Intensive approach benefits low-rainfall croppers

Low and variable rainfall is a major source of risk for many farmers, including those in the Mallee area of south-eastern Australia. This article outlines the economic and environmental benefits of opportunistic and intensive farming to manage risk and capture profits during wet seasons.

A more intensive and flexible cropping approach could better manage risk and improve water-use efficiency in low-rainfall areas.

CSIRO Land and Water, in collaboration with farmers in South Australia, Victoria and New South Wales, have developed an alternative cropping strategy for low-rainfall areas.

The approach includes an opportunistic combination of crops such as wheat, canola and legumes and matching nitrogen inputs with soil and seasonal conditions.

The main factors to consider in the strategy include the time of the seasonal rainfall break to decide on crop type, early-season rainfall as a predictor of seasonal rainfall as well as target yield, soil nitrogen and water availability at sowing.

Paddock and computer modelling studies indicated the strategy has potential to increase farm profits significantly and stabilise seasonal variations in income. The strategy can also help farmers better manage nitrogen leaching and deep drainage.

Variable rainfall risks

Low and highly variable rainfall are major sources of risk for farmers in low-rainfall areas, including the Mallee region of south-eastern Australia, where risk management is based on a low-input cropping approach.

In dryland agriculture, this attitude leads to rainfall being underused in grain production.

Water-use efficiency

Research in the Mallee Sustainable Farming Project shows that, under current practice, most wheat crops yield well below their potential (see Figure 1).

There are many causes for low water-use efficiency but low nitrogen availability is often a major factor.

The low-input approach in Mallee areas also means farmers often miss the potential to make higher returns during wetter seasons. Rainwater which is not used by nitrogen-limited, slow-growing crops will evaporate, run-off or drain beyond the root zone, potentially causing soil erosion and salinity.

While topography, land use and soil types in the Mallee make run-off unlikely, large proportions of rainfall are lost through soil evaporation and occasionally through deep drainage.

Opportunity cropping benefits

CSIRO researchers combined paddock trials and computer modelling to investigate the economic and environmental results of a more intensive and flexible cropping strategy.

In contrast to commonly used fixed crop sequences, an opportunistic selection of crops was carried out, based on the timing of the seasonal break and the risk of cereal diseases and grassy weeds.

Canola and legumes could be used as break crops in low-rainfall areas. Break crops have the potential for high profit during good seasons but are more risky partly due to high production costs.

Sowing break crops

The selection of a canola or legume crop in the rotation is mainly determined by the timing of the break of the season. The opportunity for early sowing following an early break (April–early May) significantly reduces the risk involved with these crops. Good amounts of stored soil water at sowing further reduce the risk of growing break crops.

Otherwise, wheat is the preferred option provided there are no major disease or weed problems. A high incidence of grass weeds or wheat root diseases could switch the decision towards the least preferred option such as other (more tolerant) cereals including rye or volunteer pasture.

Calculating the cropping strategy

To calculate the nitrogen fertiliser requirements for canola and cereals, the researchers considered estimated water and nitrogen availability.

Two sources of water availability were considered: plant-available water in the soil at sowing and seasonal rainfall.

Available soil water can be estimated by sampling the top one metre of the soil profile. Upper and lower limits can be gathered from paddock measurements or soil texture.

FIGURE 1 Crop yield and rainfall

Note: The figure shows wheat grain yield measured in paddocks in South Australia, Victoria and New South Wales as a function of seasonal rainfall plus change in soil water content between sowing and harvest.
Seasonal rainfall, which is obviously unknown at the time of decision-making, is the key source of risk in the system.

To account for uncertain rainfall, a forecasting rule was used which takes April rainfall as an indication of seasonal conditions. This means that if the rainfall during April is below a site-dependent threshold, then the season is considered to be probably drier than average. If April rainfall is above threshold, the season is likely to be wetter than average.

Thresholds and details of the method were featured in a previous issue of *Farming Ahead* (No. 127, July 2002).

Improved forecasting tools could be linked to these guidelines as they became available.

Target yield was calculated using a French and Schultz approach, which assumes seasonal soil evaporation between 60 and 110 millimetres and an ideal productivity of 20 kilograms of grain per hectare per millimetre of seasonal rainfall and soil-available water.

Two sources of available nitrogen for the crop were considered: soil inorganic nitrogen at sowing, which is obtained from soil sampling; and a fixed amount of nitrogen mineralisation, which was taken from measurements in the Mallee Farming Systems Project.

The fertiliser rate was calculated as the difference between crop requirement and supply from these two sources.

