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Effect of fallowing on cereal yields

By D. Tennant*

The practice of fallowing land to keep it free from plant growth for nine to 12 months before sowing, made a significant contribution to early development of cereal areas in Western Australia. The benefits attributed to fallowing included:

- Conservation of moisture from rainfall for use during a crop's growing season.
- Greater availability of soil nitrogen from breakdown of bound soil nitrogen into nitrogen forms more suited for plant use.
- Better weed control.
- Better seed-bed preparation.
- Better control of insect pests and diseases.
- Earlier seeding.

On average, yields were 30 to 40 per cent higher with fallow than non-fallow.

Since the early 1930s advantages of fallowing were gradually eroded by improving technology. Rapidly improving machinery allowed faster and more efficient land preparation; chemical weed and pest control measures became available; and new disease-resistant crop varieties were developed.

Over the same period, leguminous pastures were shown to significantly improve stock carrying capacity and soil fertility. This was reflected in time by substantial increases in light land farming and in overall pastoral activity.

In a climate of steadily increasing wool prices it soon became apparent that benefits from fallowing on light clover ley land were only marginal at best, and that fallowing was largely uneconomic in medium rainfall areas. Since the mid 1950s fallowing has not been generally recommended as a land preparation practice for cropping.

Benefits from moisture conservation with fallowing have nonetheless continued to contribute to the success of cropping on heavy land in light rainfall areas. The area under fallow in Western Australia (Figure 1) remained fairly constant throughout the 1940s, 1950s and 1960s.

Changing economic conditions in the early 1970s resulted in a situation in which reliable crop returns appeared more important than maintaining maximum pasture area. As a result, the Department of Agriculture renewed investigations into fallow.

Fallowing for moisture conservation

Fallowing allows the conservation of moisture from rainfall for use during the crop's growing season. As rainfall is the most important limitation on yields over a considerable part of the wheatbelt, fallowing offers a means of conserving soil moisture, increasing

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Non fallow: 2nd year of 2 year crop treatment</td>
<td>1056 (26)</td>
<td>1722 (130)</td>
<td>590 (28)</td>
<td>533 (22)</td>
<td>243 (46)</td>
<td>1734 (51)</td>
</tr>
<tr>
<td>Non fallow</td>
<td>1547 (47)</td>
<td>1933 (132)</td>
<td>637 (31)</td>
<td>506 (31)</td>
<td>323 (46)</td>
<td>1786 (74)</td>
</tr>
<tr>
<td>Short summer fallow</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>2012 (102)</td>
</tr>
<tr>
<td>Chemical fallow</td>
<td>1445 (52)</td>
<td>1756 (136)</td>
<td>1063 (45)</td>
<td>740 (49)</td>
<td>407 (49)</td>
<td>1917 (83)</td>
</tr>
<tr>
<td>9 to 10 month fallow</td>
<td>1570 (60)</td>
<td>1717 (139)</td>
<td>1410 (59)</td>
<td>750 (50)</td>
<td>439 (57)</td>
<td>1885 (86)</td>
</tr>
<tr>
<td>12 month fallow</td>
<td>1792 (80)</td>
<td>1583 (146)</td>
<td>1540 (91)</td>
<td>1043 (77)</td>
<td>637 (67)</td>
<td>1881 (95)</td>
</tr>
<tr>
<td>Growing season rainfall</td>
<td>270 mm</td>
<td>307 mm</td>
<td>245 mm</td>
<td>165 mm</td>
<td>154 mm</td>
<td>181 mm</td>
</tr>
</tbody>
</table>

* Soil moisture results in parentheses.
+ Short fallow treatment not effective due to lack of summer rainfall.
crop yields and insuring against poor growing season rainfall.

A series of trials were begun in 1972 on a sandy clay-loam soil at the Department of Agriculture's Merredin Research Station. Measurements were made of the effects of various fallow treatments on soil moisture storage and wheat yield. The fallow treatments were established in the year preceding cropping and included:

- Twelve month fallow with initial cultivation done late May or early June.
- Nine to ten month fallow with initial cultivation done late July to early August.
- Chemical fallow with weed control achieved through use of the herbicide Gramoxone applied early to mid August.
- Short summer fallow with cultivation after summer rains if any.

