Biosolids at the Farm Gate

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Abstract
Approximately 15,000 tonnes of dry solids (t DS) of biosolids are spread onto agricultural land throughout Western Australia (WA) annually by a select number of farmers as a substitute to commercial inorganic fertiliser. The costs and management of spreading biosolids are typically perceived as being more difficult and expensive than a conventional fertiliser program. This combined with the added stigma of dealing with a product, which is often controversial, presents the question, "why then do these farmers persist in continuing with their biosolids fertiliser programs"? Very few studies in Australia have examined the cost/benefit to farmers that use biosolids in their farming program and associated factors as to why these farmers continue to want to have biosolids delivered to the farm gate.

A survey was therefore conducted on a few key farmers in WA who have routinely used biosolids as part of their farming operations to provide information as to the direct cost comparison between biosolids and commercial fertilisers. All farms surveyed were situated in the 400-450 mm/pa rainfall zone of the northern wheatbelt of WA. The biosolids products investigated included dewatered biosolids cake (DBC) and lime-amended biosolids (LAB). Information was summarised as to the costs for labour and spreading typically associated with either biosolids or commercial fertiliser. The costing structure was based on a 100 ha paddock and took into account such factors as the numbers of person hours worked each day, the number of tractors and loaders and the amount of fuel required for each activity. The costing for biosolids was compared with a traditional inorganic fertiliser program, over a three year period.

The average estimated cost to spread and apply biosolids over a 100 ha paddock in a given season was comparative with that of a traditional fertiliser program, being $13,440 and $14,530, respectively. Crop yields were used as a simple indication of the economic value of either biosolids or commercial fertiliser, with some increases to yields of canola in biosolids, but no changes to wheat yields. Given that the cost of spreading biosolids and inorganic fertiliser was similar, the apparent economic benefit of the biosolids was primarily its residual nutrient value in subsequent years. There was no attempt made to analyse changes in the physical, chemical or biological properties of the soil over time.

Introduction
The production and distribution of biosolids in Perth, WA is managed by the Water Corporation, with guidelines for its use regulated by the '*Western Australian Guidelines for Direct Land Application of Biosolids and Biosolids Products 2002*' (DEP *et al*. 2002). Biosolids are defined as the stabilised organic solids produced by wastewater treatment processes, which in most cases can be beneficially recycled (NRMMC 2003). Perth's two major wastewater treatment plants (WWTPs), Woodman Point and Beenyup, stabilise their sludge by mesophilic anaerobic digestion. These secondary WWTPs are located along the coast and discharge effluent via outfalls to the ocean. Biosolids are dewatered by the use of enclosed centrifuges to approximately 19% of total solids, and as such are a suitable consistency for transporting. The Subiaco WWTP stabilises raw sludge by the addition of lime,

although previously it produced pelletised biosolids by thermal drying using an indirect rotary drum dryer, with pellets used for energy recovery at the plant (Bridle *et al.* 2000).

In total, these three WWTPs treated 280 ML/d of raw wastewater and produced 20,000 t DS of biosolids in 2004/2005, which comprised of 10,700 t DS dewatered biosolids cake (DBC) and 9,300 t DS lime-amended biosolids (LAB) (see Collins, Pritchard & Penney this conference). All of the biosolids products meet minimum use criteria of Pathogen Grade P3 and Contaminant Grade C2 or better, as described in the Western Australian Guidelines (DEP *et al*. 2002), making them suitable for direct land application or reprocessing to improve quality. The Water Corporation presently considers agriculture to be the most cost effective and beneficial use option for the use of biosolids in WA. The agricultural sector currently uses 74% of all biosolids produced with forestry and composting accounting for 5% and 17%, respectively. The application of DBC to agriculture commenced in 1996, mostly to wheat and canola crops in a dryland farming system, and since that time, demand for the product has consistently exceeded supply.

All paddocks nominated by farmers for biosolids land-application programs are assessed by the Water Corporation on a site-by-site basis as to their suitability after considering factors such as the existing level of soil contaminants and distance to watercourses etc (DEP *et al.* 2002). The Water Corporation transports biosolids at no charge to the farmers that have satisfied the specific site requirements. All properties must be within the designated trucking distance zone (less than 200 km radius of Perth). To ensure that biosolids are spread evenly onto paddocks, the Water Corporation provides specialised spreaders at no charge to farmers. During spreading, farmers are responsible for providing a loader, tractors, fuel and labour. It is perceived that the spreading of biosolids involves a high input of management, equipment, fuel and labour; however, no data has been collected to date, to establish the costs to farmers. This paper summarises the costs borne by farmers of applying biosolids in agriculture in Western Australia and compares this with costs associated with a traditional conventional fertiliser program.

