An Alternative to Methyl Bromide: Electrically Produced Steam

John R. Bunker
Redlands Greenhouses Holdings P/L, Redland Bay, QLD 4165

INTRODUCTION

The use of aerated steam for pasteurisation and sterilisation is not a new technique in our industry. It first gained interest in Australia following a visit by Dr. Ken Baker in 1960. The release of the *UC Manual for Container Growing Plants* by Baker led several nursery operators to embrace this technique. Alan Newport (Newports Nursery), Jack Pike (Pikes Nursery), and Gavin Wilton (Falg Nurseries), all introduced aerated steam into their bedding plant and house plant operations in the early 1960s. The traditional users of aerated steam have been the bedding plant and seedling producers, probably because of the critical importance of hygiene in raising seedlings.

In the last 2 years the use of aerated steam has gained momentum again in the nursery industry because of two key issues.

1) Methyl bromide which has been widely used as a disinfesting agent has been labeled as a serious ozone depleting gas. Through the U.S. Clean Air Act it will be banned from use in the U.S. The 1st of January 2001 was one proposed date, however it is currently uncertain when the final cut off will be. The Netherlands no longer uses methyl bromide. In Australia methyl bromide use is being reduced by gradually restricting imports with a proposed complete phase out around 2005.

Australia is one of 149 nations who are signatories to an international agreement "The Montreal Protocol" on substances that deplete the ozone layer.

2) With the creation of the Nursery Industry Accreditation Scheme Australia (N.I.A.S.A.), accredited nurseries need to have disinfesting programs in place for media and used containers which may contain disease organisms.

Under the accreditation guidelines the use of aerated steam, pasteurisation, methyl bromide, solarisation or Basimid® are accepted treatments for many soil borne diseases. Aerated steam (sterilisation), methyl bromide, and sodium hypochlorite solution used at 5000 ppm of free residual chlorine are the suggested treatments for used containers.

Our nursery operation continually reuses propagation tubes and growing on pots which needed to be disinfested. Methyl bromide had traditionally been used for disinfesting filled propagation media trays and used containers. Sodium hypochlorite solution used at 5000 ppm of free residual chlorine was used for manual hand washing of used containers because it was a more effective treatment than methyl bromide, but it was a very labour intensive operation.

At Redlands, we identified the need to find an alternative to methyl bromide gas disinfestation. We did our research and settled on steam. Initial planning started around 1990 with its inclusion in the budget and its entry on our 5-year plan.

REASONS FOR CHOOSING STEAM

1) Safety to employees: risk was reduced by removing the need for toxic chemicals such as methyl bromide and sodium hypochlorite.

2) To achieve an effective treatment of our propagation media and used contain-

ers: we weren't entirely happy with the results of methyl bromide, e.g. a perpetual *Rhizoctonia* problem in propagation and losses experienced in used containers after methyl bromide disinfestation.

3) To reduce labour costs and increase efficiencies in these operations: the number of operational steps with methyl bromide is reduced greatly in comparison to the use of heat treatment.

4) To work in with planned future automation and more effective materials handling.

5) To completely eliminate the need for methyl bromide well prior to its legislated unavailability.

SOLUTION

After consultation with other growers and David Spencer from South East Queensland Electricity Board (S.E.Q.E.B.) we settled on using electrically produced steam with a Mastersteam Generator produced by ACA Engineering, in Victoria.

Advantages Over a Fuel-Fired Boiler.

- The operator does not need a boiler ticket and the machine can be left unattended during operation.
- There is no requirement for either licensing and yearly safety inspection by the Qld Department of Workplace Health and Safety or the need for annual maintenance.
- The system is simple to operate and can be made fully automatic.
- The equipment is a compact unit which is easy to relocate and can be placed right at the point of usage.
- There is no flame or fire risk and no fuel storage is required.
- It is environmentally friendly generating the waste products of heat and steam.
- There is a lower capital cost involved.

EQUIPMENT

The equipment I am discussing in this paper is a 100 kW steam generator. The supplier, ACA Engineering, manufactures steam generators from 40 kW upwards. We decided on this capacity for both our present needs and with a view to our future requirements, coupled with the need for flexibility. However regardless of the size of the equipment the principles remain the same to achieve the desired treatment.

A secondhand steam vault was purchased. It is constructed of Bondor Insulated Panels with the dimensions being 2040 mm in height, 2650 mm in length, and 3000 mm in width. It has two barn doors on the front and its working floor capacity is $4 \times 1.2\ m^2$ conventional pallets. Also included in the original purchase was 3 kW electric blower and 150 mm PVC pipework from the blower to the steam vault.

For the volume of the steam vault and the operational load, the manufacturer suggested a 100 kW steam generator. This has a power requirement of 140 amps per phase. To make the unit more flexible we had it fitted with a 40 kW and 60 kW option so that it could be used for small batches or a steam gun at 40 kW setting. For large media batches and with both the 40 kW and 60 kW buttons depressed, it gives a 100 kW power rating.

