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FERTILISER OPTIONS:

BENEFICIAL USE OF WASTE MATERIALS

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Abstract. Public awareness of organic fertilisers as a nutrient resource has been increasing in recent times. In a country with some of the world's oldest and poorest soils, this is an important awakening. With 80 percent of Australians living in towns and cities, and as a major exporter of agricultural products, we cannot persist in tipping this potentially valuable commodity into oceans and landfill sites. This paper describes current research which is providing valuable information about the agricultural potential of organic fertilisers. The results to date are encouraging, but research needs to continue to determine the long-term effects on soil, plant animal and water systems.

Application of sewage sludge to agricultural land is relatively new in Australia. In fact, the guidelines for use of sewage sludge on agricultural land in NSW are less than 5 years old. Disposal methods are fast becoming politically unacceptable and reuse methods are evolving into feasible utilisation options. Approximately 3000 wet tonnes of sewage sludge are produced daily in NSW, and with increasingly stringent pollution laws governing effluent quality, sludge tonnages can only increase as sewage treatment plants become more efficient at reducing pollutant levels in effluent.

With the abolition of sludge disposal to sea in NSW and increasing demands on landfill sites, land application of sludge represents one of the most cost-effective and environmentally acceptable methods of disposal. The distinct problems with Australian soils and the long distances involved for transport of sludge from the coast to the agricultural areas inland, make the need for research into Australian disposal methods imperative.

In this paper I will concentrate on three different products I have been involved with evaluating under dryland conditions on Southern Tablelands pastures, and will expand this with other information from published literature and/or current research work, where appropriate. The three major fertilisers which I will be discussing are:

- Sewage ash from the ACT;
- Sewage sludge from Sydney; and,
- Dynamic lifter.

Canberra sewage ash

Sewage ash is a complex and variable combination of materials resulting from the combustion of organic material and added chemicals. Many of these elements emanate from within the sewage collection system, while others are added as part of the sewage treatment process. Sewage ash is produced at temperatures above 650^{0}C and is sterile. It contains no organic matter or nitrogenous fertilizer value. The major useful constituents are calcium carbonate (limestone) and calcium phosphate. Sewage ash has about half the neutralising value of lime. The phosphorus level is around five percent, none being water soluble (*ie.* the phosphorus only becomes slowly available to plants). Acid soils (*ie.* those with a pH test below 4.5 to 5.0 in $CaCl_2$) and with low phosphorus levels (Bray No. 1 less than 10 ppm) should be highly responsive to the application of sewage ash.

Like many other products used in agriculture, sewage ash contains traces of heavy metals - lead, iron, zinc, copper, mercury and cadmium. However, because Canberra has a small industrial base, the quantity of heavy metals in the sewage ash is very small. Soil analysis from a trial where sewage ash had been used up to 4.0 t/ha showed no significant increases in the top 10 cm of soil (P. Simpson, unpublished data).

In the late 1970s Paul Dann, then Research Agronomist at Canberra, was approached by the Lower Molonglo Water Quality Control Centre (LMWQCC) to assess whether sewage ash being dumped at the Molonglo tip had any potential for agricultural use. Experiments ensued comparing sewage ash and other liming materials at equal neutralising value and at different rates, plus varying rates of superphosphate (Dann *et al.*, 1989). Similar work was also undertaken by CSIRO, Division of Land and Water Resources on the southern tablelands. (Willets *et al.*, 1984; Willets and Jakobson, 1986).

Results

The results in average or better rainfall years showed:

- legume-based pastures grown in low phosphorus acid soils responded well to sewage ash; and,
- clover leaf phosphorus concentrations rose with increasing application rates, indicating phosphorus uptake by plants.

After eight years, Paul Dann's trials were re-sampled and it was noted that lime was more effective in reducing soil acidity than sewage ash. The residual value of lime was about 20% better than sewage ash. I have obtained similar results on an acid duplex soil at Collector and the soil analyses from this trial two years after application, are presented in Figure 1.

