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FERTILISERS FOR THE WHEATBELT

A review of fertiliser research findings and recommendations for fertiliser applications to crops and pastures in the 12 to 15 inch rainfall areas

By W. J. TOMS*

NOT long ago, fertiliser to the cereal grower meant only superphosphate for cropping. Today, phosphorus, sulphur, nitrogen, copper, zinc and molybdenum are all important, and the needs of improved pastures must be considered as well as those of cereals.

We must now know what type of each fertiliser to use, what rate, the best method of application and how long the effect of the fertiliser will last.

Numerous experiments are being carried out to find the answers to these questions. Each year, more than 300 experiments with crop and pasture plants are carried out in a research programme by advisers in the Wheat and Sheep Division, and research officers in the Plant Research Division.

Phosphorus and sulphur

Superphosphate is still the most important fertiliser in the cereal growing areas, where its main use is to overcome phosphorus deficiency. Super also contains sulphur and if it were not for this, sulphur deficiency would probably be widespread throughout the agricultural areas.

Sulphur is largely contained in the organic matter of the soil and is released as this decomposes. The sulphur is then available to plants, but it is also readily leached (washed out) from the soil. After many years of super applications the soil phosphorus level is built up because phosphorus is not easily leached, but sulphur does not build up nearly as much. This means that as the rate of super applied each year is reduced there may come a time when the plants do not receive enough sulphur. This will mainly happen in areas of moderate or high rainfall where leaching is most severe.

Apart from one instance reported in 1967, we have not seen sulphur deficiency in the 12 to 15 in. rainfall areas where phosphorus deficiency is corrected by super application. However, if we consistently used fertilisers which contained phosphorus but no sulphur, sulphur deficiency could become very common.

This could happen if compound fertilisers or "triple super" containing little sulphur were used on both crop and pasture. In the wheatbelt however, it is likely that non-sulphur phosphorus fertilisers could be used for cropping as long as pastures were topdressed annually with super.

It will be necessary to determine the minimum annual rates for both phosphorus and sulphur on old crop and pasture land, and a number of experiments have been started to determine these rates.

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This article is based on a talk delivered to a meeting of farmers and farm management consultants at Quairading in mid. 1967. The information presented is largely from the results of the collaborative research programme carried out by advisers of the Wheat and Sheep Division and research officers of the Plant Research Division of the Department of Agriculture.
Rates of superphosphate

Although we know that super will nearly always provide the necessary sulphur, it is still important to know the most economic rates of application to provide phosphate for crops and pastures. Experimental results tell us these rates fairly easily for crops, but for pastures, where the cash value of feed is not easily determined, this is more difficult. One assessment of the economic rate for pasture is that which gives about 90 per cent. of the growth given by fully adequate super.

In deciding rates of super, each farm has its own special problems, besides soil type and past super history. These include stock numbers, pasture quality, managerial ability and so on. However, the results of a large number of experiments carried out by the Department of Agriculture over many years do give a guide to the rates of super which will give best results.

The super requirement of crops on new land is about 200 lb. per acre, and of pastures about 170 lb. per acre. This requirement falls progressively as the amount of super previously applied increases, until it remains at a constant, fairly low level. This constant rate is termed the maintenance rate and for crop and pasture it would be something like 50 lb. per acre.

The results are of course average—if high rates of super had been applied over the last few years, lower rates would be recommended. If lower rates or less frequent applications had been given, a higher rate of super might be needed.

For pasture, super responses in many experiments have been obtained from much higher rates in the second year than in the first, or establishment year. This is because the super is drilled in with the seed in the first year, whereas it is placed on the surface in the second year—where it is less available to the plant. Also, pasture growth in the first year is generally much less than in the second year, so less super is required.

Soil testing

Soil testing is often advocated as a basis for recommendations for super application rates. Numerous experiments have been planted in a Department of Agriculture programme (organised by Mr. W. Bowden, of the Plant Research Division), to assess the value of soil testing for this purpose. However, results so far have not been better than predictions by the Department’s district advisers, although soil tests may have a use for particular soil types, or perhaps in modifying recommendations made by advisers. The CSIRO is also investigating chemical soil tests to see whether various modifications can improve present methods, but it is unlikely that we will have an accurate soil test in the near future.