Materials and methods

A survey was distributed during 2005 to a number of farmers who are regularly involved in the land-application of biosolids in WA. Mean costs were summarised for labour and spreading typically associated with either biosolids or commercial fertiliser, with both based on a 100 ha paddock. The survey took into account the numbers of person hours worked each day, the number of tractors, loaders and the amount of fuel required for each activity. Commercial fertiliser costs were based on such factors as the costs and transport of inorganic fertilisers and spreading.

Farmer crop yields were used as a simple indication of the economic value of either biosolids or commercial fertiliser. Research data by Pritchard and Collins (2006) was used to compare grain yield of wheat and canola grown in DBC (sourced from Beenyup and Woodman Point) at typical farmer application rates of 7 t DS/ha. Yields were compared with those obtained using farmer rates of commercial inorganic fertiliser consisting of 100 kg/ha of diammonium phosphate (DAP) at seeding and 100 kg/ha of urea post seeding, providing a total N rate of 66 kg N/ha, i.e. similar to the plant available nitrogen supplied in the biosolids. Costs associated with seeding the crop, i.e. seed and herbicides were assumed to be similar between the biosolids and inorganic fertiliser and consequently were not included in this paper.

Results and discussion

Comparisons between biosolids and commercial fertiliser

The agricultural region surrounding Perth, WA consists of highly leached and infertile soils, which require regular applications of fertiliser, particularly nitrogen (N) and phosphorus (P), to maintain productivity (Moore 1998). Soils have formed from landscapes that are generally very old by world standards, are low in organic matter and nutrients, complex and highly variable. A small proportion of farmers in WA are substituting biosolids for commercially applied fertiliser in agriculture. For example, a typical analysis of Perth biosolids on a dry weight basis would comprise approximately 5% total N, 2.5% total P and 40% total carbon (Pritchard 2006). Agricultural land application rates of biosolids are commonly applied at rates necessary to satisfy the crop nutrient uptake requirement of N, referred to as the nitrogen limiting biosolids application rate (NLBAR). In Western Australia, the NLBAR is equivalent to 7 t DS ha^{-1} (i.e. 70 kg of plant available N ha^{-1}). To provide a comparable amount of N compared with a standard rate of inorganic fertiliser, for example urea (46% N), up to 60 times more biosolids may typically be required, which contribute to higher spreading costs due to increased labour, machinery and fuel.

Crop yields were used as a simple indication of the comparative economic value of either biosolids or commercial fertiliser. Research by Pritchard and Collins (2006) showed that grain yield of wheat grown in DBC at typical application rates of 7 t DS/ha was comparable to yields obtained using standard rates of commercial inorganic fertiliser in the first year of application (i.e. mean = 2.57 t/ha). Canola yields, however, were 136% higher ($P<0.05$) in biosolids (2.08 t/ha) compared with inorganic fertiliser (1.52 t/ha). In the second season, grain yield of both wheat and canola in the residual biosolids was no different to that of freshly applied inorganic fertiliser ($P>0.05$). By the third season, wheat yields in residual biosolids were still no different to freshly applied inorganic fertiliser ($P>0.05$), whereas canola yields had declined by 74% to that of freshly applied inorganic fertiliser. Thus over a total of three years, it can be assumed that crop grain returns would be equivalent between a once-off biosolids application and three continual years of annual inorganic fertiliser application. Farmers surveyed recorded typical yield increases in biosolids from 110% to 134% higher than average inorganic fertiliser.

Comparison of associated costs between biosolids and commercial fertiliser

The raw data obtained from the survey was used to summarise the minimum and maximum costs associated with spreading 7 t DS/ha of biosolids in a 100 ha paddock, as given in Table 1. Although the mean spreading cost supplied by farmers for biosolids was calculated at $134.41/ha, costs ranged from $102.50/ha to $166.32/ha. Some farmers surveyed also applied small amounts of starter fertiliser, such as 100 kg/ha K-till or 40 kg/ha Agstar at seeding, for potassium not supplied in biosolids, adding an extra $59/ha to spreading costs. There were no major cost differences between the two biosolids products, LAB and DBC. The average spreading costs for commercial inorganic fertiliser was more consistent at $145.28/ha, with the two main fertiliser products being DAP spread at sowing and urea broadcast post-sowing.

Table 1. Examples of costs associated with spreading biosolids at 7 t DS/ha on a 100 ha paddock in WA compared with an inorganic fertiliser application.

