A long-term study into compost applications for broadacre cropping

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Abstract

Increasing organic matter in soils can minimise the impact of cropping on soil health, ensuring the sustainability and profitability of broadacre farming. This can be achieved through the application of processed organic waste materials, such as compost. Compost is a rich source of slow-release nutrients and can absorb up to 10 times its weight in water, resulting in improved soil water and nutrient availability. To determine the optimal rates and frequency of compost application over several cropping seasons, it is necessary to understand the effect of organic matter addition on soil over long periods.

A long-term study was established in 2001 to investigate the effect of compost applications on a broadacre site at Southern Farming Systems, Gnarwarre, in southwest Victoria. Compost was applied at 10 different rates, replicated 6 times. The site currently uses raised beds to overcome waterlogging in wet winters and springs. However, during dry seasons, raised bed cropping may result in inadequate water availability for optimum growth and yields.

A variety of soil and crop properties were monitored during the first year. Results from the first season are presented and show that compost incorporated into the beds has increased soil water retention and reduced soil bulk density. This suggests that run-off and fertiliser loss can be reduced and soil treated with compost can provide a better environment for crop root development. It is expected that these findings will assist in the understanding of beneficial responses that are typically found after compost has been applied to soil.

Keywords

Soil conditioner, wool, sludge, canola.

Introduction

The application of compost to land has the potential to improve the soil's structure and thereby drainage, microbial activity and water-use efficiency. This may lead to an increase in crop production while reducing the amount of inorganic fertilisers normally required for optimum production. Recent vegetable trials conducted by the State Chemistry Laboratory (SCL), a research institute of Victoria's Department of Natural Resources and Environment (DNRE), in the market gardening areas of Werribee have shown that the application of compost can significantly reduce the amount of water required for optimum production, contribute to nutrient input, and reduce residence crop time to allow early harvest[1]. Other trials in different horticultural regions of Victoria have also shown compost applications to significantly improve production[2]. However, there has been little investigation of long-term compost use in broadacre cropping across Australia.

Soil drainage and organic matter (OM) are inadequate in many broadacre cropping soils in southwestern Victoria. A trial to study the effects of compost on soil quality and crop improvement in raised beds was established at the Gnarwarre site to address these issues. It is necessary to determine the optimal rates and frequency of compost application over several cropping seasons in order to predict effects on soil and water quality. This paper describes the trial designed to investigate these parameters and presents results from the first year of the trial.

Materials and methods

Compost analysis

The compost used for this trial comprised of wool scour sludge and timber fines produced from a sawmilling company. Prior to application, it was quality tested at SCL and assessed for compliance to the Australian Standard AS 4454:1999 for composts, soil conditioners and mulches[3]. The compost satisfactorily passed the requirements of a composted soil conditioner, containing nitrogen (N 0.82%), phosphorus (P 0.05%) and potassium (K 0.54%) on a dry weight basis. The nutrients are mostly present in an organic form, which are released slowly as the compost breaks down. The pH of the compost was 5.6. The OM content was 70%(w/v) and the bulk density was 0.54 kg/L.

Site description

The mean annual rainfall in Gnarwarre is 520 mm. The surface soil has a light clay texture and is dark brownish grey (10YR 3/1) in colour[4]. The soil pH is 5.5 in water (1:5 w/v), and it contains 3.9%(w/v) OM. The soil is classed as a Black Vertosol[5]. The site was fallow in 2000. Prior to applying the compost, the N status in the surface soil was high (total N 0.17% w/w).

Experimental design and compost application

The site has 60 raised beds (each 60 m long x 1.7 m wide), divided into 6 blocks, each containing 10 different treatment regimes, including a control (ie. 1 plot/bed.). Table 1 lists the rates of compost that will be applied over 3 cropping years.

In April 2001, the compost was applied to the soil with a commercial spreader and incorporated into the beds when they were reformed, producing a bed depth of approximately 20 cm. In May, canola *(Brassica napus* cv. Grace) was sown (6 kg/ha) with fertiliser (MAP 100 kg/ha) using a cone seeder.