Comparative costs of sewage ash vs lime and superphosphate

The relative costs of lime and sewage ash are determined largely by freight charges. Using the Collector area as an example (85 km from Molonglo), the comparative costs are as shown in Table 1.

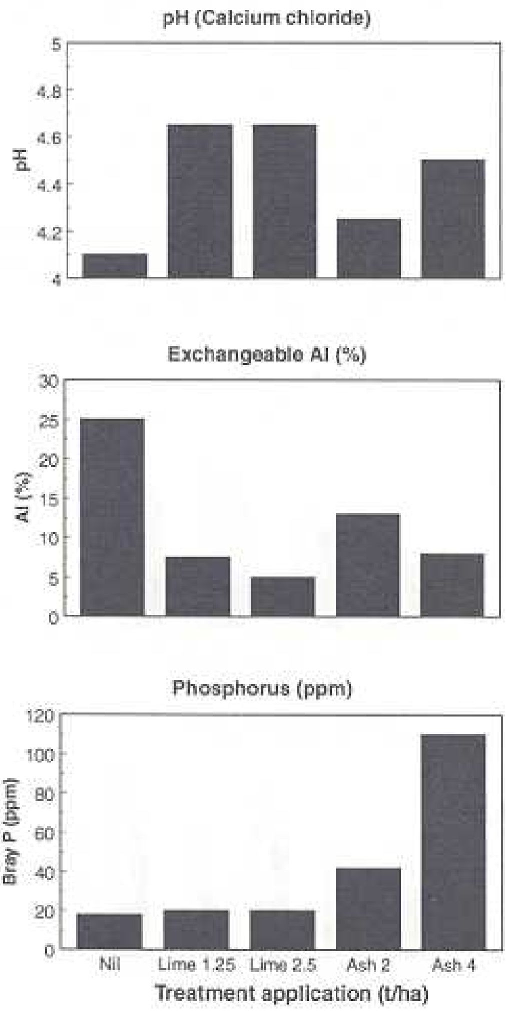

Figure 1. The effects of lime and sewage ash on soil pH, exchangeable Al and avalable P at Collector, NSW.

Table 1. Comparative costs of Canberra sewage ash and lime at Collector.

Sewage ash (12 t load)	Lime
Ash costs = $90	F70 grade lime approximately $65/t delivered & spread.
Cartage = $170	
Spreading = $240	
Total = $500 (or nearly $42/t)	

Because the neutralising value of sewage ash is approximately 50% of that of lime, sewage ash equivalent to lime at 2.0 t/ha would be 4-5 t/ha costing $168-$200/ha. These figures allow for a 30% loss - 10% through spreading and 20% less neutralising value. So, where cartage is 85 km or less, there is not a great difference in costs between the two products. However, sewage ash also supplies phosphorus and, at application rates of 2.5 to 4.0 t/ha, there may be no need to apply phosphorus for up to five years. Thus, there is a saving of about $22/ha/year, which is a big bonus on low phosphate soils. Obviously the closer you live to the source, the cheaper sewage ash becomes. The economic transport limit is probably 120 km from Canberra.

In summary, sewage ash certainly has potential as a source of lime and phosphorus for the Southern Tablelands. However, the product is extremely fine and difficult to handle and has little or no sulphur. Current investigations are looking at the possibility of blending it with other organic materials, granulating the product, investigating the need for additional sulphur and the significance of heavy metals. This work is partly being funded by the ACT Electricity and Water Authority.

For further information on lime and sewage ash, refer to Agnote 4/61 - Using Canberra Sewage Ash on Southern Tablelands pastures (Simpson, 1993).

Sydney sewage sludge

In 1992, NSW Agriculture commenced a research program in conjunction with the Sydney Water Board, evaluating the use of sewage sludge in agriculture. This program is coordinated by the Organic Waste Recycling Unit at Richmond and is looking at the use of sludge as a fertiliser on dryland crops and pastures, orchards, sugar cane, vegetables, summer fodder crops and for use in landscaping. All major aspects of concern are being monitored, including soil, water, plants and animals in terms of nutrient uptake and soil movement and contaminants, including heavy metals, pathogens and pesticides.

