also requires consideration in regards to land management practices to reduce soil erosion and soil loss.

The soils favoured for centre pivot use are generally sandy, lack structure, are low in organic matter and fertility and prone to wind erosion if left with no ground cover. Soil erosion is costly through the loss of valuable top soil which contains nutrients and organic matter.

Under the Natural Resources Management Act 2004, a person has a general statutory duty to act reasonably in relation to the management of natural resources within the State.

These guidelines provide information on management options for soil conservation in the dryland areas associated with centre pivot irrigation.

THE MANAGEMENT OF LAND ASSOCIATED WITH CENTRE PIVOTS

In recent years there has been a substantial increase in the use of centre pivot irrigation in the South Australian Murray-Darling Basin (SA MDB), due largely to relatively cheap land and the supply of water.

Much of the land in the SA MDB under centre pivot irrigation is for the purpose of vegetable crops (mainly potato, carrots and onions) with smaller areas being used for annual and perennial forage crops.

The condition of the land pre and post centre pivot irrigation can be an issue, in terms of soil loss and disturbance increasing the risk of erosion. The care of land outside of the centre pivot circle also requires consideration in regards to land management practices to reduce soil erosion and soil loss.

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FACT SHEET
A guide for irrigators on soil conservation

For further information please go to our website: www.samdbnrm.sa.gov.au

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Above: Most soil movement takes place within a metre of the soil surface.
SOIL EROSION

Erosion is the gradual wearing away of land by wind, water and general weather conditions.

Soil erosion involves the effects of moving water or wind on soil and takes place in three sequential steps – detachment, transport and deposition.

The impacts of soil erosion may be direct such as loss of fertile topsoil, clay, organic matter and nutrients and hence loss of production. Or indirect such as damage to established crops (sand-blasting), and infrastructure such as the covering of fences and roads.

SOIL EROSION IS A THREE STEP PROCESS

Detachment
This is the breaking away of particles or small aggregates at the surface of the soil. Common with soils that lack structure and are low in organic matter.

Transportation
The actual loss of soil material and may involve one of the following:

• Surface creep occurs when particles roll along the soil surface. This relates to soil particles larger than 0.5mm which are too heavy to be lifted by wind.

• Saltation is the picking up of soil particles by wind or water and their subsequent return to the soil surface where they “energise” further detachment of soil particles or surface creep. This relates to soil particles that are of intermediate size (0.1 – 0.5mm in diameter) which are too heavy to be carried any great distance and so are lifted and bounce across the soil surface.

• Suspension describes the holding of small soil particles (smaller than 0.1mm in diameter) in wind or water. Depending on their size, suspended soil particles can be transported very long distances prior to deposition. These very fine particles form the basis of dust storms.

Deposition
This occurs when there is insufficient energy to keep the soil particles in suspension.

Deposition is very important as it has a large influence on off-site impacts of erosion commonly seen, for example as soil builds up against fence lines and vegetation.

MANAGING WIND EROSION

Reducing the impact of wind erosion principally involves reducing the exposure of the soil surface to wind, improvements in soil structure and increasing soil organic matter. This can be achieved by maintaining adequate surface cover and managing soil to limit the exposure of bare, fine and dry soil surfaces that are very prone to wind erosion.
Cover crops, maintaining effective surface vegetative matter, surface roughness, limiting cultivation, addition of clay and maintaining soil moisture are all effective options to reduce soil loss.

**COVER CROPS**

Surface vegetative matter provides protection by reducing the wind speed at the soil surface. Sandy and sandy loam soils have a naturally low dry aggregation and therefore require a vegetative surface cover to reduce wind erosion and soil loss. The establishment of a cover crop will provide surface vegetative matter thereby:

- Reducing soil loss
- Providing protection against erosion
- Preventing detachment of the soil particles
- Improving soil structural stability
- Improving soil fertility

There is also the potential for economic returns if the cover crop is harvested or grazed.

Potential cover crops that can be grown in association with centre pivots will depend on factors such as time of year, soil temperature, disease issues, the end use for the crop and how it fits with the production crop cycle. Possible cover crop options are shown in Table 2.

