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LEGUMES OR ARTIFICIAL NITROGEN?

By N. J. HALSE, Research Officer, Plant Research Division

Choosing between legumes and artificial nitrogen is not the problem which many farmers are making it. This article deals with the choice in the mixed cereal and sheep farms of the Western Australian wheatbelt.

THE development of ley farming in Western Australia has been rapid. Since 1946, the advantages of clover leys have been demonstrated on research stations such as Wongan Hills, and on many farms.

Although there are still large areas not sown to annual legume improved pastures, it has been generally accepted that good farming requires them and that, in time, all farms will be sown with improved pasture legumes. A challenge to this idea has arisen from two causes; the extensive research into the use of artificial nitrogen for cereal crops, and the improvement in manufacturing technology leading to substantial reductions in the price of nitrogen fertiliser. Good crops can be grown on poor soils with nitrogen fertiliser and there is a general interest in the extent to which such fertiliser will eliminate the need for legumes.

USING NITROGEN FERTILISER ON THE FARM

Artificial nitrogen can be used on the farm to replace legumes for cereal cropping only, or for both cereals and pastures. Whether it will be better to use fertiliser or legume nitrogen will depend on—

- whether pasture legumes can be grown,
- what proportion of the farm will be cropped. (If the whole area is in crop, pasture legumes must be excluded).

For the purposes of this article it is assumed that it is possible to grow pasture legumes on all farms in the wheatbelt. Although establishment is more difficult and production is lower in the drier areas, pasture legumes currently available can persist in all parts. Difficult soils, such as deep white sands or wet valley clays, do not favour legume establishment, but neither do they make up substantial proportions of many farms.

It is further assumed that, for a wheat-belt farm, the property will remain a cereal—grazing—livestock operation instead of being cropped completely. Three reasons are advanced for this assumption, although the first two are applicable only in the short term:

(i) Operational

Few farms or farmers are geared to crop the whole farm and cropping bigger areas would require large capital outlays to overcome substantial deficiencies in farm machinery. Farm labour would also be insufficient.

(ii) Product sales

Wheat marketing is meeting increasing difficulty and an increase of 200 million bushels in the West Australian harvest would probably precipitate an industry crisis.
Continuous cropping could bring about substantial soil structure and soil erosion problems. Continuous cultivation would damage soil structure and, on sandy soils, wind erosion would be severe if stubble burning left the whole countryside bare of ground cover.

ALTERNATIVE FARM SYSTEMS
Four different combinations of nitrogen fertiliser and legume pasture could be used as farm systems. Pastures could have legumes and grasses or just grasses, and nitrogen could be applied to crop and pasture, applied to the crop only, or not used at all.

Non-legume pastures
Nitrogen applied to crops and pastures
Research workers believe the use of nitrogen on pastures in the wheatbelt is uneconomic and the limited experimental work carried out has supported this opinion. Therefore it is very difficult to make definite statements about the application of nitrogen to both crops and pasture.

Possibly by using very cheap nitrogen on grass pastures in winter (with the high winter production of grasses) and using stubbles to overcome the low feed value of dry grass in summer, an economic system could be devised. However, a lot of research would have to be done before such a system could be developed. Until then, a pasture-crop system based entirely on nitrogen fertiliser could not be recommended to farmers.

Nitrogen applied to crops only
The use of nitrogen on crops only is already widely practised. However, farmers using it are missing out, economically, both on crop and animal production—particularly on the lighter soils of lower initial fertility.

Legume pastures
No nitrogen fertiliser used
Legume pastures were used on well-managed farms, and on research stations, for a number of years before the general use of nitrogen fertilisers. Farmers using the system made big gains compared with farmers with non-legume pastures. The following rough budget, for a rotation involving three years of legume pasture followed by cropping on light land, shows why:

Cost of establishing and maintaining legumes (3 years)—

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
<td>$1.50</td>
</tr>
<tr>
<td>Seeding operation</td>
<td>$1.50</td>
</tr>
<tr>
<td>Additional super</td>
<td>$2.50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$5.50</strong></td>
</tr>
</tbody>
</table>

In an experiment at Wongan Hills Research Station, subterranean clover pasture produced an extra 7 pounds of wool per acre compared with volunteer pasture—this should be regarded as conservative.