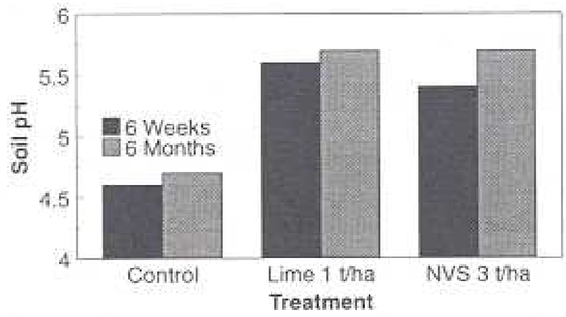

Figure 2. The effects of lime and N-Viro Soil on soil pH 6 weeks and 6 months after application (I. Bamforth, unpublished data).

Dryland cereal production in the Central West

Figures 2 and 3 summarise results obtained from a project conducted in the Central West which evaluated the use of dewatered sludge and N-Viro Soil (see later section for a description of this product) on wheat production. I gratefully acknowledge the assistance of Ian Bamforth for providing this unpublished information.

The sludge was incorporated prior to sowing and the growing season was fairly dry. The results suggest that N-Viro Soil produces a slower liming reaction than lime and that there was no vegetative or grain response to either form of lime (Figure 2). There were, however, significant additional responses to nitrogen and phosphorus over both lime sources.

There were no significant differences in dry matter response or grain yield between the control and the various sludge rates and lime sources where no additional fertilizer had been applied (Figure 3). This suggests that under the dry seasonal conditions that prevailed, the nitrogen and phosphorus is not quickly available.

Pasture grazing trial on the Southern Tablelands

This project, on a 105 ha site at Boxer's Creek, north of Goulburn, is currently one of the largest extensive grazing research projects to be undertaken in Australia. The site was deliberately chosen as representative of low fertility, moderately acid soils that are widespread throughout the tablelands.

The aim of the project is to measure the effects of dewatered sludge at various rates on the soil, pasture, livestock and water systems. The project commenced in 1992 and will run for a minimum of six years, with Merino breeding ewes and their progeny on the plots for their lifetime. Animals removed to undergo testing for heavy metal and organochlorine accumulation will be replaced by progeny bred on the same plots. Treatments, which are replicated twice on three distinct soil types, are:

- Control (lime at 2.5 t/ha, incorporated prior to sowing, plus annual topdressing of superphosphate at 250 kg/ha);
- N-Viro Soil applied at equivalent neutralising value of lime (*ie.* 7.5 dry t/ha); and,
- Dewatered sludge at 30, 60 and 120 t/ha.

The pasture mixture included phalaris, cocksfoot, ryegrass, subclover and white clovers. Ryecorn was sown as a light cover crop with the pasture to prevent soil loss during establishment. Soil samples were taken

