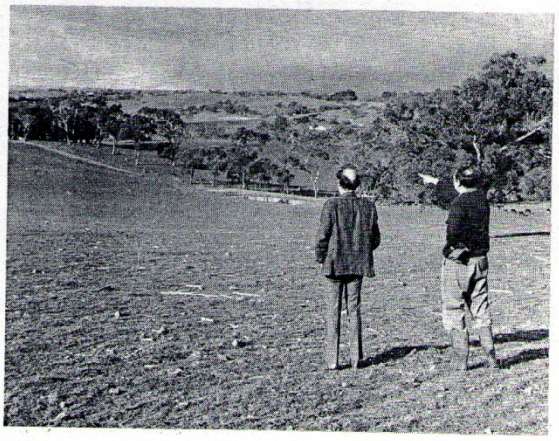
SOIL TESTING

IN SOUTH AUSTRALIA-

Tentative standards for interpreting the bicarbonate soil phosphorus test



Farmers are asking how much fertiliser they really need to apply.

By J.S. Potter, Senior Soil Conservation Officer, and R.J. French, Principal Research Officer.

In their natural state, South Australian soils are grossly deficient in phosphorus, and phosphorus fertiliser, particularly superphosphate, has been widely used by farmers for many years. In just the last five years, South Australian farmers have invested about $60 million in superphosphate and the Federal Government has contributed a further $24 million in the form of subsidies.

Until the early 1960's most farmers were obtaining consistently large yield responses to superphosphate, and the rate applied was determined largely by finance available. Since then it has become obvious that responses have become much less consistent, particularly where phosphate has been applied for a number of years. Farmers have been asking how much phosphate they really need to apply. Maybe they can cut back their rate of application, at least for a time.

One approach to this problem is to try to find a simple chemical test which will indicate how much of the phosphorus in a soil is available to plants. Such tests have been used in the old agricultural areas of the Northern Hemisphere for upwards of 35 years. They have been, in general, only reasonably successful, performing best in high rainfall areas of uniform soils where only a few types of plants are grown. It has proved much more difficult to develop meaningful tests for South Aus-

tralia due to the great variety of soils, the low and variable rainfall, the range of crops and pastures grown, and the fluctuations in available nutrients that can occur in the two to three months before seeding.

In all, some 14 phosphorus tests, all of which have proved useful in some areas overseas, have been tried here. Only four of these tests have proved of value in our conditions, and the best of these is a phosphorus test based on extraction with sodium bicarbonate.

This article explains the background behind the bicarbonate test and how the results can be used in farm decisions.

Phosphorus in the soil

When water soluble phosphate – as in superphosphate – is added to moist soil, it first dissolves in the soil water. After that four things can happen to it.

- Some phosphorus will be taken up by plants. This will be lost when the grain or other products are taken from the paddock, but some will return to the soil in crop residues or by grazing. Normally about 20 per cent of the applied phosphorus is taken up by the current crop.

- Some phosphorus will be adsorbed on to the clay and humus particles. Elements adsorbed are held sufficiently strongly to prevent loss by leaching, but are available to plants through an exchange process. The amount of phosphorus adsorbed is referred to as the exchangeable phosphorus.

In general the more clay present in the soil, the more phosphorus is likely to be adsorbed and held in an available form and therefore the higher the residual soil value. Phosphorus adsorbed on to humus is not readily available to plants, but may become so following cultivation and mineralisation.

- Some phosphorus may be fixed in an unavailable form. This is especially important in two types of soil – calcareous soils high in lime, and acid soils with plenty of iron and aluminium.

Fixation at first converts the water soluble phosphorus to less soluble forms, but as the process proceeds, the phosphorus becomes completely locked up. In calcareous soils (pH 8.0 to 8.5), the problem becomes more severe as the lime content increases. Fixation is also severe on very acid soils (pH less than 5.0) or on moderately acid soils (pH 5.0 to 6.0) with a high iron content, but it is less serious on neutral soils (pH 6.0 to 7.5).

- Some phosphorus may be leached (washed) out of the root zone by percolating water. This is not widespread because most soils have sufficient clay to hold all the phosphorus applied. But big leaching losses can occur in the white siliceous deep sand and sand-over-clay soils of the high rainfall areas. Leaching does not always reduce yield however – on the deep sands of the Upper South-East, moderate leaching of phosphorus into the one to two feet soil layer where the soil is moist over summer, favours the growth of established deep rooted plants such as lucerne.

In summary, variations in clay content, lime content and acidity of soils, have a big bearing on the fate of phosphate fertiliser. These soil factors, together with the amount of phosphorus previously applied, will determine the level of residual fertiliser held in a form available to plants.

The bicarbonate test

In the laboratory a precise weight of soil is taken from the field sample.* This is shaken for 16 hours with an exact volume of sodium bicarbonate solution. The amount of phosphorus extracted from the soil by this solution is then measured. This, in turn, is related back to the original weight of soil and the results are expressed as parts of phosphorus per million parts of soil (p.p.m.).

