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□ These photographs of a poorly structured and sloppy soil (left) and a well structured soil were taken on the same day. Water ponding on poorly structured soils is milky with dispersed clay.

# Gypsum use in the wheatbelt

By **Martin Howell**, Research Officer, Dryland Research Institute, Merredin

*One of the limitations to crop productivity in the wheatbelt is the poor structure of heavy textured soils. Many years of clearing and cultivation have caused the loss of soil organic matter and the breakdown of soil aggregates—particles of sand, silt and clay—in the surface layers. This has led to the development of unstable soils with poor physical properties.*

*Grain yield losses of up to 50 per cent and more have been measured on these degraded sites throughout the Western Australian wheatbelt. An estimated 3.5 million hectares of the State's southern agricultural regions is composed of soil types susceptible to this form of degradation.*

*Although loss of soil structure is a serious problem, it can be reversed by altering the tillage practices that caused the problem. This improvement in soil structure and return to productivity can be a slow process. However, gypsum can be applied to hasten the rate of improvement of unstable soils and when used in conjunction with sensible soil management practices, gypsum can improve long term soil stability.*

### Where gypsum should be used

Before gypsum can be used as a soil improver, the soil must be responsive. In some instances laboratory techniques can predict a soil's likely response to gypsum; however these techniques are not readily available. There are also no simple soil properties which can be used to identify responsive soils.

The clay contents of gypsum-responsive soils may range from less than 15 per cent to more than 25 per cent, and the soil type may vary from the grey or mort clays to the red-brown earths and red duplex soils, commonly called salmon gum/gimlet soils. Gypsum acts only on the clay particles. Soil will respond to gypsum only when the clay is unstable to wetting and when this instability causes the unfavourable physical properties of the surface.



□ Poorly structured and well structured soil after gypsum treatment in a tillage trial at Merredin. Water no longer ponds on the treated soil.

An unstable soil will have most of the following features.

- A hard set surface when dry. For example, a pencil cannot easily be pushed into the dry surface.
- Poor rainfall infiltration. Water ponds readily on the soil surface during rain.
- Poor surface drainage. Pondered water becomes clouded with dispersed clay and remains on the surface in depressions for days or weeks after rain.
- The soil becomes boggy or slippery after little rain, making machinery operations difficult.
- Seed beds are difficult to produce under almost all conditions.
- The seed bed produced breaks down rapidly with rain, often resulting in poor seedling emergence.
- Crop growth is patchy with a characteristic undulating growth.
- When dry the soil surface may form widely spaced and deep cracks.
- The soil will give a positive result to the simple dispersion test outlined in Farmnote No. 32/85 'Gypsum improves soil stability'.

### How gypsum works

Gypsum (calcium sulphate) is a naturally occurring mineral found commonly as dunes on the south-eastern edges of salt lakes. It is also a by-product of fertiliser manufacture. Unlike common salt (sodium chloride), gypsum is only sparingly soluble in water. It is this feature, along with gypsum's high calcium content, that has led to its use as a soil improver.

When applied to soil, gypsum dissolves in rain water and interacts with the fine clay particles. This interaction improves soil structure by making the clay more stable when wet and reducing the tendency of the soil surface to set hard when dry.

Gypsum improves soil structure by altering the soil chemistry. It is not a "cement" and the effect will occur only if the gypsum dissolves in water. To be effective, gypsum should be applied before the break of the season.

Soil structure improves dramatically after the application of gypsum. After cropping the soil surface will no longer set hard, and water will seldom pond on it because of much improved rainfall infiltration. Farm machinery can travel across the paddock more easily, allowing more flexibility at seeding. Seed beds are more stable, resulting in improved plant establishment.

### Gypsum quality

Gypsum is available from pits throughout the wheatbelt. Most supplies sold for agricultural use contain more than 85 per cent gypsum, however, the sodium chloride content can also be high. Farmers should avoid gypsum supplies with more than 2 per cent sodium chloride by weight.

Gypsum supplies vary mainly in the particle size distribution. Gypsum produced as a fertiliser by-product has a very fine particle size with a measured mean diameter of less than 0.1 mm. Mined "seed" gypsum is coarse, having a mean diameter two to three times this value. "Koppi" gypsum (found in deposits with "seed" gypsum) has a particle size distribution similar to that of fertiliser by-product gypsum. In many wheatbelt situations the coarser the particles the better because the gypsum will persist at the soil surface for a longer period, thus extending its effectiveness.

However the main consideration in the use of gypsum is the cost involved and the distance it has to be carted.

### Rates of application

There is no benefit in applying more than 2.5 t/ha gypsum to an unstable soil for at least the first four years of continuous cropping. Since 1983, 12 rate of gypsum trials have been established throughout the wheatbelt. In nine of these trials crop yields increased by more than 20 per cent, and grain yields were highest when gypsum was applied at a rate of 2.5 t/ha. The graph shows the percentage grain yield responses obtained in a field trial near Merredin from 1984 to 1986.

Application of more than 2.5 t/ha of gypsum does no harm to the soil or crop. The higher application rate may last longer, but it may cost considerably more. When gypsum is applied and a conservation tillage system such as direct drilling is adopted, one 2.5 t/ha application should be adequate to achieve long term soil structural stability without the need for further application of gypsum. If farmers persist with multiple cultivation techniques, gypsum will need to be re-applied at regular intervals, a costly exercise.