**IMPORTANT CONSIDERATIONS**

Several factors need to be taken into consideration when choosing a cover crop such as time of year, end-use, tolerance to drought, waterlogging, frost and salinity and soil temperature required for germination in the case of summer crops.

In addition to these factors, several general issues also need to be considered.

**Disease Bridge**

When deciding the type of cover crop consideration needs to be given to the risk of providing a disease bridge between successive crops. For example, sowing a barley crop in a paddock that will be sown to barley the following winter may provide a disease with an off-season host and hence the risk of a disease outbreak in the following barley crop.

**Nitrogen Drawdown**

Micro-organisms in soil prefer a carbon to nitrogen ratio of about 30:1 (Handreck and Black, 1994). If these micro-organisms are to break down organic matter within soil with a higher carbon to nitrogen ratio they need to get additional nitrogen from somewhere and hence they use up any soluble nitrogen in the soil which is then not available to plants. This is commonly known as nitrogen drawdown.

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**Recommended Dry Matter Cover to Prevent Erosion**

Recommended dry matter cover levels for reducing soil loss based on soil types are shown in Table 1. The amount of protection depends on the percentage of ground covered and the height of ground cover.

![Suspended soil particles can be transported long distances.](image)

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Minimum Cover (tonnes)</th>
<th>Desirable Cover (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loam</td>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>20 0.5</td>
<td>50 1.5</td>
</tr>
<tr>
<td>Sand</td>
<td>50 1.5</td>
<td>70 2.5</td>
</tr>
</tbody>
</table>

*Table 1: Recommended dry matter cover levels for reducing soil loss (DWLBC 2008).*

While this cover is desirable, there are situations when a cover crop is not compatible with the proposed management. Residues and a rough soil surface are suitable alternatives.

**SOIL MANAGEMENT OPTIONS**

The main cause of soil loss is the removal of ground cover and subsequent exposure of the soil surface by cultivation and herbicide use. A reduction in wind speed at the soil surface and managing soil to prevent the exposure of loose, bare dry surfaces will assist in reducing soil loss. This can be achieved by maintaining adequate surface cover and limiting the time soils are exposed without cover.
<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Winter or Summer</th>
<th>Grain</th>
<th>Hay Grazing</th>
<th>Drought Tolerance</th>
<th>Frost Tolerance</th>
<th>Waterlog Tolerance</th>
<th>Salt Tolerance</th>
<th>Soil Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>Winter</td>
<td>✓</td>
<td>✓</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Triticale</td>
<td>Winter</td>
<td>✓</td>
<td>✓</td>
<td>Good</td>
<td>Very Good</td>
<td>Fair</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Oats</td>
<td>Winter</td>
<td>✓</td>
<td>✓</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Vetch</td>
<td>Winter</td>
<td>✓</td>
<td>✓</td>
<td>Fair</td>
<td>Good</td>
<td>Poor</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Forage Legumes</td>
<td>Summer</td>
<td>X</td>
<td>✓</td>
<td>Good</td>
<td>Fair</td>
<td>Poor</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Forage Sorghum</td>
<td>Summer</td>
<td>X</td>
<td>✓</td>
<td>Very Good</td>
<td>Poor</td>
<td>Poor</td>
<td>Good</td>
<td>16°C</td>
</tr>
<tr>
<td>Grain Sorghum</td>
<td>Summer</td>
<td>✓</td>
<td>X</td>
<td>Very Good</td>
<td>Poor</td>
<td>—</td>
<td>Good</td>
<td>15°C</td>
</tr>
<tr>
<td>Corn</td>
<td>Summer</td>
<td>✓</td>
<td>X</td>
<td>Good</td>
<td>See Notes</td>
<td>—</td>
<td>—</td>
<td>10°C</td>
</tr>
<tr>
<td>Temperate Millets</td>
<td>Summer</td>
<td>X</td>
<td>✓</td>
<td>Good</td>
<td>Poor</td>
<td>Good</td>
<td>—</td>
<td>16°C</td>
</tr>
<tr>
<td>Safflower</td>
<td>Summer</td>
<td>✓</td>
<td>X</td>
<td>Very Good</td>
<td>See Notes</td>
<td>—</td>
<td>Moderate</td>
<td>10°C</td>
</tr>
<tr>
<td>Sunflower</td>
<td>Summer</td>
<td>✓</td>
<td>X</td>
<td>See Notes</td>
<td>See Notes</td>
<td>—</td>
<td>—</td>
<td>10°C</td>
</tr>
</tbody>
</table>

Table 2: Cover crop options to protect soil from wind erosion.

