needs to be screened and the equipment available to carry out the work. The techniques may need to be adjusted on a case-by-case basis to get the best outcome.

EXTRACTION, SCREENING AND STOCKPILING

How you go about pushing up and stockpiling the on-farm lime will affect how it handles when it comes to spreading. Care should be taken to achieve a relatively consistent stockpile of fine lime particles, free of large lumps of lime or rock.

EXTRACTION

The best results are achieved when the on-farm lime is pushed up in shallow runs, only scraping off 5 to 10cm of product in one pass. This reduces the amount of larger soil and carbonate particles and increases mixing of the product. Using a ripper before pushing up on-farm lime is not recommended if this creates large blocks of products that may not break up. A bulldozer or excavator is generally the best machine for this work, although some on-farm lime sources are soft enough that a front-end loader can be used.

On-farm lime excavation and stockpiling at Kalannie, WA. PHOTO: THE LIEBE GROUP

STOCKPILING

The on-farm lime will not blow away like coastal limesand so it can be stockpiled where it is extracted. This allows for large quantities to be pushed up at one time before it is transported to the paddock. On-farm lime can also be taken to the paddock and stored in dumps for long periods of time and will not be affected by wind or rain.

SCREENING AND CRUSHING

On-farm lime sources that do not have large blocks of lime, rock or tree roots may not need to be screened, which will reduce the time and cost of the operation. If screening is needed, it can take place before the product is stockpiled, before it is taken to the paddock or as it is spread. Screening can be carried out using a simple mesh or grizzly screen or a hired mobile screening plant. Crushing is not generally required or recommended due to the additional costs, although some sources of on-farm lime can have large carbonate nodules that provide a higher NV product if crushing is undertaken. The economics of using a mobile crushing plant would need to be fully explored before this is done to make sure it is viable to do so.

SPREADING ON-FARM LIME SOURCES

Spreading the on-farm lime is no different from spreading any other product in that you will need to take time to set the spreader up correctly to get good results. The density and fineness of the lime will affect the spread pattern and how wide the product can be spread, with adjustments likely to be needed to each machine to get an acceptable result.

Application rates of on-farm lime are much higher than most other products, which can cause logistical issues. The distance travelled while spreading may require lime dumps to be strategically placed in each paddock to reduce the time spent travelling empty and loading. Rainfall after spreading has been shown to break apart the lime particles of some types of on-farm lime.

Although the rainfall does not change the NV of the lime, this breakdown may produce much smaller particles and result in a faster change in soil pH. This may be particularly important if any soil tillage is planned as it may be beneficial to wait for rain before incorporating the lime.

In addition to screening, the potential for large chunks of lime or rock will need to be managed and all care should be taken to protect the spreading machinery from damage. For example, a recommendation by a grower using on-farm lime is that the spreader door setting should be wider than the distance between bars on the grizzly screen to help stop blockages occurring and protect the belt.

Grizzly screen on spreader takes out large lumps of soil near Bencubbin, WA.
PHOTO: MAP IQ

Extracting on-farm lime near Narembeen, WA. The source is first pushed up in shallow runs with a bulldozer. PHOTO: MAP IQ

The on-farm lime is screened through 50mm mesh while loading and then taken to the paddock for spreading. PHOTO: MAP IQ

Economics of on-farm lime

On-farm lime needs to cost significantly less than using other sources of lime for the equivalent amount of NV.

The cost of the traditional coastal lime source should first be calculated, which can be done by combining the product, freight and spreading costs.

The cost of on-farm lime may be harder to calculate before carrying out the process for yourself, although some average costs of those using contractors are shown in Table 5.

LIME ECONOMICS CALCULATION

TABLE 5: Example calculation of economic comparison between limesand and on-farm lime.

