MALLEE CATCHMENT
TECHNICAL BULLETIN

Technical Bulletin #30

Improving the knowledge of mineralisation potential in Mallee soils

Above: Collecting samples in the Millewa land system. Photo: Mallee CMA.

This technical bulletin aims to increase the knowledge among landholders about the mineralisation potential of soils to encourage the efficient and effective use of fertilisers, resulting in higher productivity and increased groundcover and soil carbon turnover.

Background

With a shift to more intensive cropping Mallee farmers are increasingly applying nitrogen fertilisers to cropping rotations dominated by cereal crops. Fertiliser recommendations are calculated as a balance between crop demand (yield and protein) and soil nitrogen supply (inorganic nitrogen and mineralisation). Nitrogen fertiliser inputs are targeted to bridge the gap between demand and supply, balancing risk and profitability. It is important to know the total supply of mineral nitrogen by the soil during crop growth, because if supply exceeds crop demand there is no-need for additional nitrogen through fertiliser; however, if demand exceeds supply, there is a need for nitrogen fertiliser.

At a glance

- A total of 24 soils were assessed for mineralisation potential;
- In this set of soils potential mineralisation was highly and positively correlated with total nitrogen, organic carbon and clay-silt percentage;
- Laboratory based measurements of potential mineralisation were two and a half times higher than what would normally be predicted through a generic formula;
- Intensive cropping systems tend to be net exporters of nitrogen, therefore if mineralisation potential is to be maintained or improved, legume phases are required to replenish soil nitrogen reserves.

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During 2011, a project was undertaken to compare laboratory based measurements of the potential nitrogen mineralisation of Mallee soils, with traditional approaches to estimating nitrogen mineralisation. Improved knowledge of the mineralisation potential of Mallee soils will have a large impact on the efficiency and effectiveness of nitrogen fertiliser inputs, resulting in higher productivity and soil health benefits through increased groundcover and soil carbon turnover.

Methods

Soils collected during the 2011 Mallee Soil Health Monitoring Program (Mallee Sustainable Farming 2011) were assessed for their mineralisation potential. Soils were analysed from 24 sites sampled in 2011. The sites were located in the Millewa, Boigbeat and Tempy land systems. CSIRO then determined the nitrogen mineralisation potential of each soil using a laboratory based technique. Correlations were made between potential mineralisation and the soil properties: organic carbon (OC); total nitrogen (N); and the percentage of clay and silt in the 0-10 cm soil layer. Potential mineralisation was also compared to the commonly used formula to estimate growing season nitrogen mineralisation.

Results

In the soils analysed, potential mineralisation was positively and linearly correlated with total N, OC and clay-silt percentage of the 0-10 cm soil layer (Table 1). Total N correlated best with potential mineralisation (R^2=82.4) (Figure 1), followed by OC (R^2=74.8) and clay-silt percentage (R^2=71.9). For every 1% total N, 499 mgkg^{-1} of inorganic nitrogen would be mineralised in the 0-10 cm soil layer over the growing season (Table 1). However, when both total N and OC were considered simultaneously the mineralisation potential increased considerably (1178 mgkg^{-1} N per 1% of total N). Furthermore, as OC increased, mineralisation rates decreased. The effect of lower mineralisation under soils with higher levels of OC could be due to either immobilisation of nitrogen or slower rates of mineralisation in these soils.