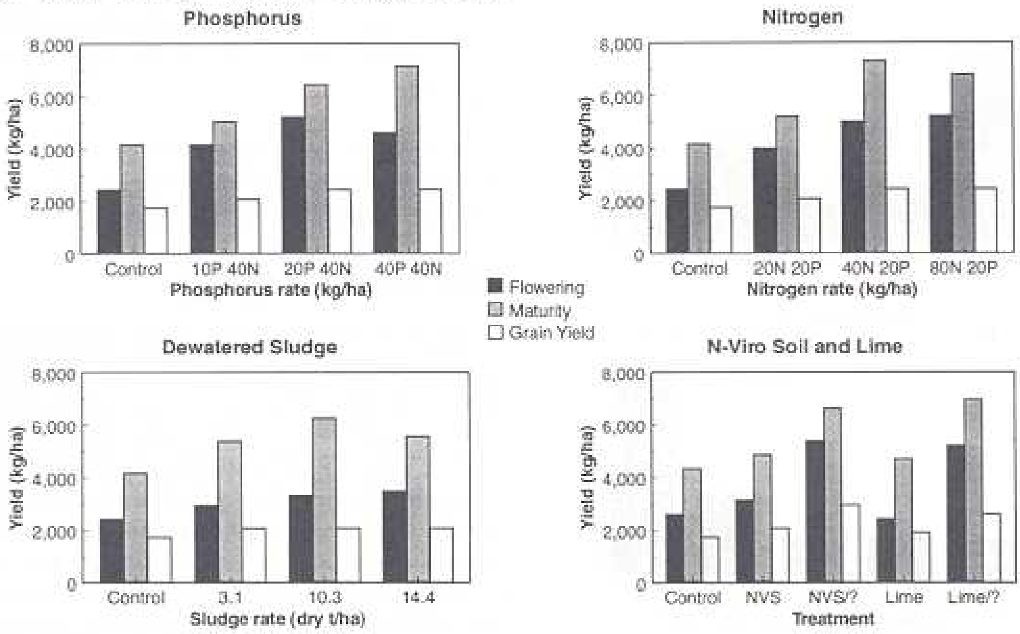

Figure 3. The effects of lime N-Viro Soil sewage sludge and fertilizer on dry matter and grain yields of wheat (I. Bamforth, unpublished data).

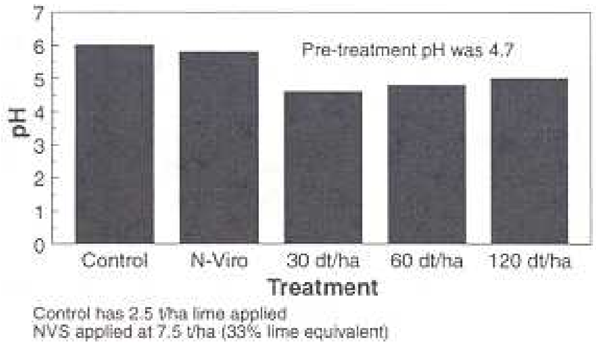

Figure 4. The effects of N-Viro Soil and sewage sludge on soil pH at Goulburn, NSW.

prior to sowing and six months later. N-Viro Soil and lime had similar effects on soil pH, but there were only small increases in pH with increasing application rates of sludge (Figure 4). Other aspects of effects of sludge application on soil chemistry are given by Michalk *et al.* this proceedings). There was a significant dry matter response of ryecorn to sludge application but no response to N-Viro Soil (Figure 5).

The environmental impact of sludge application is being intensively studied in this project. In the short time the project has been in progress, there have been no unacceptable heavy metal or pesticide levels measured in the run-off water. There have also been no results exceeding the current sludge guidelines for heavy metals and pesticides in the soil. The only minor exception to this has been copper and zinc which are slightly over the recommended guidelines where 120 t/ha of dry sludge was applied. (Michalk *et al.*, this proceedings). This application rate is about eight times that currently being recommended for commercial use and has been used for research purposes only.

Pasture experiments on the Central Coast

Professor K. Bell from the University of Newcastle, has undertaken both field and glasshouse comparisons of applications of sewage ash and manufactured fertilizers (Bell *et al.*, 1993). The experi-

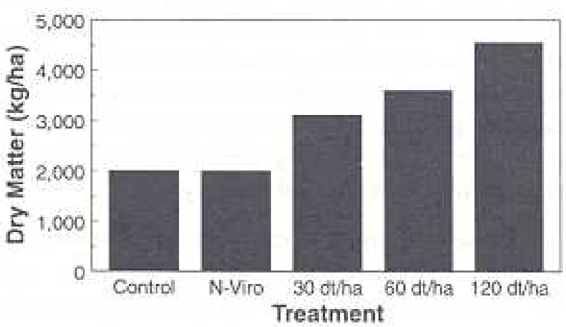

Figure 5. The effects of N-Viro Soil and sewage sludge on dry matter yield of ryecorn at Goulburn, NSW.

