Alternatives to Methyl Bromide for Control of Quarantine Pests: Can Composting of Bark Provide Consistent Lethal Heat Accumulation?

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Abstract

Under the Montreal protocol (1991), methyl bromide has been recognized as a significant ozone depleting compound and a program to phase out its use has been agreed. This will involve a 25% reduction by 1999, a further 25% reduction by 2001, a 20% reduction by 2003 and a complete ban by 2005. There are exemptions for developing countries so that use will remain at average levels used during the period 1995 to 1998, followed by 20% reduction by 2005 and complete phasing out by 2015. Although there are further exemptions for quarantine usage, including pre-shipment treatments, there is now a world-wide effort to address the methyl bromide issue in an attempt to find viable alternatives for both pest management and for quarantine pre- or remedial treatments. This paper describes work under a joint program, part funded by the European Union, entitled *New Quarantine Treatments for Horticultural and Timber Products as Alternatives to Methyl Bromide Fumigation* (Project Code: FAIR CT98 4259) involving partners in the UK (Central Science Laboratory (Coordinator) and Forest Research) and the Netherlands (Research Station for Floriculture and Glasshouse Vegetables (PBG)). Further information can be found at http://www.csl.gov.uk/mebr/index.htm.

Purpose of the Research

Although exemptions for critical use of methyl bromide are to be allowed under the Montreal protocol, these are only allowed under specific criteria, including:

a. there are no available technically and economically feasible alternatives or substitutes that are acceptable from the standpoint of environment and health
b. work is underway to investigate, evaluate, field test, commercialise and, where necessary, facilitate regulatory approval for alternatives and substitutes, with a view to phasing out methyl bromide as soon as possible
c. methyl bromide has been regularly used as an integral part of fumigation operations in the crop and region concerned during the previous five years.

Within the current research program, the scientific consortium is studying a number of potential alternative measures that might be suitable as quarantine treatments. These include heat treatments, composting, extreme controlled atmospheres and alternative fumigants. The current paper describes work carried out by Forest Research on composting of bark as an alternative to methyl bromide for shipment of bark between quarantine zones.

There has been a long history of international trade in wood chips, mainly to serve the pulp and paper industries. In recent years there has been increasing interest in the use of bark and wood chips for mulches in the horticulture and amenity areas. Research into composting schedules has tended to concentrate on the rate of decay of the bark or wood and, particularly, on the suitability of the final product for plant growth, ensuring that quantities of toxins are below required levels. Research on composting as a plant health regime requires that temperatures throughout the compost heap should exceed the thermal death time for any quarantine organisms that might be present. Current heat treatment schedules specify 56°C for 30 minutes for wood and wood products and this has been used as the minimum criterion in carrying out research into compost heat treatments.

The baseline protocol used to assess compost heat treatment is the European and Mediterranean Plant Protection Organization (EPPO) Phytosanitary procedure PM 3/53 *Fermenting (composting) of bark of conifers*. This includes requirements such as milling the bark to below 50 mm mesh size, addition of up to 2% N and 4% P and the turning of the stack 3-4 times during a 4-6 week period (based on research by Solbraa (1979). The target is to achieve heat accumulation of >60°C throughout the compost heap. Although this process is likely to provide a high level of security in relation to various quarantine organisms associated with bark (mainly bark beetles), the physical limitations on bark particle size and the extended time period in which the bark actually is rendered into a compost tends to rule out many markets for unmodified bark with larger

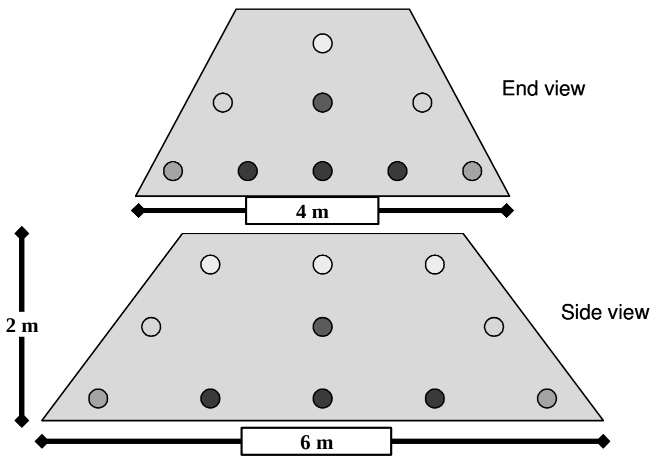

Figure 1.—Diagram of side and end views of experimental bark heaps showing positions of the 37 temperatures sensors. Additional sensors measured air and ground temperatures.

dimensions. Our research has, therefore, concentrated on the basic requirement that any bark, irrespective of particle size, should be capable of being *heat treated* using natural metabolic activity such that a temperature exceeding 56°C for 30 minutes is achieved throughout the bark heap. It is known that, under suitable conditions, metabolic activity can be very rapid, leading to temperatures exceeding 60°C in 2-3 days. Experiments on both small and larger scales were designed to test the ability of unmodified bark (i.e. bark generated by commercial debarking machines without further milling to smaller sizes) to support aerobic metabolic activity and to reach suitable temperatures for quarantine purposes.

Basic Experimental Approach

Bark heaps were constructed as indicated in Figure 1, where the positions of temperature probes at three layers are indicated. The probes were connected to a data logger taking regular readings throughout the experiment. Particular attention was paid to the spatial distribution of temperature accumulation, with the express aim of assessing whether temperatures exceeded 56°C throughout the heap. Both C and N concentrations were measured on some samples and moisture content was assessed in all cases. In some experiments, additional aeration was achieved by use of perforated plastic piping in the base of the heap.

