

PRINCIPLES OF STEAM PASTEURIZATION

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There are essentially three methods that can be used to control pathogens in growing mediums viz

- Chemicals
- Dry heat
- Steam

CHEMICALS

Chemical control is an environmentally unfriendly sterilizing method that works by interrupting the life processes of living cells by restricting essential supplies or waste products to or from cells. Chemical fumigation of soils is usually done with toxic heavier than air gasses, such as Methyl Bromide and requires skilled and licensed operators. Chemical fumigation of media is a timeous process requiring specific moisture and temperature conditions to be successful. Careful preparation and planning management is necessary to meet the demand of fumigated media in the larger nursery.

DRY HEAT

Dry heat kills by an oxidation process causing living cells to expire from heat exhaustion and temperatures in excess of 150°C may be required to effect 100% kill rate. The most common method of applying dry heat to a root media is to make a fire above or below it. This method is hardly applicable in the nursery situation and other methods of dry heating are energy intensive and laborious to apply.

Dry heating can also damage the soil structure and affect the chemical balance by introducing toxicity from the breakdown of certain elements such as manganese or aluminium.

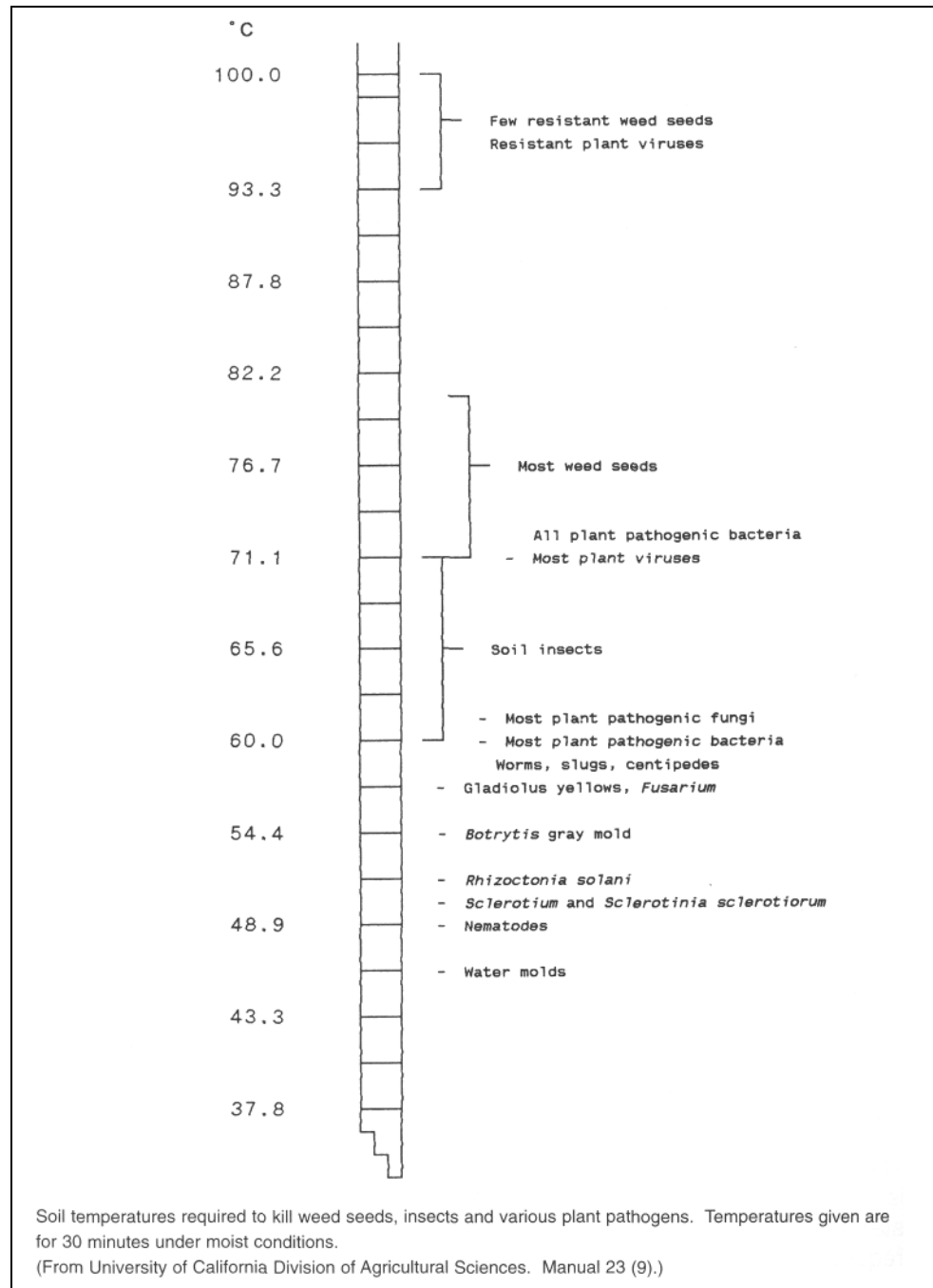
STEAM OR MOIST HEAT

Steam kills very uniquely using the latent heat of vapourization of water. Each litre of water at 100°C requires approximately 2250 Kj or 5,35 times more energy to make dry steam than it does to raise the same litre of water from 0°C 100°C. This vast energy is instantaneously released when the steam condenses on a body cooler than itself. This surge of energy is enough to coagulate the contents of a living cell resulting in irreparable damage that no unicellular organism can survive.

