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Decreasing seedling mortality in nurseries by the use of the "Appropriate Technology Soil Steamer"

A simple and non-toxic method of soil sterilisation for container and seedbed nurseries in the developing countries

Keywords: Appropriate Technology, low input management of small scale nurseries, reduction of chemical inputs, soil-borne pests and diseases, soil disinfection

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1 Introduction

Damping-off diseases[1], nematodes, root-feeding maggots and various other pests and diseases are a major problem for nursery managers throughout the world. While in developed countries chemical and other technological inputs for the successful control can be afforded, small scale nurseries in the developing countries often encounter financial problems in applying these First World means. Thus the quantitative and qualitative production and provision of tree seedlings for various purposes such as erosion control, afforestation, amenity planting and fruit, timber and firewood production can in some cases be seriously affected.

According to EVANS (1982) serious outbreaks of damping-off can cause 50% seedling mortality if unchecked, while damages caused by white grubs (*Melolontha* spp.) annihilated teak seedlings in some nurseries in Maharashta State (India). The list of serious pests and diseases could be further elaborated, however, this would go beyond the scope of this paper.

In order to avoid losses of planting material already in the early production phase, where plants are extremely sensitive to damaging agents (GIBBS and STROUTS, 1991), sterilisation, or more precisely pasteurisation, of soil or other growing media can be regarded as one of the most important, if not essential factors for raising healthy seedlings.

An appropriate method for the sterilisation of low quantities of growing media was developed at Qaba Nursery of Matelile Rural Development Project (MRDP), an area based project in the foothills of Lesotho. One of the various project activities had been

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1 Including species of *Pytium*, *Fusarium*, *Rhizoctonia*, *Penicillium* and *Phytophthora*

the operation of a project's nursery with an annual production rate of 100 - 130,000 multipurpose trees and shrubs, composed of some 70 - 100 species. Since 1987, when the nursery was established, problems with soil-borne pests and diseases had frequently caused losses, which in certain cases were difficult to control even with chemicals.

Rather than to attempt continually to suppress pests and diseases by the frequent use of chemicals, alternatives were thought after and a simple and non toxic method of sterilising soil media for greenhouse containers was developed. This appropriate method seems noteworthy and recommendable for further replication in other small scale nurseries. Especially in the developing countries, where control methods should be affordable as well as understandable by the people who are involved, the "Appropriate Technology Soil Steamer" may offer possibilities in this respect.

2 The importance of sterilisation of growing media:

It is preferable to operate in a pathogen-free and insect-free environment but most often sources for soil, sand and manure for container plants are restricted and the media quality not known. Although losses in plant material at the nursery during the different phases which a tree seedling has to undergo in its nursing and holding period can have various reasons, it has been proven by experience that early vigour of seedlings is important for their tolerance to damaging biotic and abiotic agents and for the seedling's survival. Thus healthy seedlings can tolerate more stress than non-healthy and weakened plants, which will also show higher mortality rates at their planting sites.

To enhance early vigour of nursery plants it can be advised to sterilise the growing media of container plants. This can be achieved by various possibilities, such as chemical fumigation, sunlight sterilisation, heating, drenching and soil steaming.

Although chemical fumigation kills organisms in the propagation mixtures without disrupting their physical and chemical characteristics (HARTMANN et al., 1990), it can not be recommended. High toxicity and the necessary precautions for the application of e.g. Chloropicrin (Tear Gas), Methyl Bromide and fungicidal soil drenches require well trained labour and furthermore environmental considerations have to be borne in mind. Additionally economic reasons have to be considered, especially for small scale nurseries in the developing countries.

Experiences with sunlight sterilisation differ widely in their rate of success. Depending on the prevailing climatic conditions, season, altitude, depth of treated layer etc., solarization often fails because of insufficient temperatures being reached. According to the Forestry Extension Service (1992), temperatures under clear plastic sheeting, reaching up to 40°C eliminate most soil-borne pests without affecting the more tolerant beneficial microbes. Referring to HARTMANN et al. (1990), experiences from the University of California affirm that only watermoulds are considered to be killed at this stage, while from 60°C upwards the positive effect is much stronger (see figure 5).