Early topdressing of pastures

Because farmers must take part of their super requirements early, it is important to know whether early-delivered super can be applied at the time of delivery. Because of the effect of rain or dews the efficiency of early-applied super is less than that of super applied at seeding and this loss in efficiency can be very high on gravelly soils which require high rates of super for maximum growth. Sunlight and normal pasture or stubble fires are not important.

None of our experiments have shown a measurable difference in efficiency between super applied early (December) and applied late (April) on land that requires only a low rate of super for maximum pasture growth.

Although little information is available so far, it appears that early topdressing of super would be reasonable on soils needing less than 80 lb. per acre for maximum pasture growth. This assumes that December application would be at least 90 per cent. as efficient as April application.

Drilled or broadcast super for crops?

More information is also needed on the use of broadcast super for cropping. However, the following points give a guide to the use of broadcast super—

- Where medium to high (over about 80 lb. per acre) rates of super are needed for maximum grain yield, rates of broadcast super will need to be about double those for drilled super.
- Where only low rates of super are needed for maximum yields, losses in efficiency are likely to be relatively smaller.
The earlier that super is broadcast for cropping, the greater is the chance of loss in efficiency.

In some cases where farmers claim equal yields from broadcast and drilled super, they are in fact getting no response to super at all.

Most farmers who intend to broadcast part of their super would be prepared to drill an additional 35 lb. per acre at seeding.

Considering these points, my personal conclusions would be:

1. When more than 80 lb. super per acre is needed for maximum yields drill all the super.
2. When less than 80 lb. per acre is required for maximum yields, drill 35 lb. per acre and broadcast one and a half times the difference between 35 and the rate that should have been drilled. For example, if 75 lb. per acre should be drilled, broadcast 60 lb. per acre and drill 35 lb. per acre.
3. If you need less than 80 lb. super per acre and plan to broadcast it all, it is probably going to cost you money—either because of reduced yields, or because of the cost of extra super needed.

An example

Consider the case where 70 lb. super per acre is the best rate to drill. Top-dressing 140 lb. per acre in April would cost about $1.90.*

For super purchased in bags and allowing nothing for drilling or short term storage costs, 70 lb. per acre could be applied for 90 cents. This is a difference of $1 per acre. However, since we are applying a higher rate of super with the broadcast application, it will be possible to reduce rates in subsequent years. Allowing a 50 per cent. residual effect for the additional super broadcast, this difference in cost might be more like 50 cents.

If by using broadcast super the whole crop goes in an average of one day earlier, and if yields are increased by one bushel for each week of earlier planting (which experimental results indicate could be reasonable), this would mean an increased return of about 17 cents per acre, and reduces the loss to about 33 cents per acre. You may be prepared to suffer this loss just for the physical convenience of not handling super—that is, of course, if your contractor spreads your super evenly. If he does not, your losses could be considerable.

Broadcast super for cropping should be applied as close to the break of the season as possible, otherwise losses due to early application may be nearly doubled since double the rate of super has to be applied.

Sources of phosphorus

The Department of Agriculture has compared a number of different sources of phosphorus, such as basic slag, ground rock phosphate, calcined rock phosphate and other treated rock phosphates. These sources, at least in the first year or two after application, have not been as effective as superphosphate.

In 1966, a “triple” super was tested at a number of sites. It appears that at equal phosphorus rates, this fertiliser is as good as normal super as a phosphorus source. In two experiments however, super gave higher yields than “triple” super, but this was shown to be due to the sulphur content of super. At least in some situations therefore, it seems that concentrated superphosphate may not be as suitable as super.

Copper and zinc

When evidence of widespread copper and zinc deficiencies in Western Australia was first obtained, recommendations of application rates for these elements were based on limited experimental results. It was realised that in some situations the recommended rates would not be ideal, but it was better to apply them than to wait until all the different situations had been investigated.

The recommended rates worked fairly well, and experiments in the 1950's concentrated on defining areas of response to copper and zinc rather than determining minimum rates of application.

