Low-tech gin trash composting to remove pathogens and residues

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Abstract
Gin trash and mixtures of gin trash were composted using a minimum of equipment and labour inputs. Questions of cotton pathogens and synthetic chemical residues were addressed by lab testing pre- and post- composting. Guidelines were developed for overcoming practical problems with wetting the trash initially, handling the trash so that all was heat treated for long enough, determining the time to end composting, and how to use the compost.

Introduction
The ginning sector in Australia currently processes approx. 3,000,000 bales of cotton lint per year. At an estimated 7% trash in seedcotton, and a typical 37% turnout, this represents approx. 130,000 tonnes of trash per year. Current methods of use/disposal of this material are marginally adequate. It is expected that in the next few years the industry will expand further, and also that environmental controls over some of the current methods will become tighter.

Cotton gin trash comprises leaf, bract, stick, waste lint, dirt and a micro-biological component. The gin trash is suitable for composting because its ratio of carbon to nitrogen is in the right range and it can be had for nominal cost in large amounts at a selection of locations. Composting is a process whereby organic matter and some inorganic materials are oxidised using micro-organisms so that they are transformed into heat carbon dioxide, water, and more stable organic material known as humus. Composting gin trash is common overseas and there are several *ad hoc* trial sites in Australia.

Composting has the following advantages for disposal/use of cotton gin trash:
- The 130,000 tonnes represents a sizeable amount of fertilizer equivalent.
- It also represents a source of organic carbon to replace that lost through intensive cultivation. Because this organic carbon arises from compost, it will be longer lasting than that arising from, for example, uncomposted animal manures. This organic carbon will have the effect of broadening soil micro-organism populations away from cotton pathogens.
- When manure is added to balance the carbon:nitrogen ratio of sawdust, it brings with it slow-release Potassium, an important and sometimes limiting nutrient for cotton;
- Together, these aspects mean that gin trash can become a gin product with a positive net value rather than a gin waste with associated costs, if it can be shown that it has been composted in the right way;
- The trash is markedly reduced in volume, so handling, storage and transport become easier. Currently, some gins estimate they spend around $60,000 pa on handling and storing trash. These

costs may increase markedly if a trash heap spontaneously catches fire, because the lint content of trash means it is notoriously difficult to extinguish. Composting converts trash from a dusty, low density waste into a stable, dense, useable and saleable by-product;

- Soil borne cotton pathogens, most weed seeds and most synthetic chemicals are removed when the temperature rises high enough for long enough within a compost heap.
- Trash dumped in large heaps will naturally compost, but in an uncontrolled manner. Under certain conditions of temperature and oxygen supply, the material may spontaneously combust, causing smoke hazard and the risk of fire spreading. This destination for trash in particular is expected to become a problem in environmental regulation terms in the future. (Laying the trash in windrows in typical composting practice is very unlikely to cause spontaneous combustion as the depth of material is not great enough.)

Composting also has the following disadvantages that need to be addressed before it will be widely accepted:

- The thermal effects of composting only occur towards the centre of a composting material. At other places, e.g. along the edges of windrows, it is likely that sufficient unwanted components survive to cause problems. Commercially available machinery for turning compost in windrows is not specifically designed to produce a 100% kill of micro-organisms, because the machinery is primarily designed to macerate and aerate, but not necessarily circulate. That all material will spend time in the centre is not guaranteed;
- Trash from a joint pool can reasonably be expected to contain propagules of whatever diseases are present in the grower 'catchment' of that gin, including Fusarium and Verticillium. Growers have an understandable reluctance to put trash or trash derivatives on their land if there is a likelihood that diseases will be introduced. This would very likely prevent the wide acceptance of composted gin trash, and reduce its value;
- In particular, it is very likely that local quarantine requirements against *Fusarium oxysporum* f.sp. *vas infectum* (FoV) cannot be met;
- Composting represents a distraction from usual ginning practice that requires finance and management time. Adoption of new methods of handling trash must be as 'painless' as possible.