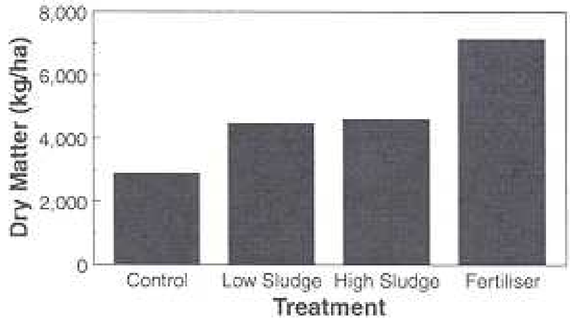

Figure 6. The effects of applications of sewage sludge and fertilizer on dry matter yield of pastures at Raymond Terrace, NSW (Bell *et al.*, 1993).

ments were conducted at Raymond Terrace on a yellow podzolic soil with pH 5.4 and a low potash level.

The fertilizer treatments were incorporated just prior to sowing a pasture mix based on annual ryegrass, white clover and oats. Treatments were:

- Low sludge (6 t/ha dry);
- High sludge (12 t/ha dry); and,
- Fertilizer (N, P, K rates equal to low sludge).

Two yield cuts were taken in May and October and the pooled field responses are presented in Figure 6. In brief, there was a significant yield response to sludge application indicating its effectiveness as a low analysis fertilizer. However, sewage sludge was not as effective as conventional inorganic fertilizer as a short-term fertilizer (smaller response to first yield cut and in total). Also, there was a significant response to potash on sludge treatments (sludge is low in potash).

N-Viro Soil

N-Viro Soil is a granulated dry product based on dewatered sludge cake which has been sterilised with a mixture of cement kiln dust and quick lime. The product has little or no odour and is partially dried to produce a relatively dry, granulated product which can be applied with conventional farm spreading equipment. The composition of N-Viro Soil can vary depending on age and sludge source within the ranges shown in Table 2.

Early results from a wide range of trials and demonstrations carried out by NSW Agriculture indicate that N-Viro Soil, when applied at an equivalent neutralising value, will change soil pH in a similar fashion to lime (Figure 4). However, no significant fertilizer responses have been obtained to the nutrients in N-Viro Soil in many of the comparisons, and it is probably best considered as an alternative form of lime. The economics of utilising N-Viro Soil will very much

Table 2. Average composition of N-Viro Soil.

Element	Range (%Dry)
Nitrogen	0.7 to 1.3
Phosphorus	0.25 to 0.35
Potassium	2.4 to 3.0
Sulphur	0.4 to 0.6
Calcium	12 to 20
Liming value	40 to 50
Organic matter	20
Moisture content	(as delivered)25 to 40%
Density	500 kg/m^3
Heavy metals	(all below requirements)

depend on comparison with the purchase and spreading cost of agricultural lime. Since N-Viro Soil has 40% neutralising value of lime it will have to be applied at two and a half times the lime application rate, and the purchase and spreading costs should be adjusted accordingly.

There may be some fertilizer value of the nutrients contained in N-Viro Soil but these nutrients are not readily available to plants, and may be seen as a medium to longer-term benefit and not as a short term alternative to the use of traditional fertilizer at sowing. However, we have no evidence of this at accepted application rates.

Dynamic lifter

Dynamic Lifter® is composted and pelletised chicken manure containing approximately 3% nitrogen, 2.5% phosphorus, 1.6% potash and little sulphur. It is primarily a source of organic matter and slow-release nutrients, probably best suited to intensively farmed areas where building of soil structure and a broad nutrient base is desired.

A series of trials were undertaken by the Chemistry Branch of NSW Agriculture between 1990 and 1992. The sites were at Oberon, Blayney, Vittoria and Goulburn, all on highly acidic soils (pH 4.0 to 4.2 $CaCl_2$ test). These trials contained various comparisons of single superphosphate at rates varying from 5 to 35 kgP/ha. There were two (control) plots which received lime at 2.5 t/ha prior to sowing, plus superphosphate at 250 kg/ha/year. The Dynamic Lifter fertilizer used was a 50:50 mixture of single superphosphate and Dynamic Lifter which averaged out at approximately 5.7% P.