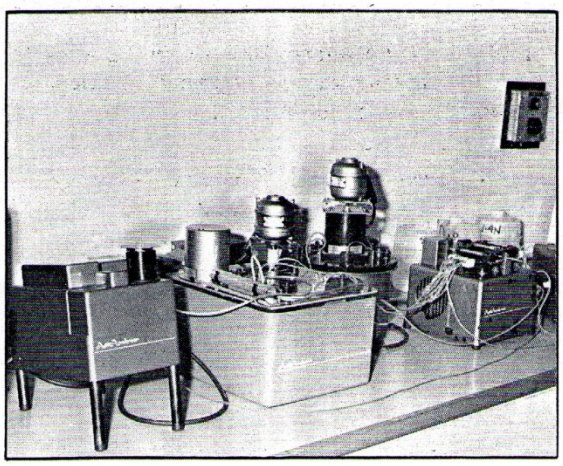
It is believed that the sodium bicarbonate solution mainly extracts the phosphorus in the soil solution and that adsorbed on the clay particles. It is therefore referred to as the phosphorus available to plants (available phosphorus).

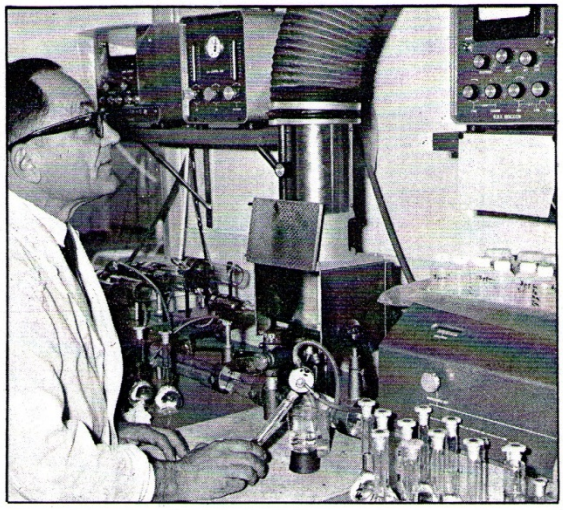
P-test standards

The laboratory analysis simply tells us that the soil contains a certain amount of available phosphorus – say 15 p.p.m. Clearly this tells us nothing unless we are able to interpret it. To do this we need information from field trials. In fact, a soil test service is quite useless unless it is backed by a local field research programme.

Over the past 10 years the Department of Agriculture has conducted a large field fertiliser research programme. Trials have been carried out over a wide range of soil and climatic conditions, from the Far West Coast through to the Lower South-East. Since 1967 the C.S.I.R.O. Division of Soils and the South Australian superphosphate manufacturers have also thrown their resources into the programme.

*"Soil Testing in South Australia – a progress report" by J.S. Potter. Journal of Agriculture, South Australia, November 1970.





There are two steps in analysing soils – extraction and measurement. The photos show two methods used to measure the concentration of nutrients extracted from soils at the Department of Agriculture Northfield Laboratories. Above: Auto-analyser Below: Atomic absorption spectrophotometer

Table 1: Tentative standards for interpreting the bicarbonate soil phosphorus test in South Australia (0–10 cm. sample) and suggested maintenance phosphorus applications. (Mostly French, R.J. and Rudd, C.L. – unpublished data).

Land use zone	Annual rainfall (in.)	Soil type	Desirable P-test standard (p.p.m.)	Suggested maintenance† rate of phosphorus (lb./ac.*)
Cereal-sheep areas	Below 14	Non calcareous	20	6
		Calcareous	25	8
	14–20	Sands	25	6
		Loams, cracking clays	30	8
		Calcareous loams	35	8
		Calcareous sands	40	10
Pasture areas – high rainfall	Above 20	Sands	20	5**
		Loamy sands	25	6**
		Sandy loams	30	6**
		Calcareous loams, clay loams, peats	35	10

* See text for calculation of amount of fertiliser needed.
** See text for varying this amount with stocking rate.
† Cereal areas – sufficient for crop and following pasture; for pasture areas annual application.

From these experiments it has been shown that we should aim at a level of 20 lb. per acre of bicarbonate phosphorus in the soil. This varies somewhat with rainfall and the type of crop grown. In addition, because of big differences in the bulk density of soils in this State, different p.p.m. standards are needed to meet the required 20 lb. per acre. In suggesting desirable levels, therefore, it has been necessary to relate them to certain categories of land use, climate and soils. These, together with the appropriate tentative standards, are shown in Table 1.

Using the P-test in farm decision

In using the P-test it is important to recognise

from the start that it will not tell us exactly how much fertiliser **should** be applied in any one year. Yield response is dependent on many physical factors such as rainfall, time of seeding, effectiveness of weed and disease control as well as the amount of available phosphorus in the soil. Economic factors such as market price, and available capital will also be important in fertiliser decisions. However, used sensibly, a soil test can help in deciding the amount of fertiliser to apply.