A few years ago an assessment of all our copper and zinc experiments indicated that we obtained much larger increases in yield on gravelly soils than on sands, and

*Figures in this section are based on June, 1967 prices.
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that in areas where zinc applied alone reduced yields, copper and zinc applied together gave lower yields than copper applied alone—in other words, the ratio of zinc to copper was apparently too high.

The recommendations were altered and at the same time Mr. Gartrell, of the Plant Research Division commenced numerous experiments to test copper and zinc application rates. In general, these have supported current recommendations of 5 lb. copper sulphate and 1.5 lb. zinc oxide for gravels, and half these rates for sands.

When the copper and zinc recommendations were changed, experiments were also started to study the effect of these changes on the residual value of the applications. These include both grazing and cropping experiments. Although a number of such experiments have been carried out in previous years, there is no evidence that a second application of copper is warranted for cropping in the medium and lower rainfall areas. Therefore, at this time, we would recommend that copper should be applied only once to any paddock—as long as it receives recommended rates.

Copper sulphate is the only copper source used for fertilisers in Western Australia. In the past, various copper ores have been used and many (when finely ground) are quite satisfactory. However, unlike the ores, copper sulphate is a uniform product and can be used with more confidence.

Copper and stock

By world standards, our pastures are low in copper, in spite of the large amounts of copper fertiliser that have been used. However, copper deficiency in grazing stock is now rarely recognized in the West Australian wheatbelt.

This could be due to a number of factors:

- Copper is much more available to the animal in dry feed than in green feed and our long period of dry feed helps the animal to get more copper.
- Sheep often have access to paddocks of heavy land where there is no copper deficiency and can store enough copper in their livers to see them through lean periods in copper-deficient paddocks.

Zinc

Oats are more sensitive to zinc deficiency than other crop plants, and as long as no symptoms (blackened lower leaves) are seen on oats, an area will have sufficient zinc for other cereals or pasture.

Zinc deficiency has not reappeared on land that has been treated once with recommended rates of zinc fertiliser.

Plain super contains small but very important amounts of copper and zinc, although the level present depends on the origin of the rock phosphate used. Plants grown with a zinc-free source of phosphorus may be acutely zinc deficient, yet plants grown with plain super can be largely free of symptoms. Such impurities may be sufficient to replenish the soil's copper and zinc so that further applications are unnecessary after the deficiencies are cured.

Molybdenum

Use of molybdenum is warranted on most light land in the 12 to 15 in. rainfall belt at the rate of one ounce of molybdenum equivalent per acre. Molybdenum should never be used more than once on one paddock. In the high rainfall areas, one dressing has lasted 10 years or more, and in the wheatbelt the residual effect should be much longer.

Since high levels of molybdenum may induce a copper deficiency in animals, it is important not to use too much molybdenum. Also, molybdenum should never be sprayed on dry or green pastures that are to be grazed within a few months of application because the amount of molybdenum taken in by the animals could be dangerous.

Nitrogen

The Table below summarises current recommendations for nitrogen application to wheat crops. It was prepared by Mr. M. G. Mason, of the Plant Research
Recommended rates of urea for wheat

<table>
<thead>
<tr>
<th>Annual Rainfall</th>
<th>New land, first crop</th>
<th>New land, second crop</th>
<th>Old land, legume, first crop</th>
<th>Old land, legume, second crop</th>
<th>Old land, no legume, first crop</th>
<th>Heavy land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 13 in.</td>
<td>30</td>
<td>35</td>
<td>0</td>
<td>30</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>13-18 in.</td>
<td>50</td>
<td>60</td>
<td>30</td>
<td>75</td>
<td>65</td>
<td>0</td>
</tr>
</tbody>
</table>

(Based on mid-1967 prices.)

Division and is based on all trials with nitrogenous fertiliser since 1959. The figures should be used in conjunction with other relevant facts rather than as definite recommendations because results will vary markedly on different farms, depending on individual farm situations.

In the 1960’s, conditions in the eastern wheatbelt have been more favourable to nitrogen response than would be expected on the average. Nevertheless, the figures should give useful trends.