Steam sterilisation, commonly applied in nurseries of the developed world, often requires special devices and is expensive. The principal of physical treatment with steam penetrating into the soil has a disinfectant influence with beneficial effects for the raising and growing of planting material.

The main advantage of this method is that it is harmless to human health and non toxic to the environment. Nevertheless a fuel source for the production of steam is required. The same applies to media which is treated by artificial heating, either inside an oven or a microwave, or by boiling.

According to MaCMILLAN (1991) experiments have shown that sterilising the ground by intense heat restores soil fertility by destroying injurious protozoa. However, it should be noted that temperature levels within the treated growing media have to be considered of being important, because excessive heat above 85° C may lead to negative side effects. Certain of the complex chemical compounds in the soil are broken down so that probable toxicity levels of nitrogen and manganese may be reached (HARTMANN et al., 1990).

While oven heating has an undesirable drying effect, it also disrupts, as it is the case with boiling, the physical soil structure. Drainage and aeration behaviour, as well as texture size are negatively affected so that these methods appear to be unsuitable for the use in professional nursery management.

Amongst the listed possibilities of soil disinfecting methods steam sterilisation is most advantageous and in combination with the simple device promising results could be obtained.

3 The "Appropriate Technology Soil Steamer"

The "Appropriate Technology Soil Steamer" (ATSS), a converted 200 ltr. petrol barrel, is a device which can produce approximately 60 ltr. of sterilised growing media per hour. Due to this relatively low output it can not be considered for pasteurisation of large amounts of soil mixtures, but in cases where only limited quantities are required for small seedbeds, seed boxes or seedling trays it can be highly recommended.

The daily production of sterilised media may reach 500 litres, if a single steamer is operated for about 8 hours. Practical experience has shown that 20 minutes of steam penetration is sufficient to ensure healthy seedlings at the initial stage of germination and during the holding time in greenhouse-containers (seedling trays, seed-boxes).

The ATSS is easy to construct and can be produced in any workshop, where a welding set is available.

3.1 Construction

A)A 200 ltr. petrol barrel (appr. 90 cm height) is cut horizontally at about 10-15 cm from the top. Three feet have to be welded to form a tripod on to the bottom part, providing enough space (30-40 cm) to prepare a fire from fuelwood or coal underneath the device.