Cost of item	Traditional limesand NV: ≈85%	On-farm lime NV: ≈35%
Cost of product ($/t)	$10	N/A
Extraction ($/t) ■ Pushing up and stockpile ■ Screening ■ Loading	 N/A N/A N/A	 $1 $1 $1
Freight ($/t) ■ Limesand – 300km ■ On-farm lime – 20km	 $30 N/A	 N/A $2
Spreading ($/t/ha)	$7	$7
Total for 1 tonne landed and spread ($/t)	**$47**	**$12**
Total for 2t/ha limesand (equivalent to 1.70t/ha 100% NV) **Total for 5t/ha (equivalent to 1.75t/ha 100% NV)**	**$94** **–**	**–** **$60**

Figures presented are estimates based on grower experiences and are for farm businesses located in eastern wheatbelt, minimum 300km from a coastal lime source.

ADDITIONAL BENEFITS

While the primary reason to use on-farm lime should be based on the economics of applying carbonate for acidity management, there may be other advantages of using on-farm lime that are harder to quantify yet still beneficial.

Analysis of on-farm lime has shown total potassium content can be between 0.5 and 1.5 per cent which is equivalent to 25 to 75kg of potassium per hectare when spread at 5t/ha. While the availability of this potassium to the plant is being researched, Colwell potassium levels suggest 2.5 to 7.5 units of plant-available potassium is being applied at the 5t/ha application rate.

Being able to stockpile lime in the paddock and not have it blow away is another benefit in that it creates flexibility around spreading and eases the necessity of watering dumps.

TRIALLING ON-FARM LIME

It is highly recommended to trial on-farm lime, measure the results that it provides and quantify if it is a fit for your business before implementing the practice on a large scale. A series of trial strips that compare on-farm lime against your current source of lime and a nil treatment can be established across your property to assess the results of each in different situations and soil types.

Before spreading the trial, measure soil pH at multiple sites along each spreading run and record the GPS location of each site to get baseline levels for the trial site. Spread the various lime sources in adjacent strips at the rates you intend to use on the rest of the farm, for example 2t/ha for limesand, 5t/ha of on-farm lime and a control strip with no ameliorant. Indicate the location of treatment strips with drums or record with farm management software. Undertake plant tissue testing in season to understand any nutrition benefits from the treatments. Yield data collected from these strips can be used to assess differences between the products and the nil to find any differences between the products. Remeasuring soil pH at the same locations and recording soil pH change will let you assess the impact of each treatment and compare the sources of lime.

Regulations

Comprehensive legislation exists that regulates mining and the protection of native vegetation in Western Australia. There are no regulations that limit the extraction of on-farm lime when:

- the activity is carried out on freehold land;
- the lime is used exclusively within your own business;
- the lime is not being sold; and
- the extraction does not extend below 15m.

While not compulsory, it is recommended that you contact your local government authority and inform it of the work you intend to undertake and that the intended activities are unlikely to require a permit under the Extractive Industry Licence.

RELEVANT LEGISLATION

Department of Water and Environmental Regulation – *Environmental Protection Act 1986*

Native vegetation is protected under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* and should be consulted if the on-farm lime source may affect vegetation.

Department of Mines, Industry Regulation and Safety – *Mining Act 1978*

The Act defines products such as on-farm lime as a Basic Raw Material so it falls outside the scope of the *Mining Act 1978*. It is the Western Australian Department of Planning that regulates these materials.

Department of Planning, Lands and Heritage – *Planning and Development Act 2005*

The Department of Planning, Lands and Heritage regulates Basic Raw Material when mined on freehold land for the purpose of being sold to a third party.

Department of Local Government, Sport and Cultural Industries – *Local Government Act 1995*

An extractive Industry Licence covers the extraction of raw materials, such as gravel and sand, although on-farm lime extracted and used on freehold land does not require a permit.

References

Herbert, A (2009), Opportunity costs of land degradation hazards in the South-West Agricultural Region: calculating the costs of production losses due to land degradation. Department of Agriculture and Food, Western Australia. Report 349.

Gazey, C and Davies, S (2009), Soil acidity: a guide for WA farmers and consultants. Department of Agriculture and Food, Western Australia, Perth. Bulletin 4784.