Table 1. Compost application rates (dry t/ha) for 10 different treatments per block over 3 years

	Treatment no.									
Year	1	2	3	4	5	6	7	8	9	10
2001	0	10	20	30	15	30	45	30	60	90
2002	0	10	10	0	15	15	0	30	30	0
2003	0	10	0	0	15	0	0	30	0	0
Total	0	30	30	30	45	45	45	90	90	90

Soil and plant measurements

Soil and plant sampling was restricted to the middle 40 m of each bed, leaving buffers of 10 m on either side of each plot. Soil samples (0-10 cm) were collected at various times throughout the year to determine soil moisture, OM, bulk density, and nutrient availability. Emergence rates, plant height, and biomass were measured at different stages of plant development. Yield and oil content of the canola seed were also measured.

Results

Soil characteristics

Soil moisture was found to increase significantly with increasing compost application rate in May and July (Table 2). Bulk density samples were taken from 3 treatments (1, 7 and 10) only, in July (Table 3). Soil bulk density decreased and total porosity increased as a result of compost application. Soil OM was determined in July and November (Table 4). There was a significant increase in the soil OM content as a result of increasing compost application rates.

Table 2. Soil moisture (% w/w) for each rate of compost applied (dry t/ha)

Rate	0	10	15	20	30	45	60	90
May	23.6a	23.6a	24.8ab	24.8ab	25.4ab	26.6b	27.9b	30.5c
July	24.1a	25.6b	26.1b	26.4b	26.6b	28.0c	29.8d	31.6e
Nov	18.6a	-	-	19.6ab	-	20.6b	19.3ab	20.9b

Within rows, mean values followed by the same letter are not significantly different ($P<0.05$).

Table 3. Soil bulk density (g/cm^3) and total porosity (% v/v) after treatment

Treatment	1	7	10
Bulk density	1.22a	1.08b	1.01b
Total porosity	54.1a	59.3b	61.8b

Within rows, mean values followed by the same letter are not significantly different ($P<0.05$).

Table 4. Soil OM (% w/v) for each rate of compost applied (dry t/ha)

Rate	0	10	15	20	30	45	60	90
July	3.52a	3.84ab	3.91b	4.02b	4.24b	4.74c	4.76c	5.53d
Nov	4.43a	-	-	4.58a	-	4.93a	4.97a	6.03b

Within rows, mean values followed by the same letter are not significantly different ($P<0.05$).

Six months after the initial application of compost, potassium (K) was the only measured available soil nutrient to be present at significantly elevated levels. For every 10 t of compost applied, there was an equivalent increase in Skene K (1:20 w/v, 0.05M HCl) of about 12 mg/kg from a base of 360 mg/kg in the control.

Plant characteristics

There were no significant differences, between treatments for the crop parameters measured in the first year of the trial. There appeared to be no effect on emergence, plant height or biomass from the compost applied. The mean yield of canola seed was 2.5 t/ha, with a mean of 44% oil content.

Discussion

Our findings suggest that the use of compost has the potential to improve growing conditions for crop production. Increases in soil moisture retention, OM and porosity can improve conditions for plant development and may result in a reduction of run-off and fertiliser loss. This would benefit both the crop and the environment, since more water and nutrients are available for plant uptake, whilst the decrease in run-off reduces off-site environmental impacts. Generally, the release of nutrients from compost, such as K, is much slower compared to traditional fertilisers. This can be beneficial for soils that experience excessive loss of K through leaching.

Despite the application of large amounts of N and P, it is uncertain whether a change in N or P availability will be measurable at the trial site after 3 years. This is due to the slow change in P speciation, and the possible microbial utilisation of N with a net effect of no change in N availability. A number of important essential micronutrients were also found in the compost and changes in soil characteristics will be measured throughout the trial to investigate the effects.

Although there were no significant responses observed for crop growth and yield in 2001, the improvements in soil quality will more likely have an affect on crop yield over the longer term. This trial will continue for another 2 years at least, when we expect to see significant improvements in soil conditions. An important outcome at this stage of the trial, is a lack of any measurable detrimental effects from applying compost. Based on this study and previous investigations into the benefits from compost applications, there is a huge potential to recycle large volumes of composted solid waste produced in the agricultural industry for applications in broadacre cropping that will bring both environmental and economic gain.

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