Steam is a vapour and can permeate as easily any soil prepared for a chemical fumigant. Steam contains no toxicity and media treated with steam requires no lengthy aeration time before use. Almost without exception steam can control nematodes, bacteria, viruses, fungi and weed seeds within 30 minutes of application permitting

almost immediate use of the media thereafter.

FIG. 1. Pasteurizing temperatures



STERILIZATION vs. PASTEURIZATION

Sterilization refers to the non selective killing of every living organism, good or bad in the soil mix and creates a vacuum for any opportunistic organism to proliferate.

Pasteurization is designed to eliminate harmful organisms and results in the survival of unspecified but usually benign organisms which are able to colonize without competition from pathogens reducing the potential of reinfestation of disease.

Most chemical fumigants and heat treatments above 85°C are regarded as sterilization. Effective moist heat treatment between 60°C and 85°C for 30 minutes is regarded as pasteurization.

AERATED STEAM

The pasteurization of growing media is often regarded as preferable to sterilization, but achieving the required steam temperatures for pasteurization presents difficulties that can be overcome with specialized equipment.

Water boiled at sea level will produce steam at 100°C or 95°C at an altitude of 1500 m. The temperature of steam can however be controlled by aeration to temperatures lower than 40°C with the aid of venturis and blowers. Dry steam that has been mixed with air will become both cool and wet with a corresponding reduction in energy. A ratio of approximately 4:1 of air to steam by volume will provide a temperature of 60°C with the vapour energy reduced to about 900 kilojoules. Higher temperatures can be achieved by mixing smaller ratios of air with steam.