Additional wool, 7 lb. per acre for 3 years = 21 lb.

\[ 21 \text{ lb.} \times 40 \text{c per lb.} = 8.40 \]

The return in extra wool production is thus more than enough to cover the cost of seeding the legume pasture—even if it has to be reseeded after each crop cycle. In addition, the extra superphosphate applied will lower the long term requirement.

The nitrogen fixed by the legume will vary widely but over the three years the soil nitrogen would increase by at least 100 lb. of actual nitrogen per acre. This is equal in value to at least $7.50 of urea fertiliser. The added nitrogen may not be all recovered as efficiently as applied nitrogen but it is an additional benefit.

Perhaps the most striking benefit from legume pasture is that it increases the crop yield response of successive crops to extra nitrogen fertiliser. An example of
this is shown in the figure. The extra response to nitrogen is caused by the improvement in non-nitrogen components of soil fertility—these include changes in soil structure, soil organic matter and water holding capacity.

**Nitrogen applied to crop**

This farm system is the one which is recommended without hesitation at present. Although the details would vary between soil types and rotation methods, the overall principle of using legume pastures to obtain nitrogen build up and improved fertility, and then applying nitrogen fertiliser wherever it is of economic benefit, will remain the same. In addition, the one disadvantage which has applied in the past, oestrogenic potency of subterranean clover pastures, will disappear with the general use of non-oestrogenic strains of clover.

Where only a single crop is taken between periods of legume pasture, the advantage of applying nitrogen is not great. However, if multiple cropping is practised, very substantial gains can result from applying nitrogen fertiliser to subsequent crops. An example on a second crop, is shown in the figure.

On a large proportion of experiments carried out by the Department of Agriculture, economic benefits were obtained by applying nitrogen to even the first crop after legumes. The results from such experiments are embodied in the current recommendations for the use of nitrogen fertilisers.

Farmers should know when they will obtain economic benefits from nitrogen fertilisers. Although recommendations have been worked out in some detail it is expected that farmers will, with experience, modify such recommendations as those in the table to suit their own paddock situations. Nitrogen fertilisers are of particular benefit with multiple or successive cropping and can enable the farmer to manipulate his cropping programme and increase the overall flexibility of his paddock rotations.

**Conclusions**

Various farming systems have been discussed for the cereal and livestock farming areas. Within such areas will be some exceptional situations, such as virgin land being brought into production or areas of soil which will not grow existing legumes. On these areas nitrogen fertiliser is the most economic way to obtain high production.

Over most of the wheatbelt it is suggested that there is not a choice between using fertiliser or legume nitrogen—both should be used. This suggestion is not a compromise because fertiliser and legume nitrogen are not alternatives.

The primary decision is that pasture legumes should be used in the farm system because of the substantial benefits they confer. In many rotational situations, especially on lighter soils, nitrogen fertilisers have a substantial but secondary role in increasing production.

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**RECOMMENDATIONS FOR UREA RATES ON WHEAT**

<table>
<thead>
<tr>
<th>Situation</th>
<th>Under 13 in. Rainfall</th>
<th>13 in. to 18 in. Rainfall</th>
<th>Over 18 in. Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy land</td>
<td>0</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>New light land—1st crop (fallow)</td>
<td>45</td>
<td>50–60</td>
<td>80</td>
</tr>
<tr>
<td>New light land—1st crop (non-fallow)</td>
<td>45</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>New light land—Subsequent crops</td>
<td>45</td>
<td>90</td>
<td>50</td>
</tr>
<tr>
<td>Old light land—1st crop after legumes</td>
<td>45</td>
<td>80</td>
<td>70–75</td>
</tr>
<tr>
<td>Old light land—2nd crop after legumes</td>
<td>45</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Old light land—3rd crop after legumes</td>
<td>40–70</td>
<td>60–65</td>
<td>80</td>
</tr>
<tr>
<td>Old light land—1st crop (non-clover land)</td>
<td>40</td>
<td>60–65</td>
<td>80</td>
</tr>
<tr>
<td>Old light land—2nd crop (non-clover land)</td>
<td>70</td>
<td>60–65</td>
<td>80</td>
</tr>
</tbody>
</table>

30 lb. of urea supplies the same amount of nitrogen as 68 lb. of ammonium sulphate, 17 lb. of anhydrous ammonia, or 41 lb. of ammonium nitrate.
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