These treatments were compared with non fallow which was left in pasture during the treatment establishment year, and a two year cropping treatment.

Depending on season, soil moisture storage at planting was generally greater with fallow than non fallow (Table 1). Where fallow was imposed through cultivation, 12 month fallow from early cultivation gave greater soil moisture storage than the nine to ten month fallow. Less soil moisture was stored with the chemical fallow than nine to ten month fallow due largely to later weed kill. In each fallow establishment year, optimum time of herbicide application occurred from two to four weeks after cultivation for nine to ten month fallow. Average additional soil moisture storage after fallow was 33 mm with 12 month fallow, 15 mm with nine to ten month fallow and 9 mm with chemical fallow.

The short summer fallow was effective for the first time in 1978 following cultivation in March after heavy rains in late February. Subsequent soil moisture storage at planting was highest with the short summer fallow. Probable reasons for this include:

- Surface sealing after the heavy February rains on the cultivated fallow treatments established the previous year.
- Less evaporative loss from summer fallow from the mulching effect of cultivation after the February rains.
- Greater infiltration of early winter rains into the loose surface of the short summer fallow treatment.

Results generally demonstrated increasing yields from increasing moisture supply either through fallowing or rainfall (Table 1). Analysis of the data suggests that 100 to 120 mm of growing season rainfall is needed before any grain is set at all. Beyond this, each additional mm of rainfall gave a yield increase of the order of 7 to 10 kg/ha. Each additional millimetre of stored soil moisture at planting gave yield increases of the order of 10 to 16 kg/ha.

Soil type

The ability of fallow to store soil moisture for crop use is related to soil type.

In detailed studies in South Australia, fallowing on coarse textured (sandy) soils gave little additional soil moisture storage at planting. Moisture storage capacities of sandy soils are low, and much of the moisture stored over winter and spring is lost through vapour movement during the hot summer months.

Because of the low storage capacities of sandy soils, growing season rainfall is usually enough to wet these soils to full capacity to the maximum depth of crop root penetration. Fallowing therefore makes little improvement to soil moisture.

Best soil moisture storage after fallow was recorded in the South Australian studies on fine-textured (heavier) soils and soils with clay subsoils. With the sandy soils of South Australia, the average increase in moisture storage due to fallowing was only 9 mm, with a maximum increase of 38 mm. For fine-textured soils, the average increase was 38 mm and maximum increase 125 mm.

To get the best value from a fallow, the South Australian study recommended that the soil should have a minimum storage capacity of 125 mm of moisture in the top 1.2 metres. Such a soil would be at least a sandy loam. A coarse sand has only 50 to 85 mm of storage in the top 1.2 metres.

Rainfall

Early work in Western Australia concluded that in dry seasons or districts, higher yields with fallow were largely due to moisture conservation. With increasing rainfall, the improved availability of soil nitrogen and improved soil tilth due to fallowing, were seen to have increasing effect. "Wet" and "dry" conditions were not defined.

From a review of data available for South Australia up to 1949 it was concluded that moisture conservation was the major contributor to higher yields in areas with less than 250 mm rainfall annually. Moisture conservation had decreasing effect to 420 mm annual rainfall. With more than this rainfall the benefit from fallow was considered to be totally due to greater availability of soil nitrogen.

A later study found responses to 433 mm of April to October rainfall. This figure was consistent with the 450 mm of April to October rainfall reported for northern New South Wales.

Similar data is not available for Western Australia. However, several interesting points arise from re-arrangement of data obtained at Merredin Research Station over the periods 1925 to 1937 and 1973 to 1978 (Table 2).

- In those years in which non fallow yields were below 1000 kg/ha (Table 2A), 12 month and nine to ten month fallow yields were significantly higher than with non fallow. Average yields were 93 and 52 per cent higher respectively.
we can expect the following for crops

On the basis of these rainfall frequencies and of the rainfall-yield relationship, growing season rainfall exceeded 100 mm in one of every ten. On average, January to April rainfall was below 225 mm in five to six years in ten. In the same period, growing season rainfall averaged 226 mm.