### Achieving long term soil stability

Gypsum does not create good soil structure from unstable soils, it merely stabilises it. When gypsum is applied to a hard compact surface it can not be expected to improve soil structure unless some tillage operation is included in the first year's treatment. Tillage is only required to "break" the soil surface, and need only be shallow and minor. Direct drilling in a continuous cropping system will both maintain or improve soil structure of these problem soils. Under this system crop yield losses due to poor soil structure will no longer occur and the crop will not respond to applied gypsum.

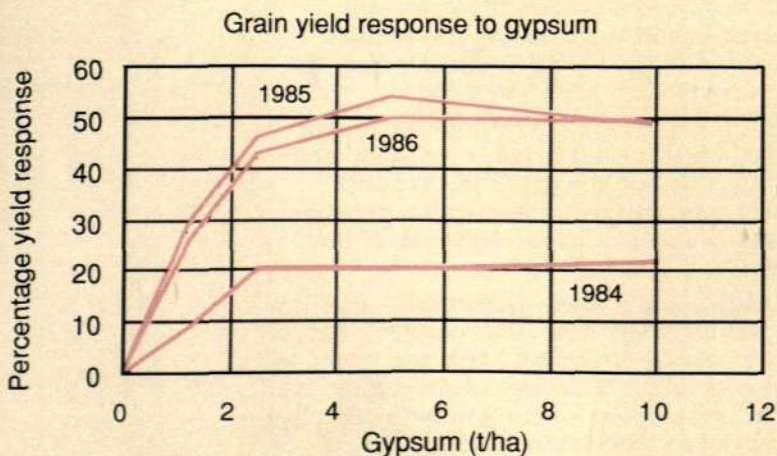
The response from applying gypsum is not permanent and only lasts while gypsum is present. Subsequent management of these soils must reduce the initial degradation and loss of productivity. Tillage practices must be altered to a minimum tillage system and ideally to direct drilling.

Table 1 shows the grain yields obtained from direct drill and conventional tillage treatments in five trials in which gypsum was applied. With the exception of the trial at Katanning, the percentage crop yield response to gypsum was greater for the conventional treatments because of the more degraded condition of the soil surface. There was no response to gypsum at the Merredin sites where the soil had been direct drilled.

**Table 2. Grain yield results for gypsum/nitrogen trial near Merredin, 1986**

	Grain yield (t/ha)	
	No gypsum	5.0 t/ha gypsum
No nitrogen	1.27	1.48
Nitrogen 20 kg/ha	1.26	1.91

□ Grain yield response to applied gypsum.



**Table 1. Grain yield from gypsum tillage trials, 1985**

Location	Tillage Method	Number of years cropped	Grain yield (t/ha)		
			No gypsum	Gypsum (5.0 t/ha)	% response
Merredin	Direct drill	9	0.90	0.96	ns
	Conventional		0.62	0.79	28
Merredin	Direct drill	2	0.75	0.78	ns
	Conventional		0.63	0.75	16
Kalannie	Direct drill	2	0.95	1.10	16
	Conventional		0.86	1.05	23
Lake King	Direct drill	2	0.89	1.07	20
	Conventional		0.66	0.91	38
Katanning	Direct drill	2	2.44	2.26	ns
	Conventional		2.30	2.28	ns

ns = not significant

**Table 3. Costs of gypsum application, 1986**

Gypsum rate (t/ha)	Distance carted (km)	Cost of application (\$/ha)
2.5	20	30.00
2.5	100	50.00
5.0	100	100.00

Costs used: Gypsum \$6.00/tonne; cartage \$0.10/t/km; contract spreading \$4.00/t.

Soil instability in the wheatbelt will reappear after the gypsum has been leached from the surface if conventional tillage systems are maintained.

Gypsum is most effective when it is placed in the top 5 or 10 cm of the soil; on many sites it can be scratched into the surface to prevent it blowing away. Conventional tillage mixes the gypsum through the top 5 to 10 cm, dramatically reducing its persistence at the surface. Minimum tillage results in less mixing of the gypsum with the soil.

Two years after gypsum was applied to a continuously cropped tillage trial at Merredin, no residual gypsum remained in the top 10 cm of soil after two cultivations before seeding. Where there were no cultivations before seeding, about 30 per cent of the applied gypsum remained in the top 5 cm of soil.

#### Nitrogen fertility

Negative crop responses to gypsum have been measured in a few field trials and have sometimes been reported by farmers, even though there was an obvious soil response to gypsum. These crops invariably were deficient in nitrogen.

The application of gypsum altered the crops' response to nitrogen in several Department of Agriculture trials. Table 2 shows grain yield results for a gypsum/nitrogen trial near Merredin. Crops at this site did not respond to applied nitrogen until the soil had been treated with gypsum, after which yield increased by 0.43 t/ha with 20 kg/ha of nitrogen. Changes in the nitrogen response curve following gypsum application have also been recorded in trials at York, Katanning and Lake Grace.

#### Costs

Table 3 shows costs of gypsum treatment based on 1986 prices. The price of gypsum from pits and from fertiliser works is relatively cheap. The major cost is transport.

#### Conclusion

Gypsum is a useful "tool" for treating structurally degraded wheatbelt soils. However, it can be expensive to use because it is difficult to predict gypsum-responsive soils. Grain yield response after the application of gypsum also varies. Therefore farmers should apply gypsum at different rates on small test strips or portions of a paddock before embarking on a larger programme. In addition, long term soil stability will not be achieved by the use of gypsum alone. The cause of the initial soil degradation must be reduced and this will require the use of minimum tillage techniques.

#### Further reading

Fosberry, G. and Howell, M. R. (1985). Gypsum improves soil stability. *Dept. Agric. West Aust. Farmnote No. 32/85.*



□ Poor soil structure in part of this paddock has influenced seedling emergence.