The steam vault was installed as a recirculating closed system to make a more energy efficient system. A closed system with little steam escaping during the

Table 1. Media and propagation tray combinations.

Media	No. of trays in batch (4 pallets)	Litres per pallet 1000 l = 1m^3	Total treated m^3 per batch (4 pallets)	Total number of cells
60% sand 40% peat or 40% peat 60% perlite	4 pallets of 42's (42's Kwikpots) = 468 trays	1 pallet of 42s = 527 litres	2.1 m^3	19,656
40% peat 60% perlite	2 pallets of 42s = 234 trays 2 pallets 50 mm tubes = 120 trays	1 pallet of 42s = 527 litres 1 pallet 50 mm tubes = 840 litres	2.73 m^3	23,028
40% peat 60% perlite	4 pallets of 50 mm tubes = 240 trays	1 pallet of 50 mm tubes = 840 litres	3.36 m^3	26,400

process requires a lower energy input. The S.E.Q.E.B. energy recommendation is 30 kW of electricity per cubic metre of media. Table 1 gives some of the different combinations of batch size, with the maximum being 3.36 m^3 on a 60 kW power setting (which is a 40% energy saving). This saving has been made possible by using a recirculating system.

The steam is fed into the steam vault through a register in the centre of the roof. It is then drawn from the room via 9 mm × 50 mm PVC pipe openings which are positioned 180 mm above the floor there is 40 mm between each opening.

Our power requirements to the property had to be upgraded to a 200 kva transformer, to provide for the extra need of the steam generator and for future property development. The main switch board was incorporated into the building housing the steam room, to reduce the installation cost of the cable needed to supply electricity to the steam generator.

The water supply is provided by two 4700 litre polypropylene tanks collecting rain water off the roof of the same building. It was decided to use rain water, as opposed to the town supply, to eliminate the need to add chemical to prevent scale build up in the steam generator. Also as the major use of the equipment was for pasteurising propagation media, it was necessary to use as pure a water source as possible. Water usage for a 100 kW unit at maximum steam usage is 136 litres per h. We budgeted on 75 min. therefore using 170 litres per session. We are currently only using the 60 kW setting which is using approximately 102 litres per session.

The water flows from the bulk tanks through an inline filter and a 20 mm copper pipe into the header tank via gravity feed and a 20 mm float valve. The recirculating pump which transfers water from the header tank to the steam generator has an output of 9 litres per hour. The water is pumped into a header tank inside the steam generator before passing through a series of electric transformers which heat the water and produce the steam.

The control panel was designed by Procon Brisbane consists of two Shinko digital thermostat controllers with individual probes and a timer. The steam room controller is a moveable probe attached to a 8000 mm cable. The air temperature controller probe is fitted just above the inlet on the roof of the steam vault. Both are able to be set at the designated temperature.

At the end of the pasteurisation cycle of 30 min at 63C, the timer activates an alarm for the start of the purge cycle. Stainless steel butterfly flaps have been installed inside the pipework to direct steam flow into the steam vault during the heat up and pasteurisation cycle and during the purge cycle the flaps are repositioned to allow ambient air to be drawn from near the roof and the heat and steam from inside the vault to then be vented to the outside of the building.

The thermostat controlling air temperature is connected to an automatic steam valve to enable regulation of temperature and closing off the passage of steam at the end of the pasteurisation cycle. The racks holding the propagation trays allow an airspace of 15 mm between each layer, to ensure rapid and thorough circulation of the steam. Each aluminum rack holds 117 trays of Yates Kwikpots®. The trays are 295 mm wide and 365 mm long. Aluminum rack dimensions are 1520 mm in height 1 m in length and 1180 mm in width.

Two microswitches have been installed at the top of both doors as a safety precaution as the steam blower will not operate unless both doors are closed.

TREATMENT

Pasteurisation is used to control plant pathogens in growing media by raising the temperature to between 60 to 70C within 30 to 45 min, and then maintaining that temperature for a further 30 min before cooling the media down by pumping ambient room temperature air through it. This process controls most pathogens, without eliminating many beneficial organisms. This is used for filled trays of propagation media.

The media is thoroughly mixed at the moisture content for planting prior to steaming. The media filled trays are left for a minimum of 4 h before steaming to enable seeds and spores to absorb water. They are less resistant to heat when they are moist.

The spectrum of disease, weed, and pest control is widened by increasing the treatment temperature to 70 to 80C for 30 min. This will control most weed seeds and plant pathogenic bacteria, and is used for treating used containers, where inoculum levels of many pathogens are potentially higher.

The steam generator takes 15 min to build up steam then approximately 45 min to bring the steam room and its contents up to the required temperature. The cook cycle is 30 min duration. The purge cycle for cooling the media with ambient air and lowering temperature back to 40C is approximately 45 min.

A six-channel digital data logger was installed by S.E.Q.E.B. to produce graphs which identify temperature dynamics inside the steam vault, and to chart the hot and cold zones.