Cregan, PD, Hirth, JR and Conyers, MK (1989), 'Amelioration of soil acidity by liming and other amendments', in Robson, AD (ed.) *Soil acidity and plant growth*, Academic Press, Sydney.

Department of Primary Industries and Regional Development (2018), Soil Landscape Land Quality – Zones accessed at: https://catalogue.data.wa.gov.au/dataset/soil-landscape-land-quality-zones.

LIEBE GROUP
Working together in Agriculture

Map IQ
smarter ag mapping

MORE INFORMATION
Joel Andrew, Map IQ, 0429 917 743, joel@mapiq.com.au
The Liebe Group, 08 9661 1907, admin@liebegroup.org.au

GRDC Contract Code: LIE1803-002SAX

GRDC

Case study

SNAPSHOT

GROWERS: Clint and Jessica, and Wayne and Diane Della Bosca

LOCATION: Yilgarn, Western Australia

AVERAGE RAINFALL: 290mm

FARM SIZE: 9500ha total, 7800ha arable

ENTERPRISE MIX: cropping – wheat, canola, oats and barley

LIVESTOCK: 1500 breeding ewes

SOIL TYPES: range from heavy Goldfields clay to acid wodjils

The Della Bosca family has been farming in the Yilgarn since the 1930s and has overcome many challenges of farming in the eastern wheatbelt over that time by implementing modern farming practices. For Clint Della Bosca, managing soil acidity has been an ongoing process and one that is proving to be very expensive, which limits the practice to only small areas of the farm each year.

Ameliorating acidity with coastal limesand has been a practice the Della Boscas adopted from the early 1990s, when their tests showed 0 to 10cm soil pH was 4.5 to 5.5. They managed to lift the surface soil pH over that time, but low subsurface soil acidity means a lot more lime is still needed to fix the problem. With large areas of their farms needing at least 2t/ha of limesand, which costs around $100/ha, the Della Boscas cannot economically fix the problem using coastal limesand.

In 2017, Clint was involved in a tour to the Nixon family farm in Kalannie to understand how they were using a Morrel soil as an on-farm lime alternative – a relatively new and seemingly economically viable concept that the Nixons were using to overcome the same challenges the Della Boscas were facing. This prompted Clint to investigate his own source at a few locations on his farm.

Over a period of four months in 2017, Clint visited many sites across his farm and dug a lot of holes looking for his own on-farm lime source. The target soil type was a heavy red loam clay, pale pink in colour with calcareous white rock or nodules in it, with Morrel vegetation evident on the edge of the paddocks. He used the basic 'fizz' test, where dripping acid on the soil sample would produce a fizz if there was carbonate. After this simple in-field test, he sent several samples off for neutralising value (NV) testing at the Agrifood laboratory.

The results that came back were quite variable, with the best sample at 40 to 50% NV – a big win for Clint as this made it almost certain his on-farm lime source would be economically viable. This site, approximately 40ha in size, also had the lowest rock content of those tested and was on the edge of a paddock, making excavation easier.

The Della Boscas pressed ahead with extraction at this site, digging up 400 tonnes to trial. This was enough to put in a replicated strip trial on an acidic paddock in 2018 to compare the pH increase from the on-farm source (at two different rates – 5t/ha and 10t/ha) to limesand.

Clint Della Bosca, with son Noah and daughter Cassidy.

Clint's aim was to investigate the best rate of on-farm lime to use and whether those rates were equivalent to limesand at 2t/ha, which was the rate he was spreading limesand.

While yield data for the trial will be examined after harvest, initial results have shown there to be a similar increase in 0 to 10cm soil pH for the limesand and both Morrel lime sources, though no difference in soil pH below the surface (which is often the case in a lime trial over such a short period of time). The surface soil pH increases have given Clint the confidence to continue the use of his on-farm lime and, in 2019, the Della Boscas will have up to 4000 tonnes available to spread on-farm across 600 hectares.