### TABLE 1  Gross margins and grain yields of three cropping strategies

<table>
<thead>
<tr>
<th>Year</th>
<th>Intensive</th>
<th>Cropping strategy</th>
<th>Wheat-pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gross margin ($)</td>
<td>Grain yield (tonnes per hectare)</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>232</td>
<td>2.5 (wheat)</td>
<td>232</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>1.6 (wheat)</td>
<td>-87</td>
</tr>
<tr>
<td>2000</td>
<td>234</td>
<td>1.2 (canola)</td>
<td>222</td>
</tr>
<tr>
<td></td>
<td>306</td>
<td>3.1 (wheat)</td>
<td>162</td>
</tr>
<tr>
<td>2001</td>
<td>882</td>
<td>444</td>
<td>529</td>
</tr>
<tr>
<td>Total gross margin ($)</td>
<td>36</td>
<td>71</td>
<td>102</td>
</tr>
</tbody>
</table>

Co-efficient of variation of gross margins (%) 36 71 102

Note: The results are for three cropping strategies in a paddock trial at Waikerie, South Australia. Gross margins were based on the five-year average of commodity prices and actual costs.

Source: CSIRO Land and Water.

**Paddock testing**

The feasibility of a more intensive, flexible cropping strategy and its performance in comparison with district practice was assessed in paddock trials in SA, Victoria and NSW.

Results are shown for Waikerie, SA, where annual rainfall averages 267 mm, of which...
About 66 per cent occurs during the growing season (from April to October).

The trial was carried out in coarse-textured soil from 1998–2001.

Table 1 (page 41) shows the production and economic output of the intensive cropping strategy compared with district practice (wheat–pasture with low inputs) and a fixed wheat–pulse rotation typical of higher rainfall areas.

At the end of the trial, the profit of the intensive approach was doubled and its co-efficient of variation was halved in relation to current district practice.

The main benefits of the intensive approach included the possibility of growing successive wheat crops provided there were no major biological constraints (1998–1999); the opportunistic use of canola as a break crop after an early break (2000) and the high wheat yield following canola (2001).

The fixed wheat–pulse approach illustrated the high risk of untimely sown grain legumes (1999) and the benefits of growing wheat after a legume crop (2000).

**Computer modelling**

Modelling trials were carried out with a locally tested computer simulation model combined with 44 years of weather records for Waikerie, involving seasonal rainfall variation from 53mm up to 334mm.

The studies provided insight into the mechanisms underlying more intensive cropping strategies and estimated the impact of cropping intensification on nitrogen leaching and deep drainage.

Figure 2 illustrates the long-term simulated yield response of crops managed with a fixed input of nitrogen (five kilograms per hectare of nitrogen) compared with a flexible nitrogen input aiming at matching fertiliser rates to soil and seasonal conditions.

As shown in Figure 2, low-input crops were largely unresponsive to increased soil moisture while a variable fertiliser rate accounted for a steady yield increase with increasing soil water content at sowing.

**Nitrogen leaching impact**

With an increased fertiliser rate, more intensive cropping strategies could be prone to higher rates of nitrogen leaching.

But the studies indicated no significant increase in nitrogen leaching with the more intensive approach despite a significant increase in fertiliser.

**TABLE 2 Intensive cropping approach can reduce deep drainage**

<table>
<thead>
<tr>
<th>Cropping strategy</th>
<th>Probability (percentage) of drainage events more than:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 millimetres</td>
</tr>
<tr>
<td>Intensive</td>
<td>21</td>
</tr>
<tr>
<td>Wheat–canola</td>
<td>26</td>
</tr>
<tr>
<td>Wheat–fallow</td>
<td>30</td>
</tr>
<tr>
<td>Wheat–pulse</td>
<td>21</td>
</tr>
</tbody>
</table>

Source: CSIRO Land and Water.

The average rate of nitrogen leaching calculated for the intensive approach was 0.01kg/ha per year of nitrogen, compared with 2.6kg/ha/year of nitrogen for wheat–fallow, 0.09kg/ha/year of nitrogen for wheat–canola and 0.03kg/ha/year of nitrogen for wheat–legume. Two reasons account for the lack of increase in nitrogen leaching despite higher use of fertiliser.

First, the nitrogen dose is ‘tuned’ to water availability. Second, higher nitrogen availability enhancing crop growth moves more rainfall through the crop, leaving less opportunity for deep drainage and associated nitrogen leaching beyond the root zone.

Reduced drainage is an environmentally positive outcome of more intensive farming (see Table 2).

**Recommendations**

Paddock trials combined with computer modelling confirmed that more intensive, flexible cropping approaches are feasible in low-rainfall areas in terms of input requirements and timely decision-making.

Improved farm profitability with neutral or positive environmental consequences could be achieved with more intensive crop management aimed at closing the gap between water and nitrogen stress.

A switch to more intensive and flexible cropping systems requires higher inputs of agronomic and financial management and increased monitoring.

There are significant economic benefits but also more risk if management is not adequate.

In low-rainfall areas such as the Mallee, the move to more intensive systems has been made easier through the establishment of farmer groups to help work through the adoption process.

**Acknowledgements:** Mallee Sustainable Farming Project and the many farmers who collaborated in the research, Bill Davoren and John Coppi for technical assistance, Grains Research and Development Corporation and National Heritage Trust.

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