This project includes work on mixing cotton trash with other wastes such as animal manures and hardwood sawdust. This is because such mixtures offer important benefits in terms of

- Increasing particle size so that the windrows remain properly aerated;
- Improve the water retention of the trash mixture;
- Increasing the value of the resulting fertilizer in terms of its chemical makeup;
- Increasing the rate of biological activity and hence heat generation within the windrows to maximize pathogen propagule and weed seed destruction;
- Decreasing the chance of nutrient leaching or volatilisation by locking those fractions up in the microbial biomass;

Method

Three windrows, each of approximately 20 tonnes over 27 metres, were laid down adjacent to the trash dump at the Queensland Cotton gin near Dalby, Qld. The windrows consisted of the following: trash from normal late season ginning (**t**); trash mixed with feedlot manure (**tm**); and trash, manure and cypress pine sawdust (**tms**). No special care was taken when laying down the trash, nor when mixing in the other fractions. Windrows were formed by the dumping action of the tipper, and the mixing in was done using the front bucket of a backhoe.

The mixture was watered, and temperatures were monitored on a weekly basis. At intervals of approximately five weeks, the windrows were turned, again using the front bucket of a backhoe, for a total of four turns. Immediately prior to each turn, temperature profiles of the windrows in cross-section were determined on a 250mm grid.

At the beginning and end of the composting, samples were sent for analysis of chemical makeup and for the presence of organo-chlorine and organo-phosphate synthetic chemical residues.

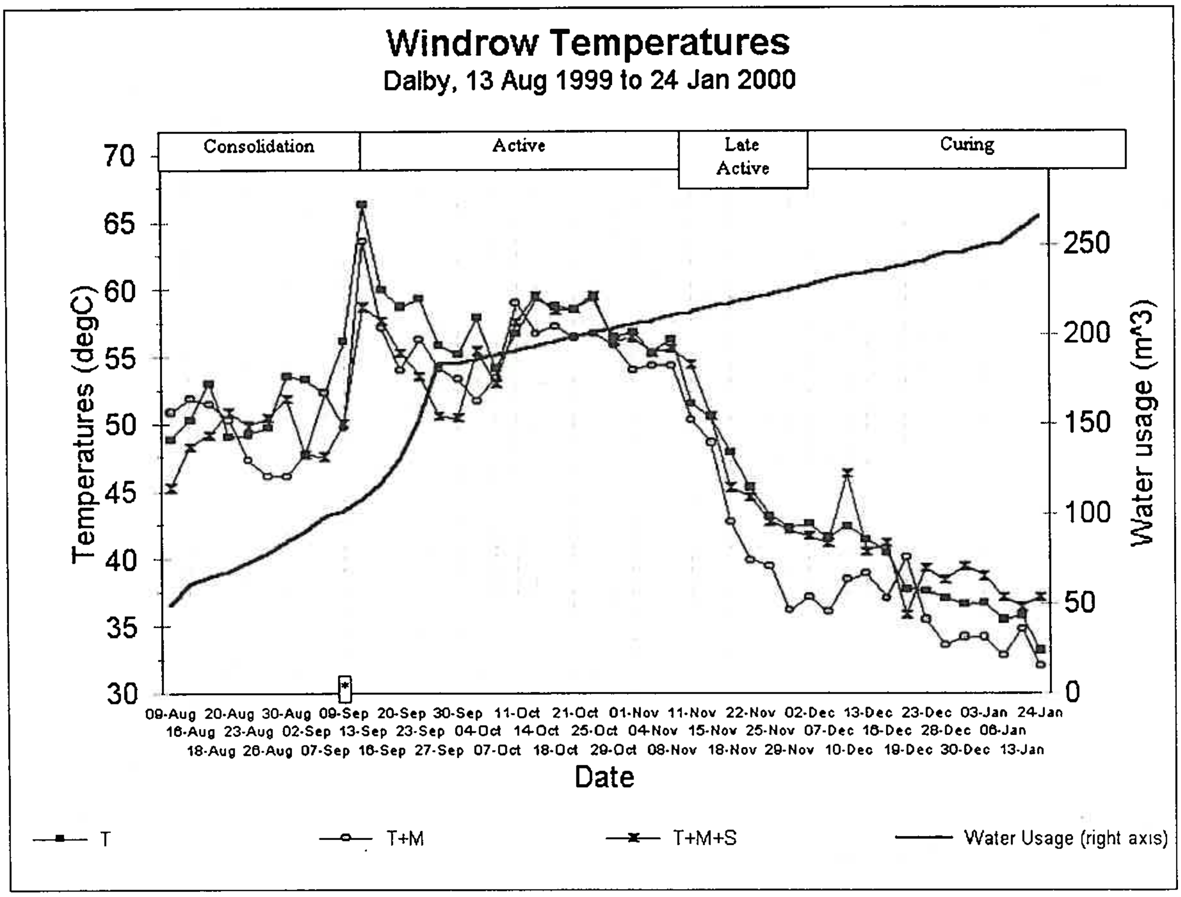
At an early stage, fabric mesh bags containing cotton plant material known to be infected with FoV were placed in several positions within each windrow. These were removed after two weeks and sent with unburied control samples for analysis (direct plating and bio-assay) of survival of FoV.