In terms of the numbers, Clint believes it's likely to be around $30 to 40/ha cheaper than limesand. However, he still has not got accurate numbers around several factors, such as contractor charges, as he has not moved big tonnages. The Della Boscas used the services of a local excavator and truck operator to dig up the on-farm lime, and screening was carried out using a simple grizzly screen. Their average costs to date are $1/t to dig up, $1/t for screening and $3/t for transport, which can be reduced if they carry out some of the work themselves. It will be approximately $7/t for spreading, so they think they can get 5t/ha spread for about $60 to 70/ha.

The biggest challenge they have faced has been around finding the most suitable source. Although the current source is suitable and producing positive trial results, they will be continuing to try and find a better source. Screening the on-farm lime product will be an issue on the current site in the future.

This on-farm lime journey is still in the early stages for the Della Boscas. Clint is still not fully convinced this is the way to go, but sees exciting potential, and will keep trialling as they go to make sure it is working as expected and the theoretical economic advantages are real.

TOP THREE RECOMMENDATIONS YOU WOULD PROVIDE TO A GROWER WANTING TO EXPLORE THIS OPTION ON THEIR FARM?

1. Go and dig some holes and then send the samples off for NV testing. The tests are cheap enough to do a few to let you find the best source for you.
2. Do the economics for your own source and costs to make sure it will work on your farm.
3. Trial it for yourself.

Case study

SNAPSHOT

GROWERS: Nick and Tryphena Gillett

LOCATION: North Bencubbin, Western Australia

AVERAGE RAINFALL: 300mm

FARM SIZE: 9000ha arable

ENTERPRISE MIX: cropping – wheat, barley, oats, canola, lupins, pasture/fallow

LIVESTOCK: Dorper sheep

SOIL TYPES: Mallee, heavy/salmon gum, and gravel/sand

Nick Gillett

Reducing cost of production, specifically the cost per pH unit increase to ameliorate soil acidity, has been the driving force for Nick and Tryphena Gillett to use an on-farm lime source on their Bencubbin property.

The Gilletts started liming with coastal limesand in 1993, with most paddocks having had three applications at an average 1.5t/ha to date. Despite seeing increases in pH they still need a lot more lime to get the pH above the 5.5 topsoil and 4.8 subsoil targets. Lime freighted to Bencubbin ($40 to 45/t for lime and freight) has become an expensive input and therefore they were keen to find a cheaper alternative.

Their investigations into the feasibility of an on-farm lime source started with conversations with other growers who had identified and trialled on-farm lime on their own properties. Nick saw that other growers were getting good soil pH increases by using on-farm lime for a lot less cost than traditional coastal lime. Other benefits were the ability to treat more hectares a year and get the job done quicker using the on-farm lime source: “With on-farm lime being cheaper we can cover more hectares or use a higher rate for the same cost.”

In 2016, Nick identified and tested some areas of Morrel soil on-farm for its neutralising value (NV). He initially used yield maps to identify the lowest-yielding parts of the heavy soil type paddocks, then went out with the post-hole borer and, sunk holes in those areas. Samples were sent off for NV analysis and although some areas that they thought would be higher NV were quite low, they found one site that was around 30 per cent NV. They are now excavating on-farm lime from this site.

The Gilletts spread 10,000 tonnes over 3000ha in summer 2017-18. During this first year Nick also took samples from each load that went out to the paddock, noting that they were all relatively consistent. He was therefore confident of the NV at the site and that the amelioration would work well.

In relation to the excavation process, the Gilletts use contractors to extract the lime and transport it to the paddock. It is then spread using their own equipment. A dozer pushes up the source from the pit, then a loader puts it into a road train running side tippers. Unlike limesand, the on-farm lime dumps do not blow away, so contractors are able to extract and cart the on-farm lime to the paddock in advance of spreading.

The Gilletts were fortunate their on-farm lime source had no requirements for thorough screening (which adds additional costs), as there are no large rocks. They did build a grizzly screen that sits on top of the spreader to remove any large lumps that may block the spreader.