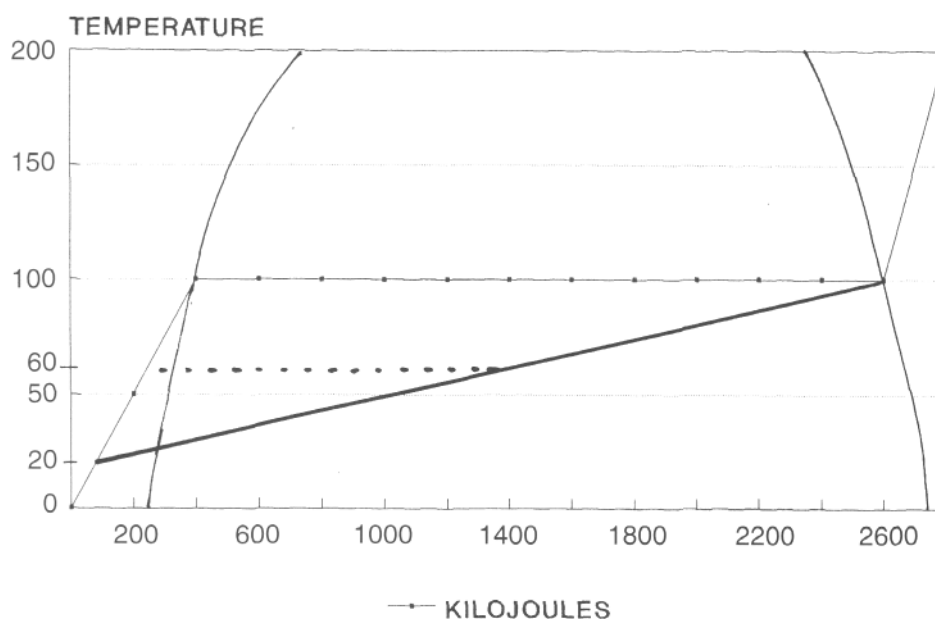
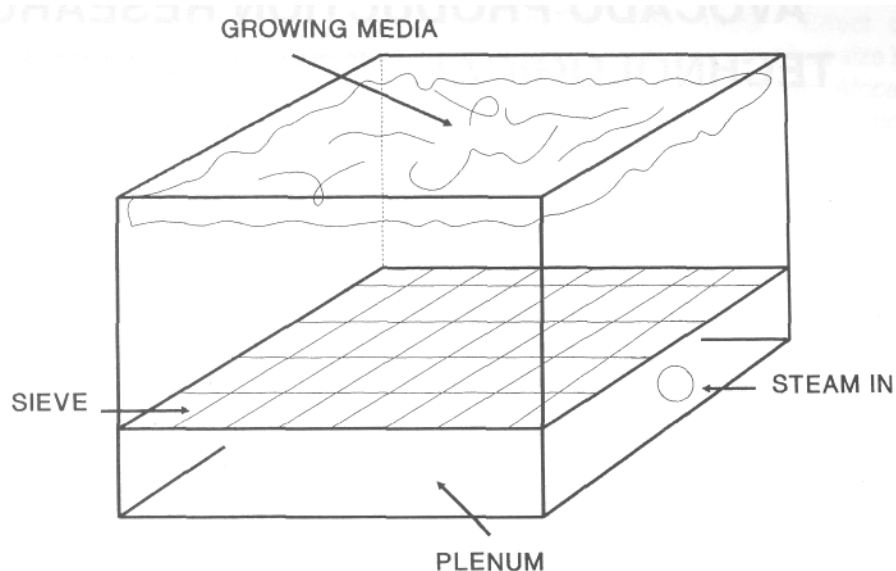
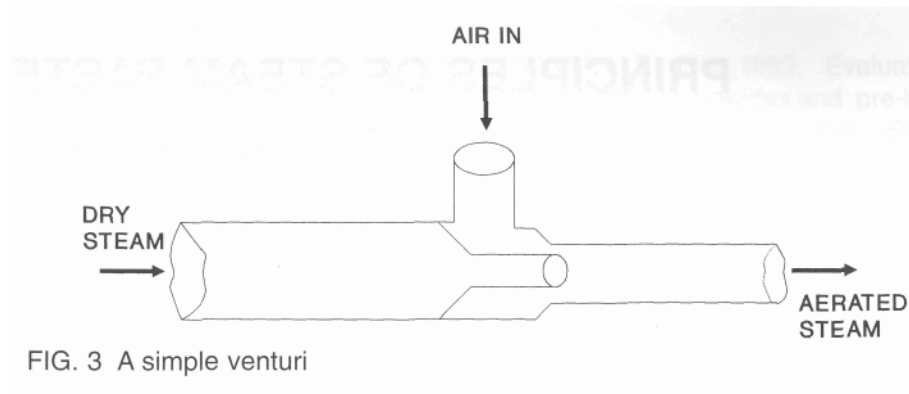