Results and Discussion

Watering

It was found that the hydrophobic nature of the waste lint in the trash made the trash difficult to wet. This had been expected (going by anecdotal information from the industry), and the watering from the beginning was done at a slow rate (29 lpm over each 27 metres) by use of long lengths of soaker hose, inverted to minimize drift and to place water at the top of the windrows. However, the water moved straight down and pooled beneath the windrows and did not move outward by capillary action. The hose was then used upright allowing a fine spray to fall all over the material, and the application was automated by use of solenoid valves and a timer so that the water was applied in the early hours of the morning when the wind was at a minimum. This change is marked by the asterisk near the date 9th Sept, at the bottom of *Figure 1*. The change in temperature within the core of the windrows after this change in watering regime is evident. The temperature rose rapidly directly after the change, then fell again when the material became saturated, but after fine tuning of the watering times the process continued satisfactorily. This suggests that attempting to water trash by high flows of water directed at points along the windrow will not succeed, and that the windrows should be watered by broadcast means at a rate low enough for the material to absorb without shedding.

Figure 1

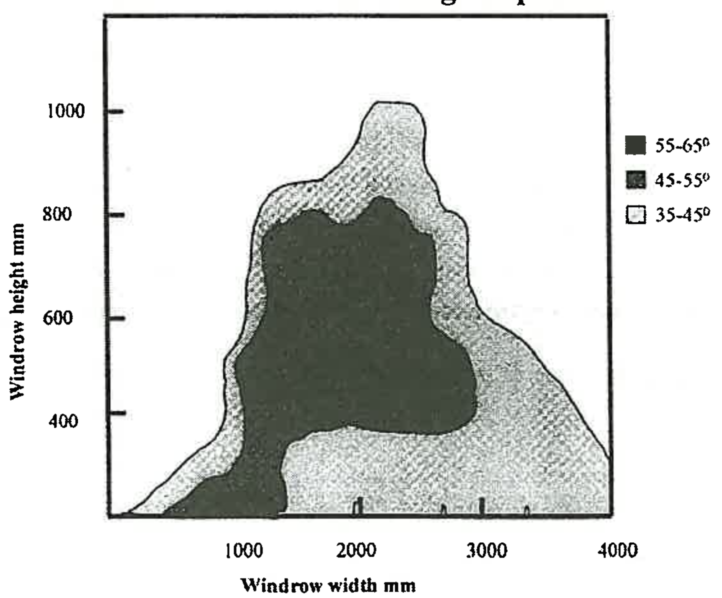


Temperature

It was found that the windrows developed a hot zone high in the centre of the windrows (see *Figure 2*), where peak temperatures were found. High (45°C) temperatures persisted quite close to the surface especially early in the process when activity was highest.

Figure 2

Cross-section of windrow showing temperature zones



Handling

For the initial mix (5th Aug) and then the first two turns (31st Aug and 8th Oct), the emphasis was less on fine mixing of the material and more on making sure all the material was circulated to the hot zone (see *Figure 2*). This was done by using the bucket to divide the windrow in two to open up the hot core, dropping in the cooler edges and then reforming the peaked shape of the windrow. Later turns (16th Nov and 11th Jan) were done by moving the entire windrow across by one width by lifting it high and dumping it so that pockets of unmixed trash, manure or sawdust were distributed. Even so, throughout the process pockets of unmixed material could be found, and could be detected by local hot zones even when the rest of the windrow was cooling slightly. For this 'lo-tech' method, this is not considered a problem. The material was intended for application back onto broadacre land, and the appearance of the compost was not as important as ensuring that all of the material had been hot enough for long enough.