Our first batch of media showed a temperature differential of 4C between the highest and lowest temperature at 60 kW setting. We did one cycle at 100 kW which did not work successfully as it produced a temperature differential of 10C. The conclusion was that it raised the temperature too quickly in this case, therefore sacrificing uniformity. This batch was done before the racking system was finished and the trays were only separated by 10 mm. The coolest zones were in the lower section of the pallet, at the front of the steam vault (facing the doors).

One problem we had been experiencing was a runaway system with the designated temperature being exceeded. We have overcome this problem by better regulating the manifold steam flow automatically by setting the thermostat controls as follows:

For pasteurisation cycle:

1) Steam vault thermostat set at 60C, when the temperature reaches 61C it activates the cycle 30-min timer.

2) The steam flow in thermostat is set at 65C which is our upper limit.

3) This thermostat is coupled to the automatic steam valve on the steam generator.

4) When steam-flow in probe reaches 65C it shuts off the steam valve.

5) The steam valve then reopens when the temperature drops to 63C.

6) This process continues through the pasteurisation cycle regulating temperature at 63C.

This strategy has increased our steam room heat up time to 1 h and maintains a constant temperature with only a 2C temperature differential. This is now achieved now on both the 60 kW and 100 kW setting.

The significance of this is the degree of temperature control an this enables the pasteurisation cycle to run unmonitored by the operator, effectively saving 30 min labour per batch. With a projected current usage of 80 treatments per annum it amounts to 40 h of labour saving.

The power controls will be modified shortly so that when the timer reads 30 min (at the end of the pasteurisation cycle) it closes the automatic steam valve and then activates a motor drive to change the position of the butterfly flaps thus starting the purge cycle and cooling the media with air at ambient temperature.

TREATMENT COST

The electricity tariff we are connected to in Queensland is the Non Domestic Heating Time of use tariff No. 37. The most economical hours of operation are 10:30 PM to 4:30 PM, a total of 18 h at the rate of 6.5 cents per kWh. From 4:30 PM to 10:30 PM, a total of 6 h, the rate increases to 16.2 cents per kWh.

In Table 2 a comparison of treatment costs is made between methyl bromide (applied by a commercial contractor, whose requirement was a minimum of 6 pallets) and electricity on the above tariff rates.

Table 2. Comparison between methyl bromide and steam.

	Methyl bromide	Steam
Treatment time	Minimum of 48 h Maximum of 72 h plus airing time of 12 h	3 h Use when media has cooled to 40C
Type of treatment	Fumigation (soil sterilant)	Pasteurisation (beneficials still intact)
Cost/pallet	$18.33 min/mm 6 pallets	$7.27 $1.82/pallet
Byproducts	Ozone depleting substance	Heat, steam, and water

PROBLEMS

We have made other observations:

- Always have the same type of media in the steam vault or uneven heating can be experienced.
- When sterilising empty containers a mixed load of different sized containers does not cause uneven heating.
- Do not have too great a depth in containers or try to do bulk media in the steam vault.
- Hygiene is extremely important and one weak link in the process can ruin the effect of the treatment. Therefore after treatment the media and used pots are shrinkwrapped. This both identifies treated media and pots, and keeps treated material clean until use.

CONCLUSION

As outlined earlier we will advance to fully automatic controls on the unit within a short time. We are currently researching the use of a steam gun for sterilising machinery and equipment, to eliminate chemically based wash-down procedures. At a design capacity of 130C at the gun tip it will guarantee control of all known pathogens, if used in the correct manner.

The unit was commissioned in Nov 1995. In that short time we have seen a difference in the efficiency of our propagation unit as a result of pasteurisation. A good example is our current azalea propagation system which now has a failure rate of less than 1%. In *Dipladenia* it has eliminated a perpetual *Rhizoctonia* problem which always presented a problem in propagation. Chemical needs and dependency are subsequently reduced.

We will see these results flow right through the production phase adding to the finished quality of our crops. Plants in reused steamed pots have performed better than those in chemically treated used containers.

The installation of the steam generator equipment is seen as stage 1 in a facility which will eventually house media manufacturing, tray filling, cutting and seed preparation, thus becoming an integrated system. The steam gun will play an important role in cleaning these work areas.

As we continually look at improving systems and production techniques we can use the experience of the past coupled to the technology of the future to make further advances and improvements in our industry and ultimately the crops that we grow.

LITERATURE CITED

Anon. 1993. Heat treatment of potting mix. Technology Centre Notebook S.E.Q.E.B. Bulletin No. 5/93. Customer Technology Centre, Milton, Queensland.

Bodman, K. and **L. Forsberg.** 1994. The Nursery Industry Accreditation Scheme Australia. Australian Horticulture Corp.

Brown, R.H. 1986. The use of heat to sterilise soils and potting mixtures. Agdex 280/22 Order No. 3514/86. Agnote. Dept of Agriculture.

Stirling, G., K. Bodman, G. Fullelove, N. Greer, and **N. Vock.** Methyl bromide - Where to from here. Q.D.P.I. and the Environment Protection Agency Bulletin.

Baker, K.F. (ed) 1957. UC system for producing healthy container-grown plants.