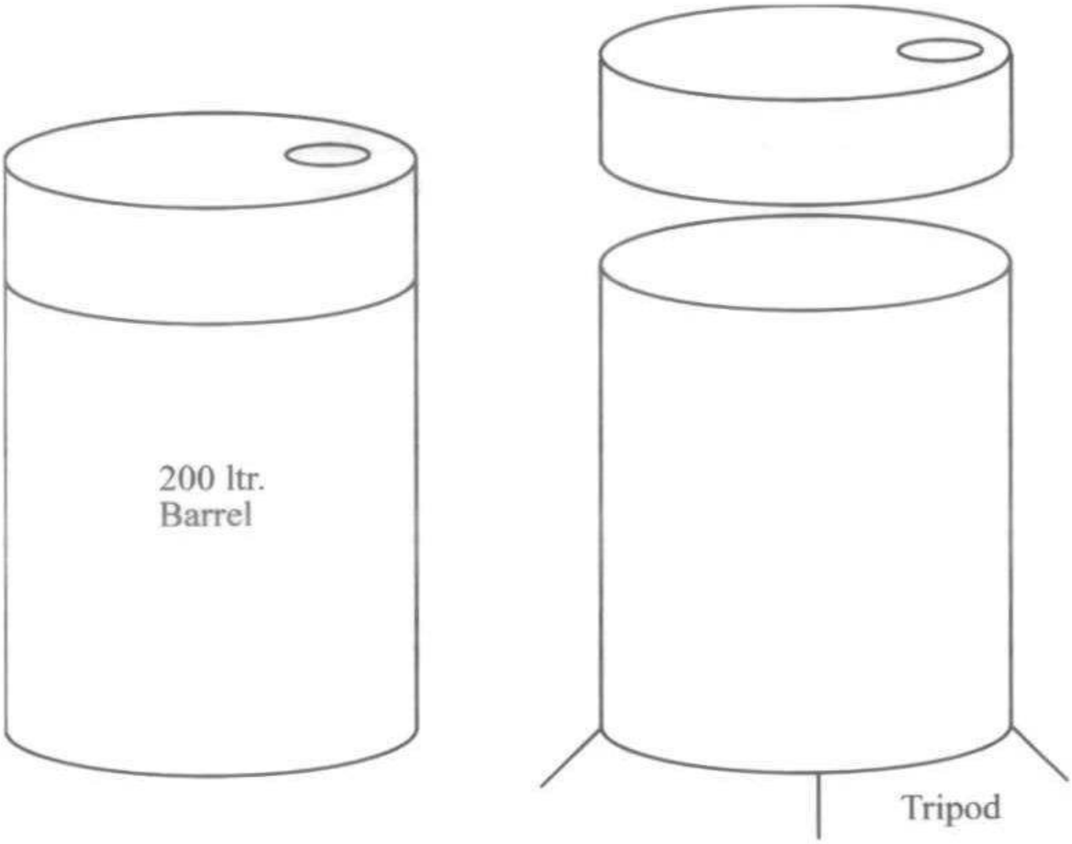

Figure 1: Transformation of the petrol barrel

B) The upper part of the barrel has to be transformed into a lid, which should have sufficient diameter to close the steamer in a way that only little of the produced steam can escape. At the top of the lid a handle should be attached in order to avoid the risk of burnt hands.

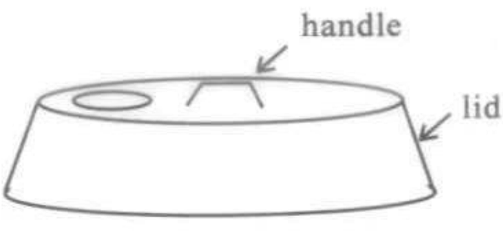

Figure 2: Steamer lid

C) A sieve should be constructed with a diameter slightly less than the one of the barrel so that it will fit inside. Two to three layers of dense metal flymesh, underlain with a solid mesh or screen to support the weight of the mixture are ideal.

The height of the sieve-rim determines the quantity of media to be treated. It should preferably not exceed 30 cm; otherwise time periods for each application will have to be extended. The efficiency of the pasteurisation is closely correlated to the depth of the layer.

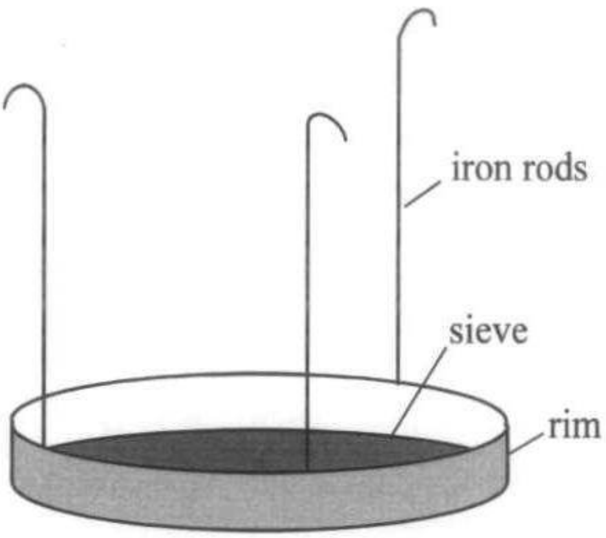

Figure 3: Insertable sieve

Three iron rods should be welded to the rim of the sieve and the ends should be formed into hooks. When inserted, the hooks should hold the sieve at a height of 20-40 cm above the bottom, providing enough space for the water being used inside the steamer.

Only solid materials should be used for the construction, especially for the insertable sieve, which has to hold the weight of the moist media.

The operation of the ATSS is simple and can be adjusted to match the required output.

A fire is lit underneath the steamer, this should be protected from wind by means of windshields or by a pit for the fireplace. The water level inside the barrel should be below the surface of the insertable sieve and during operation no water should get in contact with the media.

The empty sieve should be filled and inserted into the steamer when the water starts boiling. The media should be moist but not wet, because wet media takes longer to reach the necessary temperature.