FIG. 2
Temperature vs Enthalpy of water

VENTURIS AND BLOWERS

The mixing of air and steam can be achieved by using the venturi principle. Raising the velocity of steam through a nozzle lowers the pressure at the nozzle exit enabling air to be drawn into the expanding steam. By varying the velocity and/or the pressure of the issuing steam with different nozzle sizes the velocity through the nozzle can be increased or reduced to draw in more or less air. Alternatively, the air intake can be controlled using a blower or a damper in combination with a venturi.



The application of steam

Various methods of introducing moist heat into growing media have been devised over recent years and include plate pasteurization, the Hoddeson pipe system, the steam plough and others. Some of these methods have created the false perception that costly high pressure steam is required to achieve the necessary effectivity. Nursery men, especially in South Africa, have preferred to avoid expensive, high polluting coal, diesel or paraffin boilers that require continuous supervision and maintenance and have opted for chemical methods. Recent environmental pressures especially with regard to the effects of Methyl Bromide on the ozone layer have forced attention back to steam which is entirely environmentally safe.

Soil Medias that have been prepared for chemical vapour fumigation can also be permeated with low pressure steam since it too is a vapour. Steam passes through the spaces between soil particles at a rate determined by density of soil just as water does. Steam is not however limited by surface tension or viscosity as water is and large volumes of steam can permeate soil without back pressure provided sufficient surface area is exposed to the steam.

The addition of steam to a media results in the condensation of steam from a vapour to a liquid at the same temperature. The release of energy due to this condensation process raises the media at this point to the same temperature. At this point the media can no longer support further condensation and the heating front gradually creeps forward at a rate commensurate with the input energy.

A batching method using an insulated drum or box of up to 1 m³ is probably the simplest and most cost effective way to apply and contain moist heat for the 30 minutes required for effective pasteurization. Steam is then introduced into a correctly designed plenum chamber of the batch container. The plenum chamber is sieved on one side to both contain the media and to present a large surface area for steam permeation (See Fig 4).

In a typical application one Kg (litre) of steam is enough to raise the temperature of about 25 Kg of soil to 100°C. This amounts to the even distribution of additional 4% moisture or 40 grams of water per kilogram of soil. Medias with low densities like sawdust or bark mixtures may only absorb as little as 2% moisture. In either case the media is not soggy and does not even appear to be wet after steaming.



FIG 5.
A mobile electrode boiler.

STEAM GENERATOR

The advent of a miniature mobile, low pressure electrode steam generator that can provide instantaneous steam on demand has made the option of small scale steam sterilization of media viable. The old established boiler company, Marshall Fowler (Pty) Ltd of Randfontein, have developed with Eskom Agrelek a range of safe, low cost low maintenance steam generators that can last a lifetime. These units can simply be wheeled to the point of use and connected to a hosepipe and welding plug providing controlled volumes of up to 90 Kg of steam at the flick of a switch. A rubberized hose is used to duct the steam into the batch sterilizing container.

Electrode steam generators do not have elements that can burn out and can produce steam from all types of water. They require very little operation experience or attendance and are ideal for a multiple of nursery applications including seedling tray sterilization and humidifying.

COSTS

A basic 40 kW mobile electrode boiler costs from about R6 000,00 and requires a 60 Amp 3 phase 380 volt supply. On full load this size boiler will produce 60 Kg of steam per hour or 1,5 Kg of steam for each Kwhr (1 electrical unit). At Eskom's average cost of 15c/unit a 1m³ batch of media requiring 60 Kgs of steam to sterilize will cost R6, 00.

REFERENCES

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