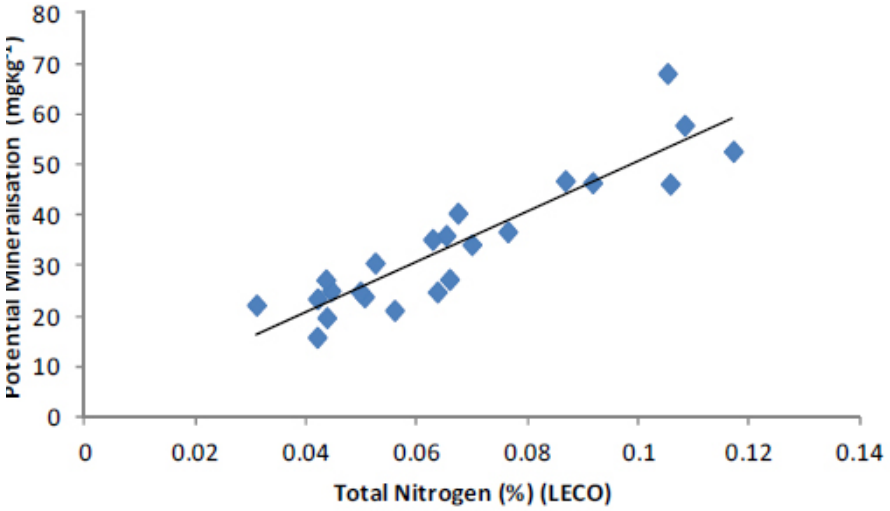

Figure 1. Mineralisation potential compared to total nitrogen % measured using the LECO combustion method (R^2=82.4).

Predictions of potential N mineralisation should be within two times the root mean square error (RMSE) value (Table 1). Therefore potential mineralisation predicted with total N should be within approximately 11.5 mgkg^{-1}, OC within 13.5 mgkg^{-1} and clay silt percentage within 14.5 mgkg^{-1} of the predicted value.

Potential mineralisation in these soils was found to be proportional to total N with 4.99(±0.49)% of total N in the 0-10 cm soil layer expected to mineralise during the growing season. Therefore, assuming that 5% of the total organic nitrogen in the top 10 cm of soil will mineralise during the growing season would be a robust estimate of mineralisation potential in the set of soils analysed in this project.

Predicted mineralisation

Potential mineralisation determined through the laboratory based technique was compared to the standard rule of thumb to predict potential mineralisation. The rule of thumb method is based on an empirical relationship between organic

Table 1. Correlations between mineralisation potential and the percentage of total nitrogen, organic carbon and clay and silt. [a]Organic C (LECO) include acid prewash before analysis to remove inorganic carbon (MSF 2011).

Predictor	Constant (mg/kg)	(error)	Slope (mg/kg/%)	(error)	R^2	RMSE (mg/kg)
Total N (LECO) (%)	0.71	3.49	499	49	82.4	5.66
[a]Organic C (LECO) (%)	3.40	4.0	42.1	5.2	74.8	6.77
Clay + Silt (%)	15.0	2.9	0.800	0.106	71.9	7.15
Total N + Total C	-0.48	3.20			85.5	5.13
(Total N)			1178	289		
(Organic C)			-60.6	25.5		

Above: Bulk density samples. Photo: Mallee Sustainable Farming.

carbon and mineralisation potential, whereas the laboratory method predicts mineralisation based on soil properties and biological activity. The commonly used rule of thumb formula for N mineralisation (in kg N ha^{-1}) is:

0.15 x Organic C (%) x Growing Season Rainfall (GSR).

Analysis of the soils also showed that laboratory based measurements of mineralisation potential were approximately two and a half times greater than growing season mineralisation predicted using the commonly applied generic formula (Figure 2).

The large discrepancy in predictions of mineralisation potential between the two methods raises the question of which method is more appropriate for the Mallee. Previous research in the Mallee has measured mineralisation rates more in line with the lab based measurements; however, further work is required to compare potential with actual mineralisation.

Implications of the findings

Through this project only a limited number of soils were analysed for mineralisation potential, therefore conclusions can not be generalised beyond this dataset without further research and validation. However, this project has highlighted that there is scope to improve estimates of mineralisation potential in Mallee soils.

Average growing season rainfall was used for both the laboratory based measurement and formula ('rule of thumb') predicted mineralisation potential. There are a number of factors that can influence actual mineralisation and therefore nitrogen supply to crops. It is therefore important to understand and adjust for the various factors that could influence mineralisation throughout the growing season. In the Mallee, the amount of rainfall and the duration of moist soil for microbial activity are the two most critical factors. Rotation is another significant factor that influences nitrogen mineralisation, with legume pastures in particular improving mineralisation during cropping phases.