3.2 Operation Manual

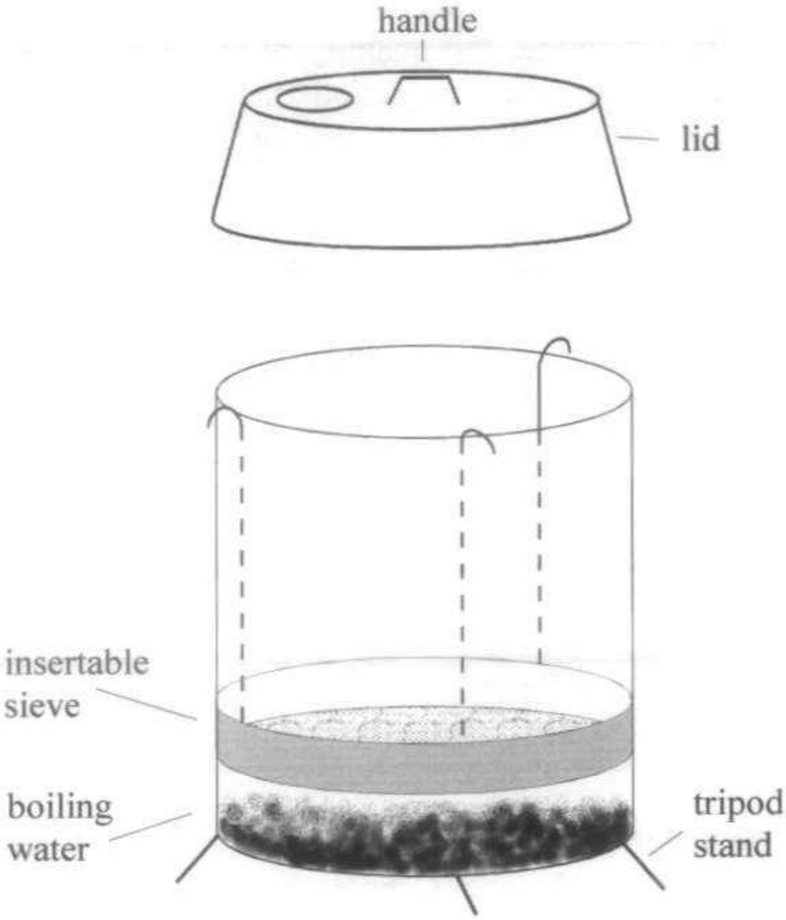

Figure 4: The ATSS in operational mode

The duration of steaming depends upon the temperature required. HARTMANN et al. (1990) state that a temperature of 82° C, applied for 30 minutes is sufficient to kill most of the harmful bacteria and fungi, as well as nematodes, insects and most weed seeds.

However, a lower temperature, such as 60° C for 30 min., is more desirable since it kills pathogens, but not many of the beneficial organisms that prevent explosive growth of harmful organisms, if recontamination occurs (HARTMANN et al., 1990).

Temperatures within the treated mixture at the project nursery were measured with a thermometer and reached 60°C when moist and 80°C when dry. As a consequence of the more beneficial effects at the lower temperature level soil sterilisation was carried out with moist media only. To avoid any harmful toxicity for seedlings being raised on the fresh sterilised media, it was not used directly, but stored for a period of 2 to 4 weeks.