Whilst organic matter with a high carbon to nitrogen ratio (such as cereals and summer forage crops) may result in some nitrogen drawdown, organic matter is more resilient and therefore remains in the soil for a longer period of time. Organic materials provide protection against soil erosion for a longer period of time and are preferred as cover crops.

Sowing Rates, Fertiliser and Other Cultural Requirements
Each crop has optimal sowing rates, fertiliser and cultural requirements and these vary depending on site. In order to meet the requirements for soil cover, cover crops should not be grazed or cut hard.

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>Resilient straw. Will grow on rundown soils. Less hay/grazing value than oats or vetch.</td>
</tr>
<tr>
<td>Triticale</td>
<td>A useful dual purpose grain or grazing crop. Resilient straw.</td>
</tr>
<tr>
<td>Oats</td>
<td>Better hay/grazing value than other winter cereals. Range of varieties available with different growth habits and maturities.</td>
</tr>
<tr>
<td>Vetch</td>
<td>Better hay/grazing value than winter cereals. Improves soil fertility. Easy to establish and quick growing. Less resilient straw.</td>
</tr>
<tr>
<td>Forage Sorghum</td>
<td>If sufficient soil moisture available, should not require additional irrigations. Rapid growth. Resilient straw. Good hay/grazing value. Risk of Prussic Acid poisoning if grazed although this is rare. Not tolerant of soil acidity.</td>
</tr>
<tr>
<td>Safflower</td>
<td>Wider planting window than other summer crops. Will tolerate frost early but susceptible to frost damage during stem elongation and branching. Small market.</td>
</tr>
<tr>
<td>Sunflower</td>
<td>Wider planting window than other summer crops. Reasonable frost tolerance as a seedling but susceptible to frost damage from 6th leaf stage to flowering. Reasonable heat and drought tolerance as a mature plant. Less soil cover than other crops. Avoid acidic soils.</td>
</tr>
</tbody>
</table>

Table 3: Information on Cover crop options as listed in Table 2.
The timing of sowing and harvesting differs between crops and growers and is dependent on factors such as regional conditions, markets and seasonal effects such as soil temperatures. As a result, there are centre pivot irrigated crops being planted or harvested throughout the entire year, therefore growers require a range of soil management options to suit all times of the year.

**LEAVING SOIL SURFACE ROUGH FOLLOWING CROP HARVEST**

Leaving as many larger soil clods as possible on the soil surface following harvest will slow down the wind reducing soil loss. The larger aggregates are unlikely to be moved by saltation and will trap saltating particles as they land (White, 1987). Only suitable for a maximum of six weeks prior to sowing.

**RIDGING OR FURROWING**

In extreme conditions where the soil is bare, ridging or furrowing will reduce soil particle movement. Ridges and furrows should be formed at right angles to the direction of wind travel using a large tyned implement, at low speed to avoid excessive soil throw.

**POLYMERS / CLAYING**

Applying polymers or clay to the soil surface aims to provide protection against soil loss by preventing detachment of soil particles. New polymers and techniques are continually being investigated and although currently an expensive option is worth considering.

Many polymers have the additional benefits of water retention. Claying can improve productivity and assist in stabilising a sandy soil and improve water use efficiency. It is important to ensure correct incorporation and non-acidic clay if available.

**CROP RESIDUE RETENTION**

Retention of crop residues on centre pivot irrigated sites is often difficult as the residues are commonly removed as part of the harvesting procedure. Growers should leave as much crop residue as possible on the soil surface. Crop residues slow the wind and trap saltating soil particles as they land.