300 mm in 72 per cent of all years for the periods 1924 to 1937 and 1973 to 1978. The summary of results in the earlier trials of the 1924-37 series was limited. Indications are that summer fallow can serve to increase infiltration from early winter rains. Normal practice at Merredin is to cultivate for short summer fallow or cropping on receipt of about 15 to 20 mm rainfall. On Merredin Research Station rainfall in excess of 15 mm in either January, February, March or April has occurred in at least 70 per cent of all years over which records are available.

Fallow or non fallow at Merredin

Annual rainfall at Merredin was below 300 mm in 72 per cent of all years for which records are available. Over the same period, growing season rainfall was below 225 mm in five to six years in ten. On average, January to April rainfall exceeded 100 mm in one of these years.

On the basis of these rainfall frequencies and of the rainfall-yield relationships apparent in Table 2, we can expect the following for crops grown on heavy land in the Merredin area:

- Fallow yields should exceed non fallow yields in seven years in ten.
- Fallow yields should be markedly higher than non fallow yields in four to five of these years.
- On average, fallow yields should exceed non fallow yields by 30 to 40 per cent with the 12 month fallow or 5 to 10 per cent with the 9 to 10 month fallow.

Higher yields with fallow than with non fallow can confer a significant economic risk benefit relative to conventional cropping. As an example, yield frequencies computed for Merredin (Table 3) show that yields with 12 month fallow were below 1000 kg/ha in only one year in ten if at all. Yields with conventional non fallow cropping were below 1000 kg/ha in four years in ten. Benefit from nine to ten month fallow was marginal.

Time of fallowing

Time of fallowing treatments were included in 19 trials at Merredin over the periods 1924 to 1937 and 1973 to 1978. The summary of results in Table 4 lists average yields from fallowing 1st week in June, 1st week in July and 1st week in August. Fallowing was not always consistent with these times. Late fallow of the earliest trials of the 1924-37 series was done early to mid August while that of the 1973-78 series ranged around late July.

The results of the trials between 1930 and 1937 illustrate the effect of a delay in fallowing. Yields were 30 per cent more with the early June fallow, and 19 per cent more with the early July fallow than the early August fallow. The increasing fall off in yield after mid to late July reflects rainfall distribution; after mid July, availability of rainfall for recharge of soil moisture falls off rapidly.

Information on short summer fallow is limited. Indications are that summer rains can reduce the benefit of fallow (Table 2), and that summer fallow can serve to increase infiltration from early winter rains. Normal practice at Merredin is to cultivate for short summer fallow or cropping on receipt of about 15 to 20 mm rainfall. On Merredin Research Station rainfall in excess of 15 mm in either January, February, March or April has occurred in at least 70 per cent of all years over which records are available.

Number of cultivations for fallow

Erosion hazard is a major problem of fallowing. In the past, when soil tillage was considered to have an important role, repeated cultivation often resulted in serious soil loss, particularly on light land. The following procedures were established in the 1940s to combat erosion losses:

- Reduce the number of cultivations.
- Maintain the fallow in a cloudy condition. Land cultivated after pasture was found to retain cloddiness.
better than previously cropped land.
- Contour cultivation and contour banks served to reduce erosion from run-off.
- Ridged cultivation at right angles to prevailing winds served to reduce wind erosion.
- Manage the land to increase the size and stability of soil aggregates. This was achieved by crop rotations which included a period of pasture.
- Use implements which do a minimum of damage to soil aggregates.
- Work implements at low speeds.

A series of trials at Merredin Research Station between 1915 and 1937 compared the following treatments: cultivated winter, spring and summer after falls of 6 mm and over and before seeding; cultivated winter, spring and before seeding; and cultivated winter and before seeding. On average yields were 7 per cent higher with multiple cultivation than with winter and seeding cultivations only.

Apart from cultivation at seeding, the 12 month fallow of the 1973-78 series of trials included initial cultivation in winter and follow up cultivation in spring. Early results suggest an average 5 per cent yield benefit from this extra spring cultivation.