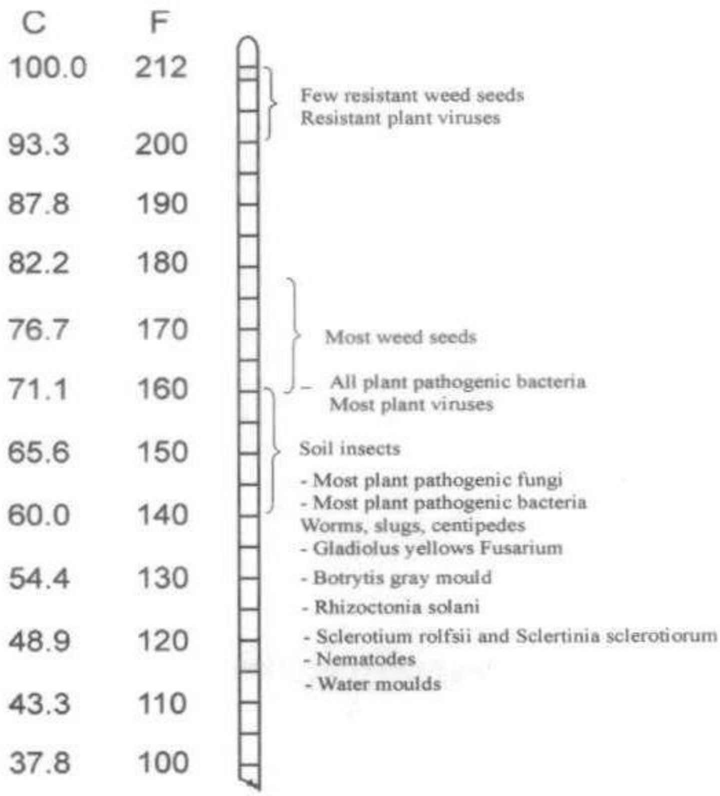

Figure 5: Soil temperatures required to kill weed seeds, insects, and various plant pathogens. Temp. given are for 30 minutes under moist conditions (derived from HARTMANN et al., 1990; from University of California Division of Agricultural Sciences, Manual 23 (7).)

3.3 Production and running costs

Production costs for the ATSS are relatively low, as only a 200 ltr. barrel, some 4 metres of iron rods (10 mm ∅), sieve material, about 0.5 m^2 of zinc sheet and some welding material are needed. Depending on the sources for above mentioned materials the overall price does not exceed R 100 [2] so that it can be easily afforded by nurseries with low input supplies.

Running costs depend on the prices and availability for fuelwood or coal. Costs in Lesotho were about R 20 for an operation time of 8 hours, with both, coal and fuelwood. With an estimated production rate of 500 litres per day the running costs were in a range of R 0.04 per litre sterilised growing media, excluding labour costs.

Running costs of the ATSS could further be decreased if a second storey is added to the device, inserted slightly above the lower sieve. This second storey could either be welded directly to the insertable sieve set or it could be handled as a second independent set.

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2 Conversion from Pound Sterling (£) to Rand = 1 : 7.31 (November 1990)
Conversion from Deutsche Mark (DM) to Rand = 1 : 2.49 (November 1990)

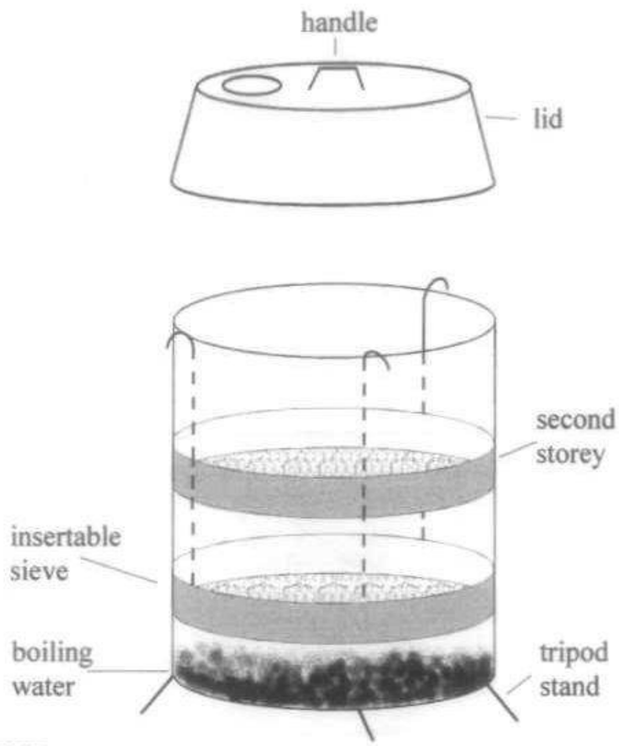

Figure 6: Improved ATSS type

4 Comments

The ATSS has been developed by Mr. Burckhardt von Roman, former Nursery Manager at Matelile R.D.P. The author would be grateful for comments on experience with the method mentioned, as well as on any other appropriate methods of soil sterilisation and/or any suggestions on further improvement of the ATSS. These should please be forwarded to the author's address, given below:

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