Worm-worked waste as an organic amendment for cotton soils

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Summary

Cotton-trash and feedlot-manure has been processed by composting-worms over three months to produce vermicompost, an organic residue reputed to improve soil conditions for plant growth. A paddock-scale trial has been established to evaluate the effects of these worm-worked organic wastes on cotton production.

The vermicompost was broadcast on cultivated soil and incorporated during bed-formation, six months prior to cotton seeding. Rates of up to 5 t/ha vermicompost or 4 t/ha cattle manure were superimposed on normal cotton fertilizer practices.

There were no obvious differences in plant height, within the first two months of growth. But there were significant effects of the vermicompost treatments on the plant establishment and flower and fruit development. The lower rates of vermicompost (1 & 2 t/ha) were associated with an increase in plant density, while there are indications that the highest rate of vermicompost (5 t/ha) may have reduced germination and establishment; the cattle-manure had no effect.

However, the higher rates of vermicompost contributed to a significant increase in internode length, and earlier development of the first fruiting-node; the manure and the lower rates of vermicompost had no significant effect.

These early indications of responses to the vermicompost treatments will be monitored to determine the value of worm-worked wastes at critical stages of growth, and an economic evaluation of effects on yield will be made after harvest.

Background

The importance of soil organic matter for the maintenance of soil structure, and efficient use of water and nutrients is widely recognized. Industry-funded research projects are currently investigating the management of soil organic matter in cotton-growing soils.

Improved cotton growth has been observed with top-dressings of cattle manure, produced locally from feedlots, providing additional organic matter and nutrients. Substantial quantities of cotton processing waste, which had been used as a cattle-food supplement, is presently dumped and left to degrade in stockpiles around the gins. Cotton-producers have recognized this waste as a potential source of organic matter which could be used to improve soil conditions.

Worm-composting of organic residues from animal and plant processing produces a finely-divided organic material, vermicompost, which is reputed to produce superior growth responses in plants. Edwards & Neuhauser (1988) report increased plant growth in potting-media enhanced with vermicompost derived from animal manures. Recent studies have demonstrated substantial yield increases when worm-worked wastes from grape-processing were used to supplement normal vineyard management (Buckerfield & Webster 1998).

Worm-growers, working with cotton-growers, have now developed mechanized technology for worm-composting of cotton-wastes with feedlot-manures. These primary producers are now keen to validate the economics of vermicompost as a soil amendment in cotton-growing, and have requested assistance from CSIRO to develop credible field-trials to evaluate the performance of the worm-worked wastes.

Experimental Design and Measurements

Site - A 60 ha paddock on the "Keytah" property 35 km W of Moree, was selected as representative of the black-soils favoured for cotton-growing in the district. This paddock had previously been sown to wheat, and could now be considered for longer-term monitoring of at least two subsequent crops of irrigated summer cotton.

Layout - An appropriate layout was determined to provide plots which could be harvested mechanically to provide complete module units for yield assessments. Each treatment plot (800 m x 40 m) was replicated three times in a randomized block design.

Treatments - The vermicompost was produced from locally-available feedstock, comprising stockpiled feedlot-manure and cotton-trash residues from the gin. Composting worms (*Eisenia fetida*) were used to process the organic-waste mixtures in outdoor trenches; after four months, the upper 10 cm with worms was removed and the remainder used immediately as a dressing on the trial plots.

Rates - Vermicompost treatments were selected at rates appropriate for comparison with animal-manures which had commonly been used as soil amendments on the property; viz. 2 & 4 t/ha feedlot manure and 1, 2 & 5 t/ha vermicompost.

Timing - Discussion with growers determined that the most appropriate time for application of the treatments was after the hills had been prepared, but immediately prior to injection of anhydrous ammonia and final bed-preparation in April. This would ensure effective incorporation of the surface-applied organic materials, and adequate time for 'stabilization', prior to sowing in October[a].

Spreading - Local contractors assisted in the calibration of fertilizer-spreaders to enable effective distribution of the 'wet' vermicompost, dug directly from active worm-beds.

Each of these treatments was applied at the prescribed rates with a truck-mounted rotary spreader, superimposed on the normal-practice applications of fertilizer (control).

Sampling and Measurements - Discussion with growers and agronomists determined appropriate stages of plant development to indicate significant effects of the treatments on growth. Plants were sampled non-destructively along the mid-row, with measurements commencing 50 metres from the end-drain; additional samples were taken two rows either side of the mid-row of each plot.

A comprehensive sampling of 1200 plants in mid-December provided adequate data to determine the influence of treatments on establishment, flowering and fruit development.

Plant height was determined on ten adjacent plants from each of three rows in each plot; number of nodes, first-fruiting node, squares and fruits formed/retained and flowers-emerged were recorded for each plant.

Plant density was estimated from the number of plants in each of ten consecutive metre-lengths of row, repeated for a further ten metre-lengths five metres further into plot; three rows were sampled from each plot.