Pathogens

The mesh bags were buried between 16th Aug 99 and 31st Aug 99, which means that this test was 'worst case', in that the material at that stage was not properly wet, biological activity within the windrows was slightly depressed for lack of water in some parts, and temperatures were not properly in the 55°C to 65°C ideal zone. Nevertheless, it was found that while FoV was present in the control samples (14% of stem pieces displayed FoV under direct plating, and 60% of cotton seedlings died under bioassay), no trace of FoV was found in the buried samples (0% under direct plating and bioassay). If the FoV infected samples had been buried after this early period, the removal of pathogen propagules would have occurred faster but with the same end result, and with a smaller proportion of the windrow cross-section being at temperatures below the ideal range.

Synthetic chemical residues

Traces of endosulfan were detected in the trash prior to composting and this was the only synthetic chemical present. No synthetic chemicals were detected in the composted material.

The need to know when composting has ended

Composting ends when all of the reactive carbon material in the composted has been converted to humus forms. Determining the time of this is important. Waiting too long (such as three years or so under dumped storage heap conditions) ties up land and the compost resource unproductively. Applying compost at an immature stage can have unintended effects. Compost is usually allowed to dry when it is judged that it is mature, which stops the composting process if it is still in the active phase and suspends the activity. However, the micro-organisms are still present and so is the uncomposted material. When the compost is spread on soil and watered the process restarts. The nutrients in the compost meant to fertilize a crop are not available to it, because the nutrients (principally nitrogen forms 'N', phosphorus P, and potassium K) are still locked up in the cell structure of the micro-organisms doing the composting. In fact the micro-organisms may take up nutrients from the soil around the seedlings the better to process the uncomposted material around them. So the compost under these conditions has a <u>zero</u> or even a <u>negative</u> effect on the nutrient status of the soil. The visible effect is a crop that emerges from the ground healthy, yellows, and dies. There is anecdotal evidence of this happening in isolated cases recently.