A summary of the responses obtained from the central tablelands can be seen in Figure 7. Dynamic Lifter had a flatter response curve, showing that the P from this product is less available than that from superphosphate. However, above 25 kgP/ha (equivalent to 280 kg/ha superphosphate), Dynamic Lifter was at least as good or better than superphosphate.

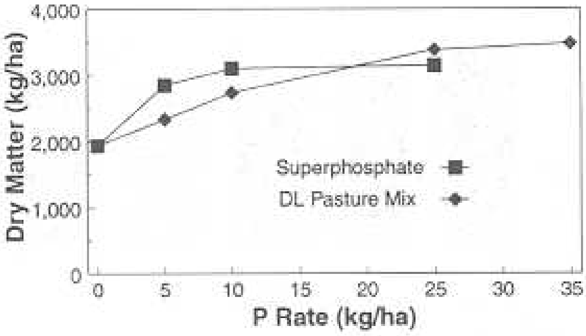

Figure 7. The effects of superphosphate and Dynamic Lifter Pasture Mix on dry matter yield of pastures on the central tablelands of NSW.

On the Goulburn site, which was a low fertility acid soil (pH 4.2 $CaCl_2$), in addition to significant responses to increasing phosphorus, there was a large response to lime in the second year of the trial, and this has continued to date.

For large-scale topdressing on dryland pastures, the comparative economic costs of applying phosphorus and sulphur usually favour single superphosphate or its alternatives. For those who only wish to use organic fertilizer, Dynamic Lifter management are currently blending a new product which will be called Organophos. This product will be based on a three way mixture of 40% gypsum, 20% reactive rock phosphate and 40% dynamic lifter.

Conclusions

There has been increasing interest in the use of organic-based fertilizer in agriculture during the last decade. As a major exporter of agricultural goods to world trade, we are losing, annually, billions of dollars worth of nutrients from the world's oldest and poorest soils. In fact, it has been estimated that the export income achieved from selling wheat overseas would barely cover the cost of the nutrients contained in the grain. (Lipsett and Dann, 1983; Dann, 1990).

Obviously this position is unsustainable, and we must become more efficient at returning nutrients to our agricultural producing areas. The recycling of digested sludge and sludge products which has for many years been pumped out to the sea or into our river systems, is one way of replacing some of this nutrient loss and achieving a less polluted water system.

The research programs currently being undertaken by NSW Agriculture and other organisations will place agriculture producers in a far better position by the 21st century to be able to make better-informed decisions on the role and place of sludge products in farming systems, and enable administrative bodies to develop and implement sound guidelines for their use. I am confident that this can be achieved within the time-scale suggested.

References

Bell, K., T. Bagnall, L. Thompson and J. Windeyer (1993). Sewage sludge - land application trial. Newcastle University, Department of Biology Report SCEN. p 301.

Dann, P. (1990). A balanced review of plant nutrition for grassland ecosystems. Grassland Society of NSW, Annual Conference, Queanbeyan. pp. 68-73

Dann, P., B.S. Dear and R.B. Cunningham (1989). Comparison of sewage ash, crushed limestone and cement kiln dust as ameliorants for acid soils. *Australian Journal of Experimental Agriculture*, **29**: 541-549.

Lipsett, J. and P. Dann (1983). Wheat: Australia's hidden mineral export. *Journal of the Australian Institute of Agricultural Science*, **49**: 81.

Simpson, P.C. (1993). Using Canberra sewage ash in Southern Tablelands pastures. *Agnote 4/61.*

Willets, I.R. and P. Jakobson (1986). Fertilizing properties of trout farm water. *Agricultural Wastes*, **17**: 7-13

Willets, I.R., P. Jakobson, K.W.J. Malafant and W.J. Bond (1984). Effects of land disposal of lime-treated sewage sludge on properties and plant growth. CSIRO Division of Land and Water Resources. Divisional Report 84/3.