Results and Discussion

The measurements in December, after two months of plant growth, give clear indications of responses related to the vermicompost treatments. Statistical significance ($P<0.05$) was determined using ANOVA on individual plant measurements.

Plant Density - There were significant differences plant density, with number of plants ranging from 5.4 to 6.9 per metre of row (Fig. 1). The lower rates of vermicompost (1, 2 t/ha) were associated with a significant increase in plant density; the dung had no effect. There were indications that the highest rate of vermicompost may have reduced germination and establishment; this may be compensated for with less inter-plant competition during later growth.

Plant Heights averaged 47.5±0.5 cm, and were greatest with the highest rate of vermicompost. Plant height was significantly correlated with higher number of both nodes and fruits ($r=0.58$ and $r=0.64$, $P<0.0001$). There is an inverse relationship between plant height and plant density ($P<0.001$).

Internode Length - Up to 18 fruiting-nodes per plant were recorded at the time of sampling; this averaged 13.0±0.1 overall, but did not differ significantly between treatments. However there were clear differences in average internode length (Fig. 2), with significantly greater extension with the higher vermicompost treatment.

An inverse relationship between plant density and internode length ($P<0.01$) could indicate contrasts in moisture stress; this can be confirmed with occasional measurements under the different rates of vermicompost.

First Fruit - The higher rates of vermicompost (2 & 5 t/ha) were associated with first fruit development on nodes significantly lower on the plant (Fig. 3). This provides potential for more fruits developing on the plant and an earlier harvest.

Conclusions

These early responses in plant growth indicate potential for using worm-worked wastes as a supplement to existing cotton-management; these can be compared with similar rates of animal manure. A detailed analyses of harvest yields and quality measures will determine (a) whether the worm-worked wastes have a significant effect on yield and (b) economic rates for cotton production[b].

The effects of these organic amendments on soil structure and plant nutrition will be monitored through subsequent crops. There is evidence that nursery plants grown in the 'biologically enhanced' vermicompost may have increased resistance to pests and plant diseases (Edwards & Bohlen 1996). The possibility of reducing fertilizer and pesticide inputs, while maintaining cotton production, will also be investigated[c].

The research has stimulated considerable discussion in the region, and following reports in "The Land" (Johnson 1998), we have received numerous calls from cotton-growers with an interest in utilizing cotton-processing wastes for soil improvement.

While we expect clear indications within the first year of the value of worm-processing organic wastes for use in cotton soils, a valid assessment of the economics and sustainability needs to evaluate the residual effects of the organic amendments on subsequent crops.

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[a] Chisel-plough cultivation, vermicompost/manure and NH_3 application, hill preparation 15-17 April 1997. Cultivation, phosphate/zinc fertilizer application and bedshaping, 2-4 August 1997. Herbicide application, sowing with 'Siokra V-15' cotton, 1 October 1997. First full irrigation 2 December 1997.

[b] We have presented only data for the lower rate of cattle manure. An economic assessment will require a comparison of responses to the manure with responses to the worm-worked cotton- and animal-wastes.

[c] In the trials we have not considered the vermicompost as an alternative to accepted fertilizer applications, but as a supplement to the normal-practice (control).

Figure 1 - Establishment of cotton, with vermicompost/manure - Moree, NSW - 16/12/97.

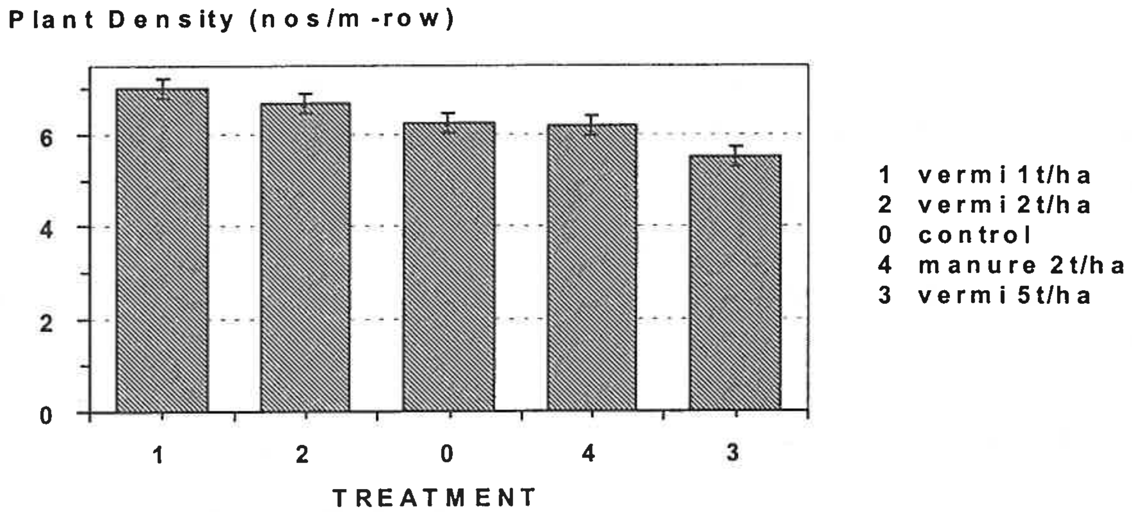


Figure 2 - Average internode length of cotton, with vermicompost/manure - 16/12/97.