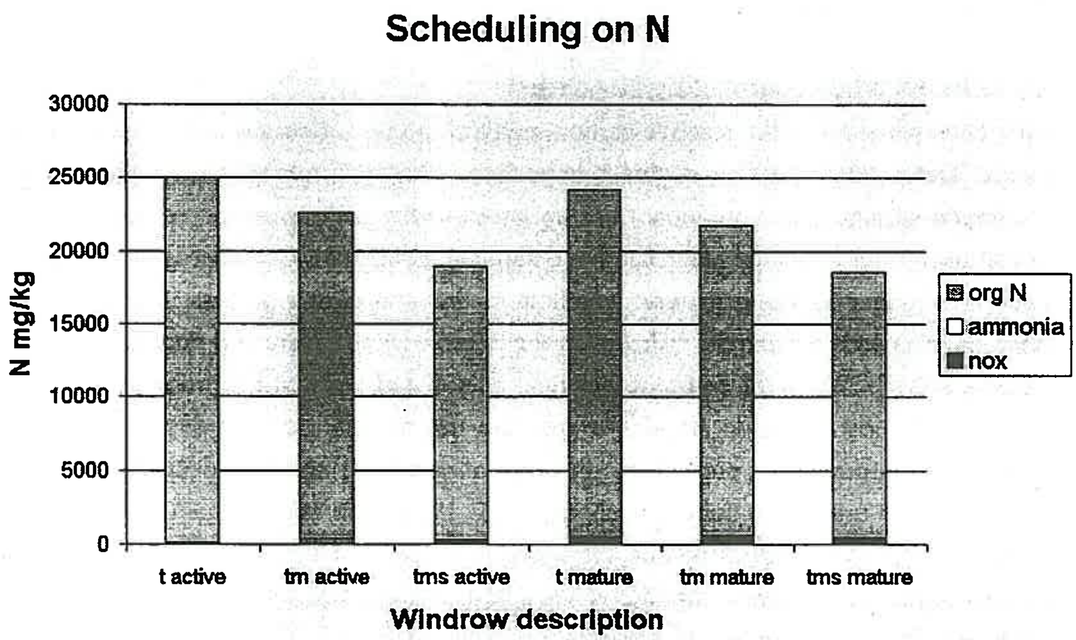
Determining the end of composting

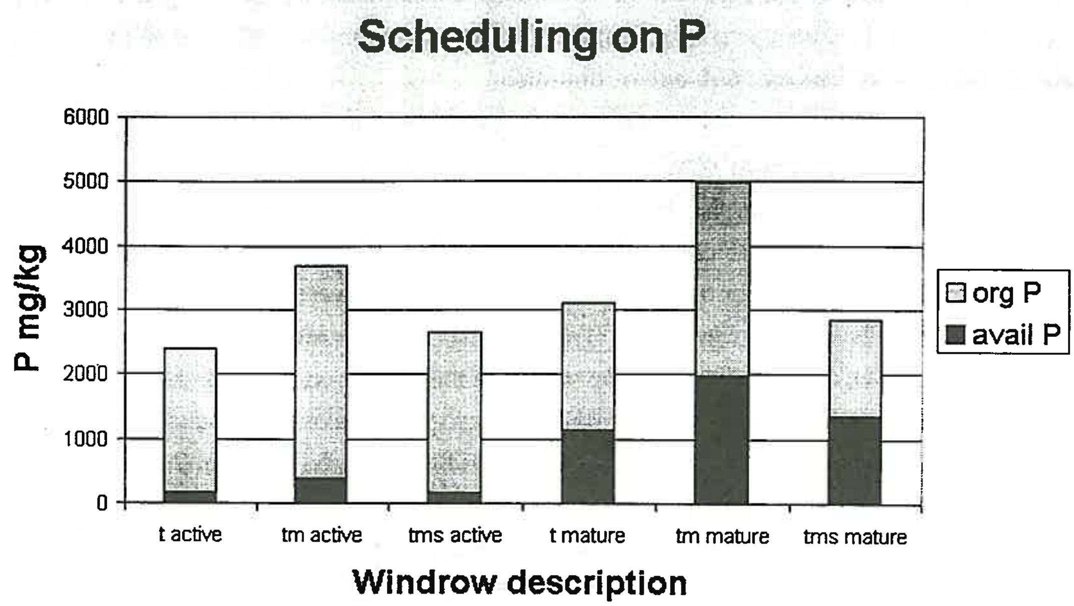
To avoid stopping the composting too early or too late, two methods are useful.