Results

Initial experiments indicated that successful heating was achieved but that temperatures varied considerable throughout the heap. A typical result is shown in Figure 2.

Although temperatures in the top section of the heap reached required temperatures, the heating rates in the bottom layer, especially in the center were too low, thus indicating that at least 60% of the bark would not have reached the required lethal temperature. This is shown more clearly in Figure 3, which is a three dimensional representation of the temperature profiles.

Further experiments confirmed this initial finding and attempts were made to assess the reasons for the low metabolic activity in the bottom layer. The possibility that activity was purely anaerobic was investigated by use of additional aeration through perforated pipes in

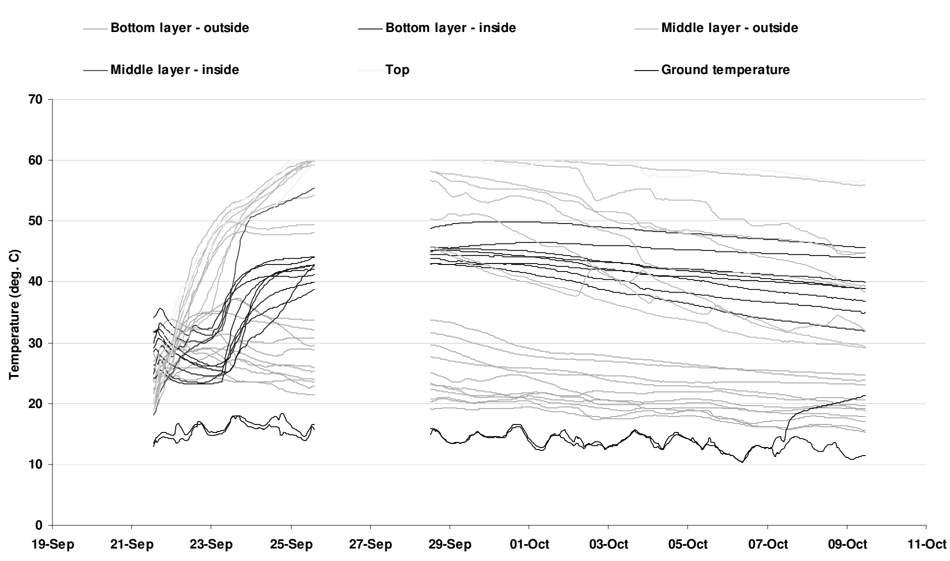

Figure 2.—Temperature profiles for representative bark heap showing differential heating by layer. Upper temperatures are limited to 60°C and there are missing data on 27 Sept.

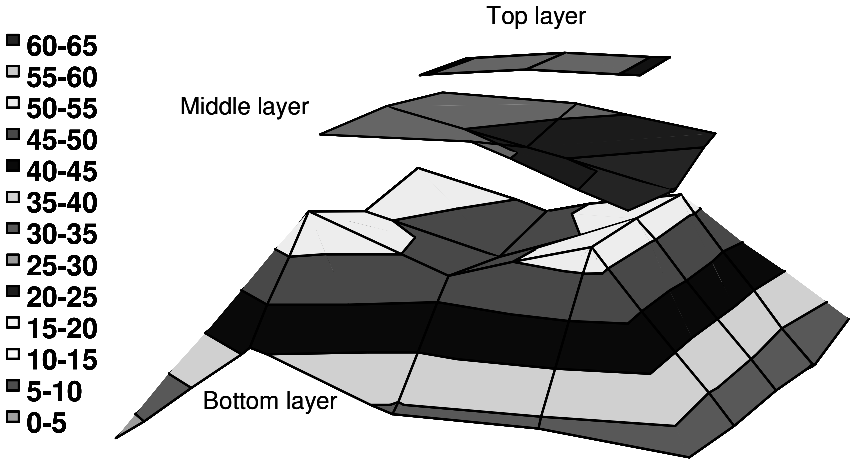

Figure 3.—Three dimensional representation of temperature profiles by layer within the bark heap.

the bottom layer. This exacerbated the problem and caused temperature depression below the ambient level, probably as a result of latent heat of vaporization as water was evaporated from the bark. It was also noted that bark differed in the rate of heat accumulation depending on the time of year, but this was not linked to ambient temperature. Experiments indicated that the moisture content of bark was the key variable in this respect and this was confirmed by addition of water to the heaps, which gave an increase in temperature in the upper layers but not in the lower layers. This was probably linked to the fact that bark pieces were generally impervious and also acted to divert moisture away from lower layers, preventing adequate re-moisturization.

Conclusions

The use of unmodified bark as a product will require adequate heat treatment before it can be transported in international trade. Current protocols for bark composting as a quarantine treatment rely on bark modification and use of a full composting procedure that might not be suitable for all commercial purposes. The experiments in this study have indicated that it is possible to achieve lethal temperature accumulation in the upper sections of bark heaps but that further measures are needed to ensure that the bulk volume of bark lower in the heap is heated adequately. This can be achieved by turning the heap, but this must recognize the fact that there are cool zones in both the outer layers on the surface of the heap and in the bottom middle layers. Addition of N and P sources to accelerate metabolic processes, particularly through lowering the C/N ratio of bark, can be contemplated, but these may be impractical and too expensive for the relatively low value market in unmodified bark. Further work is being carried out to address these issues.

Literaure Cited

Solbraa, K. 1979. **Composting of bark III. Experiments on a semi-practical scale.** Meddelelser fra Norsk Institutt for Skogforskning, 387-439.