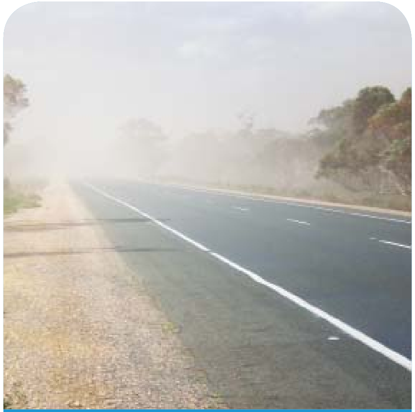
Government of South Australia
South Australian Murray-Darling Basin
Natural Resources Management Board

LAND



FACT SHEET

A guide for irrigators on soil conservation

Guidelines for Irrigators

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.

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.

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

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

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SOILS

The SA MDB comprises a diverse range of landscapes, ranging from dune/swale systems to river flats. Preferred landforms for centre pivot use within the Murray Mallee are flat with undulating sandhills, with the occasional to frequent sandplain. The preferred soil type is light textured, which is low in fertility and prone to erosion. This soil type is preferred for irrigated production of vegetables as the soil is easily removed from the produce and risk of root disease pressures is low.

Deep Bleached Siliceous Sand

- Very thick bleached sand over a brown slightly more clayey subsoil.
- Rapid drainage. Inherent fertility is low. Low clay and organic matter content.
- Moderate to moderately high wind erosion potential.

Deep Sand

- Thick loose sand becoming slightly more clayey and calcareous with depth.
- Rapid drainage. Inherent fertility is low. Low clay and organic matter content.
- Moderate to moderately high wind erosion potential.

Thick Sand Over Sandy Clay

- Thick sand with a bleached A2 layer overlying a red or brown sandy clay loam to sandy clay, calcareous with depth.
- Rapidly to well drained. Inherent fertility is low. Lower soil layers have good nutrient holding capacity but root growth in these layers is poor. Low organic matter content.
- Moderate wind erosion potential.

Moderately Deep Sand Over Sandy Clay Loam

- Thick reddish sand over a red clayey sand to sandy clay loam, calcareous with depth, grading to clayey sand below 150cm.
- Rapid drainage. Inherent fertility is low. Low clay and organic matter content.
- Moderate wind erosion potential.

Above: *Preferred soil types for centre pivot use are low in fertility and susceptible to wind erosion.*

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.

Above: *Suspended soil particles can be transported long distances.*

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.

Soil Type	Minimum Cover		Desirable Cover	
	%	tonnes	%	tonnes
Loam	15	0.5	35	1
Sandy Loam	20	0.6	50	1.5
Sand	50	1.5	70	2.5

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.

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.

Cover Crop	Winter or Summer	Grain	Hay Grazing	Drought Tolerance	Frost Tolerance	Waterlog Tolerance	Salt Tolerance	Soil Temp
Barley	Winter	✔	✔	Good	Good	Fair	–	–
Triticale	Winter	✔	✔	Good	Very Good	Fair	–	–
Oats	Winter	✔	✔	Good	Good	Fair	–	–
Vetch	Winter	✔	✔	Fair	Good	Poor	–	–
Forage Legumes	Summer	✘	✔	Good	Fair	Poor	–	–
Forage Sorghum	Summer	✘	✔	Very Good	Poor	Poor	Good	16ºC
Grain Sorghum	Summer	✔	✘	Very Good	Poor	–	Good	15ºC
Corn	Summer	✔	✘	Good	See Notes		–	10ºC
Temperate Millets	Summer	✘	✔	Good	Poor	Good	–	16ºC
Safflower	Summer	✔	✘	Very Good	See Notes	–	Moderate	10ºC
Sunflower	Summer	✔	✘	See Notes	See Notes	–		10ºC

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.

Cover Crop	Notes
Barley	Resilient straw. Will grow on rundown soils. Less hay/grazing value than oats or vetch.
Triticale	A useful dual purpose grain or grazing crop. Resilient straw.
Oats	Better hay/grazing value than other winter cereals. Range of varieties available with different growth habits and maturities.
Vetch	Better hay/grazing value than winter cereals. Improves soil fertility. Easy to establish and quick growing. Less resilient straw.
Forage Legumes	May withstand multiple grazings. Improves soil fertility. Less resilient straw.
Forage Sorghum	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.
Grain Sorghum	Rapid growth. Resilient straw. If sufficient soil moisture available, should not require additional irrigations. Not tolerant of soil acidity. Small market.
Corn	Wider planting window than sorghum. Less pest and disease problems than sorghum. Normally fetches higher prices than sorghum in the feed market. Can tolerate light frosts in early stages of growth. High temperatures at tasselling, silking and pollination need to be avoided. Very resilient straw.
Temperate Millets	Will grow on poorer soils. Better feed value than forage sorghum. Resilient straw.
Safflower	Wider planting window than other summer crops. Will tolerate frost early but susceptible to frost damage during stem elongation and branching. Small market.
Sunflower	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.

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.

Above: *Cover cropping can provide an economic return and reduce soil loss.*

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.

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 hectare 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:

Biomass production = (Stored soil water + Rainfall) × (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 crops respectively.

BENEFIT OF RESIDUAL FERTILISER AND HERBICIDE

There can be considerable reserves of fertiliser in the soil following an irrigated vegetable crop. There is likely to be sufficient fertiliser for production of a cover crop, apart from the requirement for of a small amount of nitrogen fertiliser.

Assumptions

- Estimated additional fertiliser requirement to produce cover crop depending on production goals is 50kg urea ha[1] with a cost of approximately $50 per hectare.
- No further herbicides will be needed for the cover crop. Cost of fertiliser and herbicide for the cover crop is estimated to be $50.

*Based on 2008 figures.

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.)

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