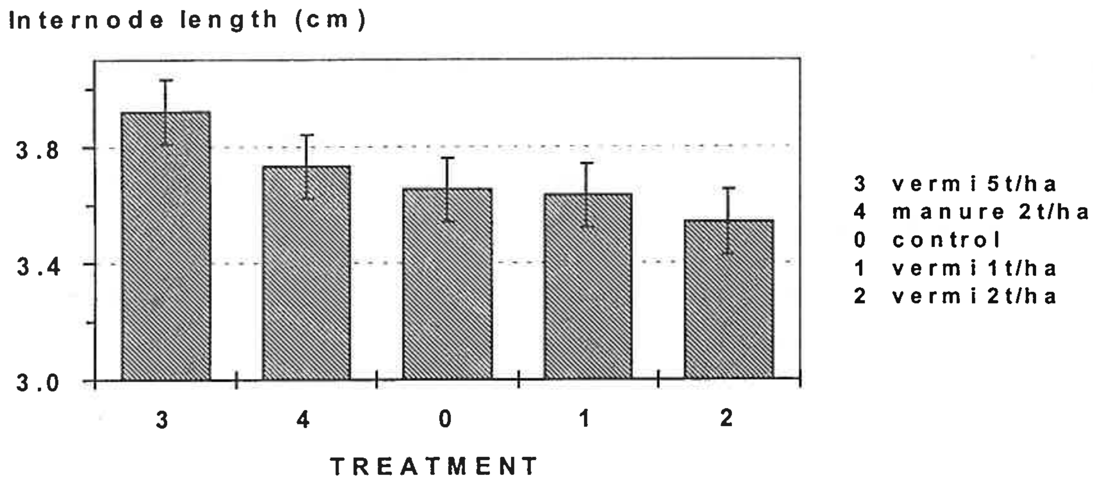
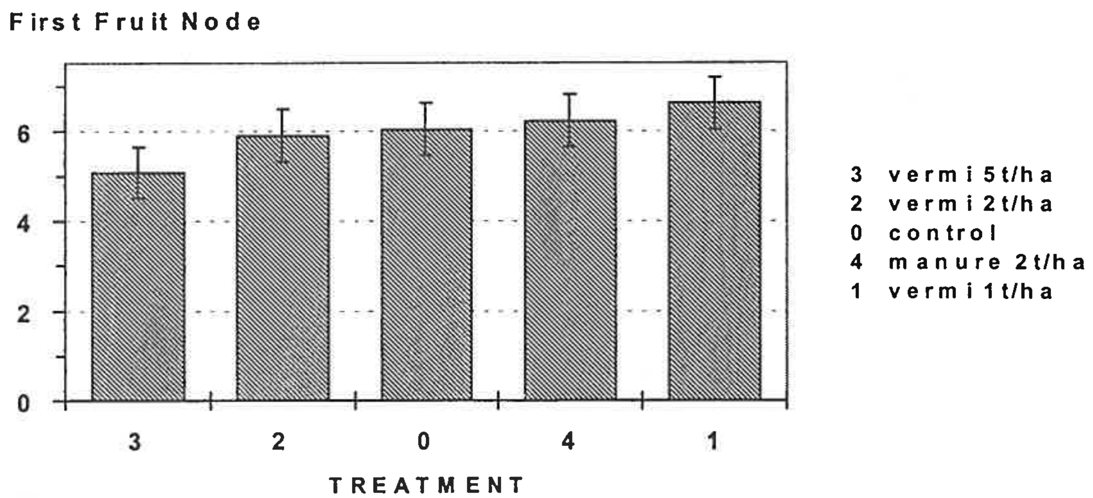


Figure 3 - First fruiting node of cotton, with vermicompost/manure - 16/12/97.



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References

Buckerfield, J.C. and Webster, K.A. (1998). Worm-Worked Wastes Boost Grape Yields - prospects for vermicompost use in vineyards. *The Australian and New Zealand Wine Industry Journal* 13: 73-76.

Edwards, C.A. and Bohlen, P.J. (1996). "Biology and Ecology of Earthworms". Third Edition. 426 pp. Chapman & Hall, London.

Edwards, C.A. and Neuhauser, E.F. (1988). "Earthworms in Waste and Environmental Management". 392pp. SPB Academic Publishing, The Hague.

Johnson, P. (1998). Cotton looks seriously at worms. Moree vermicast trials compare fertiliser values. *The Land*, January 1 1998, p.27.