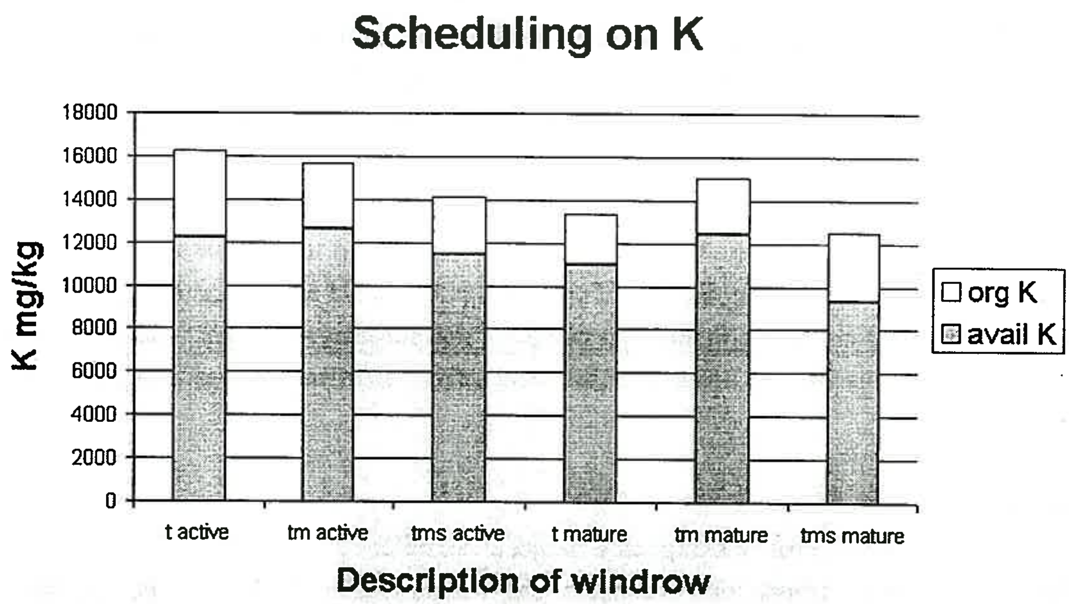
- The first is to watch the temperature in the core of the windrows (see *Figure 1*). From the left, the lines representing the temperatures within the three windrows rise at first. This is the consolidation phase when the material is taking up water, the windrows are falling in height as the air spaces collapse, and micro-biological activity and temperature are increasing. Then the lines are level, this is the active phase showing micro-biological activity in the presence of ample compostable material and limited only by heat buildup. The lines then begin to fall during the late active phase as compostable material begins to run out. The lines then change slope as the temperature falls further but at a slower rate, representing the curing phase when only the more stable humus forms are available and activity proceeds at a slower rate over a much longer period. The better the material is mixed, the sharper the change in slope between the late active and mature stages. When this change is seen, the material has entered the curing stage. Care should be taken to ensure that a drop in temperature when the end of composting is expected is not due to drying out, waterlogging, windrows becoming too small to hold heat or other events affecting the activity within the windrows.
- The second method is by reference to the proportion of P available in the mineral form. When available P approaches 50% of the total P, the compost is at maturity.
- In addition, work was carried out in this project to develop a simple means of determining the end of composting, using ion exchange resins. However, to date these methods have not been successful.

Determining the rate of application of compost

Figure 3 (in 3 parts)







Most of the nutrients in compost are in their organic forms, locked up in the cells of the micro-organisms. They will not be available until other soil microbes can break them down into mineral forms, which is to say many months after entry into the curing phase. *Figure 3* shows each windrow in the active phase and in the curing phase, and shows how in the former there is proportionately more nutrients in the unavailable organic form(s). This is more so for N and less so for P and K. Therefore, on the results of chemical analyses during the composting stage of this project, it is recommended that scheduling of compost application be done on the basis of soil tests for P and K requirements and compost tests for P and K availability. It should be assumed that all compost N is unavailable in the first year or so of compost application, and inorganic N fertilizer will be required. In subsequent years, 'post-dated' N from the compost will become available and the need for inorganic N fertilizer will end or diminish.

Survey of gin trash from other sites

As an adjunct to this project, samples from nine gins and three *ad hoc* composting sites in NSW and Qld were sent for analysis of chemical makeup and for the presence of synthetic chemical residues. In all trash samples from the gins, traces of endosulfan were found, but none was found in the output of the *ad hoc* composting sites. Traces of DDE (a non-insecticidal biologically active breakdown product of DDT) were found in the output of the *ad hoc* composting sites, but not in the gin trash. One gin sample showed traces of Endrin (another breakdown product of DDT). The DDE and Endrin results are most likely to be the result of the inclusion of dirt in the samples with a history of DDT usage. In addition, the samples were examined for the presence of cotton pathogens. Although high concentrations of fungal organisms were found, no FoV or Vert forms were found.

Summary

It has been shown that for the task of handling trash at gins and making a product suitable for broadacre farming, cotton trash can readily be composted alone or in co-composts. This can be carried out with a minimum of equipment if required, as long as the material is properly wet initially and the end point is accurately determined. It has been shown that cotton pathogens and synthetic chemical residues are removed if all of the material is cycled through the hot zone of the windrows for at least two weeks. Application of the composted trash back to cotton fields is therefore feasible. For the first application of compost, rates should be determined by reference to phosphorus and potassium levels in soil and compost, not nitrogen as compost nitrogen is 'post-dated' and becomes available to crops in subsequent years. Inorganic nitrogen may be required until then.

Acknowledgements

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