In terms of the economics, Nick knows the figures well and his understanding of these was one of the key reasons they were able to rapidly implement the practice on-farm. The Gilletts calculated costs at $1/t for a dozer, $1/t for the loader and $4/t for transport, which is $6 per tonne landed in the paddock. At 30 per cent NV, they need approximately three times the volume of on-farm lime to match the NV of coastal limesand. This equates to approximately $18/ha for 3t/ha of on-farm lime applied. The equivalent 1t/ha of limesand is $40 to $45/ha (lime and freight).

The Gilletts calculate their spreading costs at $10/t for the first tonne and $5/t thereafter, so spreading two tonnes per hectare of limesand is $15/ha for spreading plus the $80 to 90 for product, equalling $95 to 105/ha in total. Although there is extra spreading cost when using on-farm lime due to the additional volume of product being applied, it still works out cheaper. The equivalent 6t/ha of on-farm lime required is $35/ha for spreading plus the $36 for product for a total of $71/ha.

Nick’s experience of spreading 10,000t in 2017-18 and the lessons he has learnt around machinery set-up and product logistics have given him the confidence to continue using on-farm lime. The Gilletts plan to extract and spread 20,000t of on-farm lime in 2018/19 – a significant undertaking, but one that will reward them by bringing them much closer to removing soil acidity as a constraint on their paddocks.

TOP THREE RECOMMENDATIONS YOU WOULD PROVIDE TO A GROWER WANTING TO EXPLORE THIS OPTION ON THEIR FARM?

1. Make sure you get your equipment sorted at the start as that can cause headaches and take up your time.
2. Go out and look for it yourself. Look for areas that never really perform, are high pH and may have the white nodules.
3. Use contractors if you can.

Case study

SNAPSHOT

GROWERS: Bob and Daniel Nixon and family

LOCATION: Kalannie, Western Australia

AVERAGE RAINFALL: 300mm

FARM SIZE: 18,000ha

ENTERPRISE MIX: cropping – wheat, canola, barley, lupins and field peas

SOIL TYPES: wodjil sandplain, gravel, clay loam, heavy clay, red morrel

Bob Nixon

Bob and Daniel Nixon are focused on producing the same yields with fewer inputs, lowering their risk profile while increasing their gross margin. One of the many cost-saving initiatives to come from this aim was identifying a viable on-farm lime source, enabling the Nixons to ameliorate acidity in a more cost-efficient manner than sourcing limesand from the coast.

The Nixons began using a Morrel soil as an alternative to limesand in 2014, but have been no strangers to capitalising on natural resources found on-farm. In 1978, Bob and Daniel's father Robert Nixon opened up a gypsum mine, utilising the naturally occurring gypsum deposits in the salt lakes. Initially, gypsum was mined and sold for industrial purposes and as a soil conditioner for clay soils. More recently, gypsum use has increased as a non-acidifying low-cost sulpher source and to ameliorate the effects of aluminium toxicity. They first recognised there was a substantial lime resource available to the farm through their knowledge of the physical landscape, soil types and local vegetation.

The Nixons estimate they have more than 250,000t of morrel lime available that has an adequate neutralising value (NV) for combating acidity on the farm.

The Nixons started liming in 1994 with an average pH between 0 to 30cm of 4.5 ($CaCl^2$) on their acid sands. Over the next 20 years, on average 4t/ha of limesand was spread over the farm, raising the average pH to above 5 in the topsoil, although little pH change was seen below that. In the past four years, since using higher rates of the morrel source, they have seen a rapid jump in pH to 6 to 6.5, which is something that would not have been economical with coastal limesand. The Morrel lime particles are dissolving in water or slaking, leading to lower particle size and quicker pH change than was achieved with limesand.

When buying limsand, the Nixons were averaging $33/t (lime and freight) landed in the paddock, a significant cost for their farm business and giving them the incentive to find a cheaper option. They decided it was time to do further research into the morrel soil characteristics and invested in soil testing to get a clear picture of what was actually available to them. Initially they dug a three-metre pit and had each metre analysed. The top metre had the highest NV per cent. They extended this to four individual pits over the 50ha of red morrel soil they had identified.