Table 1 shows how to interpret a soil test value. To use the table, locate in turn the appropriate land use zone, the annual rainfall class, and the particular soil within this class – and read the desirable standard. It is important to remember that these standards are based on samples taken in moist soil in the April–May period. Even for this period they can only be regarded as tentative, but they are the best that research has so far been able to produce.

The next step is to compare the result from your paddock with the desirable standard. Three different situations might arise (see also Figure 1).

- **The result may be low** – (more than 10 p.p.m. below the desired level).

In this case the aim should be to build up the soil level by applying as much fertiliser as practical. This applies to both cereal areas and high rainfall country. The amount will depend on the money available for buying fertiliser, but rates of at least 16 lb. of phosphorus, that is one 187 lb. bag of superphosphate, should be applied per acre if at all possible. Where values are very low, say on new ground, doubling this amount to two bags has been shown to be an advantage. For best results it is also important that the fertiliser be applied every year and applied at seeding of crops or close to the break of the season on pastures.

A soil testing service is quite useless unless backed by a field research programme. The Department of Agriculture has carried out hundreds of field trials over the last 10 years.

Above: A phosphorus on wheat experiment on Yorke Peninsula.

Below: Different forms of phosphorus fertiliser being tested at Hope Forest.

different. Here the rate should be adjusted to suit the stocking rate. Research work has clearly shown that the more sheep that are carried, the more phosphorus is needed. If the stocking rate is low, say less than two dry sheep, then a maintenance level of phosphorus will be sufficient. With higher stocking rates, more phosphorus will be essential.

It is not possible to give precise advice to cover all pasture-stocking rate situations here. It is suggested that landholders discuss their particular situation with an adviser.

▪ **The result may be at, or above, the standard.**

The aim here should be to apply sufficient phosphorus to maintain the soil at the desirable standard, that is enough to compensate for that which will be removed by the current crop or pasture, or lost through fixation and leaching.

Maintenance levels have been worked out for the different land use and soil zones – see the second part of Table 1. The figures given are in pounds of elemental phosphorus. To convert these figures to pounds of superphosphate use the following formula:

$$\frac{\text{Maintenance level (lb.P)} \times 100}{\%\text{ available P in fertiliser*}} = \text{lb. fertiliser needed /acre}$$

*This is normally water soluble and citrate soluble phosphorus. However, current research suggests that in some areas of deep acid sands receiving above 25 in. of annual rainfall, acid soluble P in finely ground rock phosphate may be included in the calculation.

Research work has clearly shown that the more sheep that are carried the more phosphorus is needed.

The photo shows a grazing experiment being carried out by the farmers in the Mount Bryan district. The left hand paddock easily carries three sheep per acre, with only one hundredweight of superphosphate, the right hand paddock is carrying six sheep per acre, but needs four hundredweights of superphosphate per acre annually.

e.g. If the maintenance level is 6 lb./year you will need:

$$\frac{6 \times 100}{8.6} = 70 \text{ lb. superphosphate}$$

or

$$\frac{6 \times 100}{19} = 32 \text{ lb. Double super}$$

In cereal areas the maintenance rates suggested are adequate for a crop and the following year's pasture. It will usually be best to apply the whole

maintenance rate with the crop. This ensures that the crop is adequately fertilised and saves time by avoiding application in the pasture year.

In the high rainfall pasture areas it is quite possible that fertiliser can be left off for two to three years if the stocking rate is less than two sheep per acre. However, a further test should be made after that period to see whether this practice can continue. High stocking rates will require annual dressings and may require rates somewhat higher than the suggested maintenance. Again, each situation needs separate consideration, and discussion with an adviser is strongly suggested.

The balance sheet approach

The discussion presented is designed to suggest the sort of approach one should adopt in using a single isolated P-test to advantage. The suggestions are necessarily rather generalised and farmers having tests done for the first time are advised to discuss the implications with an adviser.

A single test is most useful on new land or other land where the history of fertilisation is not known. However, the full value of soil testing is only realised when a paddock is re-tested periodically. In cereal areas paddocks might be tested prior to each crop; in pasture areas it is suggested that tests be carried out every three years.

By re-testing, the effectiveness of the fertiliser programme adopted since the last test can be assessed. For instance, the original test might have been 15 p.p.m. in an area where the standard is 25 p.p.m. If after three years the paddock is re-tested at 22 p.p.m. then the programme has clearly been satisfactory. If it is 10 p.p.m. the amount applied has been insufficient – the soil has been depleted and higher rates of fertiliser are needed.

This way of using soil tests has been called the balance sheet or budgetting approach. It is the most logical way of making the best use of soil tests as an aid in fertiliser decisions.