**IRRIGATION**

Wind erosion occurs when the soil is drier than wilting point and when particles movable by saltation are present. Therefore, growers should consider irrigating to keep the soil wet and hence limit erosion.

**Row Orientation**

Prevailing winds in the SAMDB are predominantly from the south west in winter and north west in summer. Crops sown in a north south direction, at right angles to the prevailing wind, reduce the risk of wind erosion.

**INDICATIVE ECONOMIC RETURNS**

In addition to the benefits of preventing soil loss, erosion control and avoiding damage to nearby crops and assets, cover cropping can provide economic returns.

These returns result primarily from capitalising on the residual benefits arising from the intensive production methods used for the main irrigated crops such as potatoes, onions or carrots. These benefits can include residual stored soil water, residual fertiliser and reduced weed pressure.

There is a general lack of quantitative data on residual benefits in this particular situation, however, experience enables a number of reasonable (and conservative) assumptions to be made on the economic benefits.

The financial benefits from a cover crop are calculated in terms of dried biomass production, expressed as hay values. This approach is taken because of the numerous uses in which the fodder could be used, eg grazed off, cut and carried as hay, or as silage. Separate calculations of these individual components could have been made, however using the hay equivalent is valid.

Above: Cover cropping can provide an economic return and reduce soil loss.
**BENEFIT OF RESIDUAL SOIL WATER**

For those crops that continue to be irrigated up to the time of harvest such as potatoes and carrots, the soil water that remains in the soil following harvest can be utilised for the production of a cover crop. The value of this residual water is estimated as follows:

**Assumptions**

- 75mm of water remains in the soil profile at the end of the main irrigated crop.
- Light watering prior to seeding of cover crop may be required to ensure germination but is not included in the following calculations.
- Dry biomass production is assumed to be 45kg per hectare per mm for “winter” cereals and 65kg per hectare per mm for summer forage grasses.

The theoretical biomass production using the residual soil water and average rainfall over 3 months is calculated as follows:

\[
\text{Biomass production} = (\text{Stored soil water} + \text{Rainfall}) \times (\text{Biomass production per mm})
\]

Therefore, biomass of “winter” cereals and summer forage crops are estimated to be 6.75 and 9.75 tonnes per hectare respectively. However, it is not possible to achieve the theoretical maximum because of evaporation, cutting and binding losses, lack of follow up rains and the fact that not all the biomass can or should be harvested whether as hay or by grazing, given the need to maintain adequate surface cover.

Assuming only 50% of these theoretical maxima (ie. 3.38 and 4.88 tonnes per hectare for “winter” cereals and summer forage crops respectively) may be achieved and a conservative hay value of $150 per tonne, the gross returns from the cover crops in the paddock (ie. no freight) are $506 and $732 per hectare for winter cereals and summer forage grasses respectively.

**OTHER ADDITIONAL COSTS TO PRODUCE COVER CROP FOR HAY**

Apart from the small amount of nitrogen fertiliser, estimated additional costs to produce a cover crop for hay are:

- Seed - $50 per hectare. *
- Sowing operations etc. - $25 per hectare. *
- Mowing/conditioning/baling - $125 per hectare. *

Costs to produce a cover crop for hay estimated to be $200 per hectare. *

Total additional costs to produce a cover crop for hay (including residual fertiliser, seed, sowing and hay cutting etc.) is $250 per hectare. *

**NET RETURN FROM A COVER CROP FOR HAY**

The net returns from producing a “winter” cereal of summer forage grass cover crop for hay are as follows:

**“Winter” cereal cover crop**

Value of cover crop in paddock = $506 per hectare.*

Costs incurred in production of cover crop = $250 per hectare.* (fertiliser, seed etc.)

Net return from producing a “winter” cereal cover crop for hay = $506 - $250 = $256 per hectare.*

**Summer forage grass cover crop**

Value of cover crop in paddock = $732 per hectare.*

Costs incurred in production of cover crop = $250 per hectare.* (fertiliser, seed etc.)

**REFERENCES**


Maschmedt D (July 2005). South Australian Soil Classification PIRSA


*Based on 2008 figures.