The on-farm lime source NV ranges from 37 to 54 per cent (Table 1), which is low when compared with other lime sources such as limesand. The Jurien Bay pit range is 84.7 to 94.1 per cent (DAFWA Audit Limesand, 2015) and dolomite at the Watheroo pit range is 88.5 to 91.6 per cent, (DAFWA Audit Dolomite, 2015). However, the fact it is on-farm is the clincher in cutting freight costs. The Nixons are able to mine the morrel lime and have it in the paddock at below two-thirds the cost of sourcing and carting limesand from the coast. The cost is worked out using commercial dry hire rates on the machinery utilised.

The area that is now the Morrel lime pit was one of the poorest-producing parts of the farm, averaging 0.3t/ha in 2013, and has been taken out of production. The Nixons have turned this area into an asset that is helping to increase productivity across the rest of their farm.

The Morrel lime at Kalannie is a calcium and magnesium carbonate. It contains calcium (Ca) at 12.5 per cent, magnesium (Mg) at 4.5 per cent and a small amount of potassium (K) at 0.2 per cent. By increasing the farm's overall pH the Nixons have made the phosphorus (P) bank more available to the crop (Scanlan et al, 2015) and have been able to cut back P to maintenance levels as a result, further lowering the cost of inputs. The money saved on phosphorus is redirected elsewhere in the budget.

There is no mining lease or royalties associated with the venture as they are not selling the mined lime, which is similar to claying on-farm or removing gravel from gravel pits.

The Nixons have the advantage of available equipment due to their family gypsum business. However, rental machinery is available. A mobile screen can be rented out of Perth for approximately $300/hour. The screener has the capacity to screen 150t/h to 10mm, giving an average cost of $2/t. If you spread 3000ha/year with Morrel lime at 4t/ha, totalling 12,000t, it would take approximately 80 hours to have an annual supply stockpiled and ready for the paddock.

The Nixons use an excavator to mine the on-farm lime and are screening it to separate the larger rock. They intend to stockpile the dolomitic rocks, which have an NV of 55 per cent, until they have a minimum 20,000t, at which point they will crush.

They have spread a total of 50,000t of Morrel lime over the farm in the fours year since 2014. The strategy will now move to maintenance and trialling how to fix the subsoil acidity with practices such as ploughing.

The Nixons do not plan to mine the Morrel lime to sell commercially, and believe their supply will meet their liming needs for decades to come.

Screening and stockpiling Morrel lime in Kalannie, WA. PHOTO: THE LIEBE GROUP

TABLE 1: Average soil analysis taken from the four initial test sites in Kalannie, WA, to a depth of one metre.

Soil	Fines	Ca	Mg	Na	K	NV
Pit	(NV)	(ICPg)	(ICPg)	(ICPg)	(ICPg)	($CaCO_3$)
	%	%	%	%	%	%
North-west	37.1	13.4	4.8	0.2	0.2	54.2
North-east	44.6	12.9	3.5	0.2	0.2	47.5
South-west	34.6	12.0	4.4	0.2	0.2	49.0
South-east	47.5	11.9	1.7	0.2	0.2	36.9

TOP THREE RECOMMENDATIONS YOU WOULD PROVIDE TO A GROWER WANTING TO EXPLORE THIS OPTION ON THEIR FARM?

1. Look for surface indicators such as:
- high surface pH and potassium levels in current soil testing; and
- the fine-textured Morrel soil acids capillary rise, leading to higher salinity levels.

2. Dig a test hole and see if it bubbles when vinegar is applied. If so, take more samples and get them tested.

3. Contact a grower who is using on-farm lime.

P Level 4, 4 National Circuit, Barton ACT 2600 | PO Box 5367, Kingston ACT 2604
T 02 6166 4500 **F** 02 6166 4599 **E** grdc@grdc.com.au