This project compared two methods of predicting mineralisation from soil; however, both techniques fail to consider potential nitrogen sources from above ground crop and pasture residues. Current practice may be to ignore residues when sampling for OC or total N; however, these factors could make an important contribution to mineralisation,

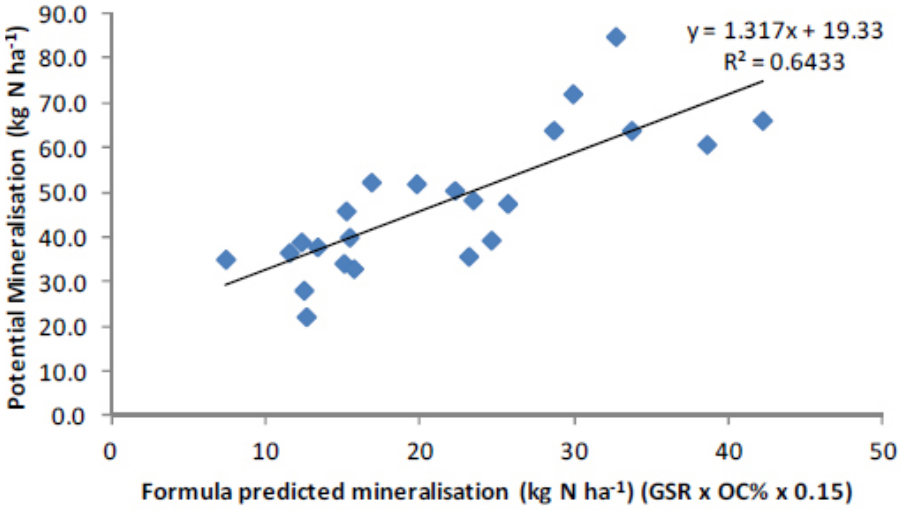

Figure 2. Potential mineralisation compared to the proportion of total nitrogen (1,2,3,4 or 5%).

Above: Wheat crop in the Mallee. Photo: Mallee CMA.

which would change depending on the residue, amount, degree of decomposition and mixing during the sowing process. At the time when the formula rule of thumb was derived, the residue fraction of organic matter was likely to have been a less important contributor to mineralisation (tilled, generally fallow after pasture system). It is possible the use of 'potential mineralisation' measurements in nitrogen management (of all kinds) needs to change to acknowledge the limitations of soil-only measurements.

The data from this project highlighted that mineralisation was proportional to the soil organic nitrogen pool. Therefore, management practices that have a positive or negative impact on the level of organic nitrogen present in the top 10 cm of soil are likely to either increase or decrease mineralisation potential. The inclusion of legume pastures (annual or perennial) would appear most suited to improving nitrogen levels in soils. Grain legume crops do not appear to be suitable for building soil nitrogen reserves in the long term due to the high levels of nitrogen export with the grain. However, grain legume crops may provide short term nitrogen boost to subsequent crops through the minerlisation of residues. Furthermore, soil organic nitrogen levels are likely to decline under cropping systems that utilise only continuous cereals, non-legume crops (canola) or fallows. Erosion will also have a detrimental impact on potential mineralisation levels as a high proportion of the soil organic nitrogen is present in the top few centimetres of soil.

As a result of this project it is noted that:

- The relationships between potential mineralisation and the soil properties of total N, OC and clay silt percentage should be validated against a larger and independent dataset;
- Potential mineralisation be determined for a larger number of sites so the results can be compared to land management data available;
- Potential mineralisation be compared to actual mineralisation measured in the field.

Acknowledgments

Mallee Sustainable Farming (MSF) would like to acknowledge the Mallee Catchment Management Authority (CMA) for providing funding for this project through the Victorian Investment Framework, and CSIRO, in particular Dr Gupta Vadakattu and technical staff, for laboratory analysis. Ben Jones of Mallee Focus also provided data analysis and interpretation.

Further information

The information in this technical bulletin has been take from: MSF 2012 Improving knowledge of mineralisation potential of Mallee soils, unpublished report for the Mallee CMA, Mildura, VIC.

References

MSF (2011). Mallee Dryland Agricultural Soil Health Monitoring Program. Unpublished report for the Mallee CMA, Mildura, VIC.

Project Partners

Published February 2012