Pricing component	Number of hours	Cost component	Number of units	Total cost $
Biosolids (min)				
Labour	35	$20/h	3	$2100
Tractor	35	$50/h	2	$3500
Loader	35	$60/h	1	$2100
Fuel	35	$1/L	30	$1050
Plant maintenance		$250	1	$250
Spreader maintenance		$250	1	$250
Biosolids incorporation		$10/ha	100	$1000
(N.B. potassium fertiliser may be applied + $5900)				**$10,250**
Biosolids (max)				
Labour	32	$25/h	3	$2400
Tractor	32	$70/h	2	$4480
Loader	32	$120/h	1	$3840
Fuel	32	$1.15/L	90	$3312
Plant maintenance		$1280	1	$1280
Spreader maintenance		$320	1	$320
Biosolids incorporation		$10/ha	100	$1000
				$16,632
Commercial fertiliser				
Labour	5	$25/h	2	$250
Tractor	5	$70/h	2	$700

Loader (small)	5	$65/h	2	$650
Fuel	5	$1.15/L	50	$288
Plant maintenance				
Fertiliser spreader maintenance				$100
Option of DAP or Agstar or K-Till at 120 kg/ha		$500/t	12 t	$6000
Urea at 140 kg/ha		$430/t	14 t	$6020
Transport of DAP		$20/t	12 t	$240
Transport of Urea		$20/t	14 t	$280
				$14,528

Hence, preliminary calculations show that the initial spreading costs of spreading biosolids compared with inorganic fertiliser costs may present only marginal cost savings to the farmer or be more expensive. In addition, given the additional management required, biosolids may not appear that attractive an option, with land often unavailable for grazing due to withholding periods for stock etc. Although no yield advantage was evident for wheat grown in biosolids over conventional inorganic fertiliser, the yield of canola was shown to increase significantly (Pritchard & Collins 2006), often being the crop of choice in biosolids programs. For example, an increase in canola yields in the magnitude of 139% at current prices ($330/t) would represent an additional return of $185/ha.

In the second season due to the residual nutrient value of the biosolids, average crop yields (i.e. 2.4 t/ha) are still possible without additional inorganic fertiliser (Pritchard & Collins 2006). Therefore, a significant cost saving of up to a maximum of $145/ha would be obtained where no additional inorganic fertiliser was required. It is more common however, for some inorganic fertiliser to be applied to take advantage of elevated nutrient levels and achieve above average wheat yields. By the third season, farmers commonly return to a normal fertiliser program, with yield benefits continuing to be realised in some crops and sites. Yields of canola in the third season were less in biosolids, and would not commonly be used in a continual rotation program due to associated problems with residual plant diseases carried over in soil and stubble.

Effects of biosolids on soil and grain quality

Western Australia has participated in the Australian National Biosolids Research Project (NBRP) since 2002 (McLaughlin *et al.* 2002). The research in WA is conducted by Curtin University under the leadership of CSIRO Land and Water in Adelaide, South Australia. Other State research units exist in New South Wales, South Australia, Queensland and Victoria. The group's expertise centres on the impact of land applied biosolids on Australian soils and knowledge on how best to reuse these products of wastewater treatment in the context of the various issues raised by this practice http://www.awa.asn.au/Content/NavigationMenu/Information/SpecialInterestGroups/BiosolidsManagement/Biosolids_Management.htm. Related papers are presented at this conference with research specific to loading rates of phosphorus (P) well documented in WA (Pritchard 2005; Pritchard and Penney 2003). The risk of pathogens transferring to cereal grains is also under investigation (Crute *et al.* 2004).

Issues relating to the trucking and on-farm storage of biosolids

The Water Corporation has limited facilities to store DBC at the WWTPs with the current storage capacity of overhead hoppers of 150 to 300 t DS, which on average provide 36 h holding. Previously biosolids were transported by truck and trailer to agricultural properties daily then unloaded and stockpiled in earthen bunds. Depending on the application area there may have been several stockpiles scattered throughout the paddocks. There are a number of problems associated with stockpiling of biosolids, including the potential for nutrient rich leachate to contaminate groundwater and the attractiveness of the biosolids to vectors. Although all flies can be described as a nuisance, the one of most concern is the blood sucking *Stomoxys calcitrans* (stable fly), which breeds in organic mediums including manures (Penney and Dadour 2002). To minimise the environmental and public health impacts of stockpiling biosolids, to prevent fly breeding in stockpiles and for the continued success of the biosolids land application program, the Corporation is proposing to construct a Biosolids Storage

Facility; the first biosolids storage facility of its kind in Australia and is currently finalising the site selection.

Conclusion

Biosolids ‘at the farm gate’ are a useful and economic option for farmers as an alternative to inorganic fertilisers in the wheatbelt of Western Australia. The positive benefits of biosolids as a fertiliser have created a demand particularly as a valuable source of plant nutrients, especially N and P in agriculture in Western Australia; with yields equal to if not better than those obtained in conventional fertiliser programs. The total cost of spreading biosolids is comparable with that of inorganic fertiliser costs in the initial year. Major cost savings are achieved by not having to purchase, transport and spread inorganic fertiliser, but additional costs associated with labour, machinery and fuel are required. The major savings would appear to be in the second and third years from the residual nutrient value of biosolids, with anecdotal evidence and research data available to support this.

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