If the indicated rates were used there would be a risk factor of about 25 per cent. —in other words, an average of one crop in every four would not give a profitable response. An interesting point is that response to nitrogen has tended to be as great or greater with second or succeeding crops after legume than with crops on new land.

For practical purposes, the residual value of nitrogen in the year following application is negligible, although when high rates are used a large residual effect may be obtained.

Of the nitrogen sources tested (urea, sulphate of ammonia, calcium ammonium nitrate, sodium nitrate, ureaform, and anhydrous ammonia), urea is the best buy. However, urea has a major disadvantage in that it can not be mixed with super. It is also risky to let it drop down the drill hose with the seed because it may harm the germinating seed if a dry spell follows seeding. Stands have been thinned out even with rates as low as 40 lb. urea per acre.

Since it will be manufactured at Kwinana, anhydrous ammonia has become an important source of nitrogen. However, application rigs are not suitable for delivering low rates of ammonia. Twenty pounds of anhydrous ammonia is equivalent to 36 lb. of urea, and such low rates cannot be uniformly applied. Even rigs used for experiments do not apply low rates satisfactorily and this makes comparison of ammonia and other sources more difficult.

Anhydrous ammonia has given its best results when placed at depth into moist soil and as close to seeding time as possible. In very sandy soils, placement as deep as 8 in. has given best results, and a depth of 6 in. or more in most sandy-surfaced soils is desirable.

When anhydrous ammonia is applied at seeding and at depth, it appears to be more effective than urea, even though it is not so available to plants early in the season. In most cases however, ammonia is obviously going to be applied a considerable time before planting and will probably be applied at a depth shallower than ideal. Under such conditions it should not be more efficient than urea.

A rate of 40 lb. per acre applied on a farm 150 miles from Perth costs $4.38. Urea at 72 lb. per acre, including freight to siding and farm and including 30 cents per acre application charge, would cost $2.64. Thus, the ammonia would cost $1.74 extra per acre.

By using a special coulter, and by crossing the rows, ammonia can be applied to crops after they have started growing. In one trial testing this method, response was reduced by up to four bushels an acre when the ammonia was applied two or four weeks after planting. It is likely that part of this reduction was caused by physical damage to the plants.

Currently used sources of nitrogen are not particularly efficient and less than half the nitrogen applied usually finds its way into the plant. From the results of a large number of “time of application of nitrogen” experiments it is fairly clear that nitrogen should be applied as close to seeding as possible in the eastern wheatbelt. In areas of medium or high rainfall, at normal times of planting, nitrogen can be applied up to three weeks after seeding. Big losses can occur if nitrogen is applied a few weeks before planting.
Compound fertilisers

Compound nitrogen-phosphorus fertilisers came on the market recently and are now being tested widely throughout the wheatbelt.

Compound fertilisers could affect seed germination, but it is unlikely that they would be released if they were dangerous in this regard. Their main disadvantage (apart from price), is that once the level of phosphorus to be applied is determined, a fixed level of nitrogen must be used. It is therefore likely that either too much or too little of one of the components will be applied.

Since they are drilled with the seed, compound fertilisers should have some advantage over super and urea combinations because the nitrogen should be less available to weeds. From the 1966 results published by CSBP it appears that the efficiency of the compound fertilisers is similar to that of super-urea combinations.

Potassium

Most sandy soils have low levels of potassium and we have seen potassium deficiency on pastures at a number of places in the cereal growing areas. However, areas deficient for pasture are not generally deficient for crop although a response to potassium by crop has been obtained at Wongan Hills Research Station.

Just as nitrogen usage has been greatly stimulated by reduced prices, any major reduction in the price of potash fertiliser could encourage considerable use of potash on some sandy soils of the wheatbelt. At present however, a large consumption of potassic fertiliser in wheatbelt areas appears unlikely.

ACKNOWLEDGMENTS

This article has drawn heavily on the results of work carried out by numerous officers of the Plant Research and Wheat and Sheep Divisions of the Department of Agriculture over a number of years. Particular use has been made of information supplied by Messrs. W. J. Cox (rates of phosphate for cereals), J. W. Gartrell (trace elements) and M. G. Mason (nitrogenous fertilisers for cereals), all of the Plant Research Division.

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