Type of fallow

The current practice of chemical fallow after seed set adds little to total moisture storage. There is evidence to suggest that chemical weed control is as efficient as cultivation for moisture conservation when it is done at the same time. However, results to prove this are limited.

Fallow investigations at other locations

Rainfall frequency data for the Department of Agriculture's Chapman Research Station suggest little benefit from fallow. In only one year in ten was annual rainfall below 300 mm and growing season rainfall below 225 mm. Trials on fallowing at Chapman over the periods 1929 to 1937 and 1948 to 1958 gave yields which support this conclusion. Average yield benefits ranged from 12 per cent (1948-58 with a nine to ten month fallow) to 22 per cent (1929-1937 with a 12 month fallow). Yield responses to fallowing were evident to 375 mm growing season rainfall or 450 mm annual rainfall. All trials were done on a medium-textured, sandy loam soil.

Rainfall conditions at the Wongan Hills Research Station are more favourable than at Merredin. Annual and growing season rainfall were below 300 mm and 225 mm respectively in three to four years in ten. On average, January to April rainfall exceeded 100 mm in one of these years.

Average yield responses to fallowing at Wongan ranged from 2 per cent (1929-31, 12 month fallow) to 48 per cent (1948-58, nine to ten months fallow). Much of the difference in the post-war trials was attributed to poor weed control with non fallow and to years with lower than average growing season rainfall.

Although all the fallow trials at Wongan were on coarse-textured soils, some of these soils at Wongan Hills can store up to 125 mm of moisture to maximum depths of crop root penetration. Overall, there was no evidence to suggest a consistent yield-rainfall relationship for Wongan Hills.

At the Salmon Gums Research Station, although total growing season rainfall was below 225 mm in six to seven years in ten, high incidence of greater than 100 mm of January to April rainfall (two to three of these years) raised annual rainfall to 300 mm and beyond for six to seven years in ten. On this basis, a lesser benefit from fallowing may be anticipated for Salmon Gums than Merredin, and short summer fallow would appear to be the preferred operation. However, results to test these conclusions are limited.

### Table 3. Yield frequencies* at Merredin Research Station — number of years in ten in which specified yields were achieved

<table>
<thead>
<tr>
<th>Yields (kg/ha)</th>
<th>12 month fallow</th>
<th>9 to 10 month fallow</th>
<th>Non fallow</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>10</td>
<td>9 to 10</td>
<td>9 to 10</td>
</tr>
<tr>
<td>750</td>
<td>9 to 10</td>
<td>8 to 9</td>
<td>6 to 8</td>
</tr>
<tr>
<td>1000</td>
<td>9 to 10</td>
<td>6 to 7</td>
<td>5 to 7</td>
</tr>
<tr>
<td>1250</td>
<td>6 to 7</td>
<td>5 to 7</td>
<td>4 to 5</td>
</tr>
<tr>
<td>1500</td>
<td>5 to 6</td>
<td>4 to 5</td>
<td>4</td>
</tr>
<tr>
<td>1750</td>
<td>3 to 5</td>
<td>2 to 4</td>
<td>2 to 3</td>
</tr>
<tr>
<td>2000</td>
<td>1 to 2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Yield frequencies were derived from data obtained with:
(a) Fallow vs non fallow trials: 1925 - 1937; 1973 - 1978
(b) Time of fallowing trials: 1924 - 1937; 1973 - 1978

### Table 4. Effect of time of fallowing on yield at Merredin Research Station

<table>
<thead>
<tr>
<th>Fallowed 1st week in June</th>
<th>Non fallow 1st week in July</th>
<th>Non fallow 1st week in August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (kg/ha)</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>1924-37</td>
<td>1610 133%</td>
<td>1248 100%</td>
</tr>
<tr>
<td>1930-37</td>
<td>1807 130%</td>
<td>1376 100%</td>
</tr>
<tr>
<td>1973-78</td>
<td>1413 117%</td>
<td>1292 100%</td>
</tr>
</tbody>
</table>