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Soil Solarisation

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Treatment of nursery potting mixes or of their components is widely carried out by either steam sterilisation (pasteurisation) or by the use of fumigants. A technique known as solarisation is an alternative to other more cumbersome and sometimes hazardous treatments currently in use.

WHAT IS SOIL SOLARISATION

Solarisation, as the name implies, utilises solar energy. It involves the use of a layer of clear polyethylene plastic to cover moist potting mix, in order to raise the potting mix temperatures for the control of soil-borne pests and diseases. Where the term 'potting mix' is used here, it can also be taken to include separate mix components and soil.

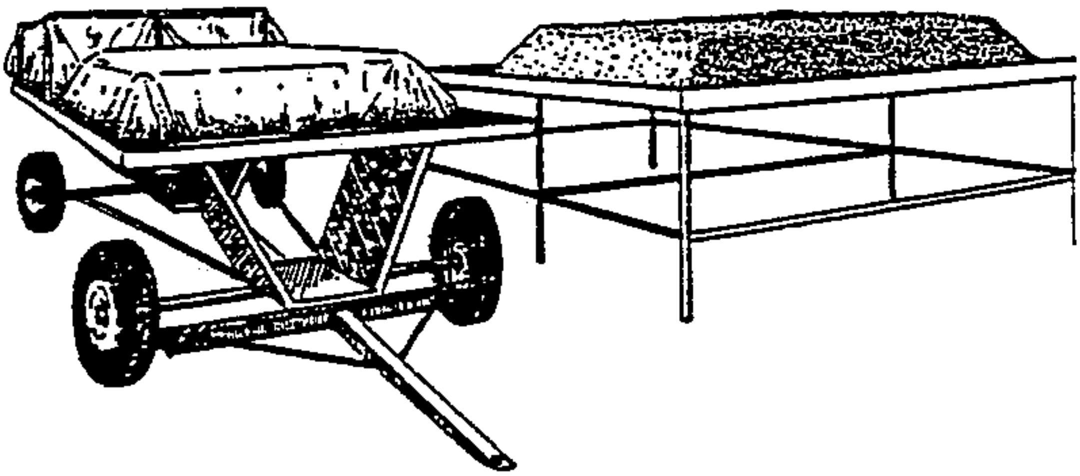

Figure 1. Solarisation of 25 cm high mounds of potting mix on self-tracking trolleys

There are five factors that need to be remembered when contemplating using solarisation:

1. Transparent, not black, polyethylene plastic should be used, as this transmits most of the solar radiation.

2. Solarisation should be carried out during periods of high temperature and intense solar radiation. In the Northern Territory, suitable conditions prevail for a large part of the year.

3. The mix should be kept moist during the solarisation in order to improve heat conduction within the mix. The resting spores of plant pathogens are more sensitive under such conditions.

4. The thinnest plastic possible should be used, as it is both cheaper and somewhat more effective in heating. Both 25 micron and 50 micron thick clear plastic can be obtained in Australia.

5. The plastic sheeting should be kept in place for as long as possible.

Plastic that is UV absorbent should last indefinitely while the plastic that is not UV absorbent will usually last only about four weeks before it starts to turn brittle. The plastic also reduces the evaporation of soil moisture thus imitating a miniature greenhouse.

Using two layers of clear polyethylene plastic increases temperatures above those achieved with only a single layer of clear plastic. A 15 cm air space between the two layers is currently recommended but the optimum distance has not been fully investigated. A metal frame to support the second layer of plastic, as seen in the illustration, is ideal. This second layer acts as added insulation, trapping the heat more effectively.

DISEASE CONTROL

Increasing temperatures to between 40ºC and 60ºC in potting mix during solarisation can greatly reduce or eliminate soil-borne diseases. Duration of exposure plays an important part in the control of such diseases, as the longer the high temperatures are maintained the less is likelihood that disease propagules will survive.

Some of the soil-borne pathogens so far investigated elsewhere that have been controlled by solarisation include *Fusarium oxysporum* f.sp. *dianthi* (Furarium wilt of carnations); *Meloidogyne* spp. (rootknot nematodes); *Phytophthora* spp., *Pythium* spp, *Rhizoctonia solani* (damping-off and root rot pathogens); *Sclerotium rolfsii* (basal rot); and *Verticillium dahliae* (wilt disease). Diseases controlled using solarisation in Darwin have included the damping-off/rootrot pathogens *Pythium myriotylum* and *Phytophthora nicotianae* and the basal rot disease caused by *Sclerotium rolfsii*.

EFFECT OF SOLARISATION ON WEEDS

Solarisation also results in the effective control of many annual and perennial weeds. Winter weeds are generally the most sensitive, while summer weeds are usually more resistant. Susceptibility is further influenced by both the soil type and moisture content.

Based on work done elsewhere, weeds from the following genera have been effectively controlled: *Amaranthus, Amsinckia, Anagallis, Anoda, Arbutilon, Avena, Calandrina, Capsella, Cardamine, Cerastium, Chenophodium, Chloris, Conium, Cynodon, Datura, Digitaria, Eragrostis, Erodium, Fumaria, Hirschfeldia, Hydrocotyle, Ipomoea, Lactuca, Lamium, Malva, Mercurialis, Molucella, Montia, Notabasis, Orobanche, Oxalis, Phalaris, Poa, Polygonium, Portulaca, Senecio, Sida, Sisymbrium, Solanum, Sorghum, Stellaria, Trianthema, Xanthium*.

Observations in Darwin have revealed that *Amaranthus* and *Portulaca* species still germinated in solarised potting mix but only in low numbers. This method of weed control provides an alternative to herbicide usage in the nursery, reducing the cost of hand-weeding pots and repeated chemical applications.

INCREASED GROWTH RESPONSE

Plants grown in solarised potting mix soon after treatment have often benefited from improved seed germination, better stand establishment, improved plant height, early crop maturity and increased yield (both fresh and dry weights). Increased plant height and earlier flowering was consistently observed in trials in Darwin on marigold and tomato plants. Such increased growth responses are thought to be due primarily to the increase in soil nutrient availability, as a result of the breakdown of soil organic material.

Nitrogen showed consistent increases with solarisation, while concentrations of potassium, phosphorus, magnesium, calcium, chlorine and sodium have shown increases with solarisation in some situations while decreasing in others. Micronutrient responses are not clearly understood and more work is needed in this area.

INDUCED SOIL SUPPRESSIVENESS

So far solarisation has been highlighted as a technique for the control of soil-borne pests, diseases and weeds, with an increase in soil nutrient availability resulting in an increased growth response of plants planted into solarised soils. It has also been observed that an advantageous shift in soil microbial populations occurs with solarisation. This results in an induced suppressiveness of solarised soils.

Beneficial soil microorganisms are likely to be prominent among those that recolonise the treated potting mixes and the root zones of plants. Such microorganisms may be able to flourish in solarised potting mix, producing antibiotic substances. Any soil-borne pathogens that have survived the solarisation process are likely to have been weakened and may thus become more vulnerable to the antagonistic effects of beneficial re-colonisers.

SOLARISATION AND SOIL FUMIGANTS

The use of solarisation in an integrated control package with soil fumigation is usually more effective in the control of certain soil-borne pests and diseases than either solarisation or soil fumigation on their own. By combining the two treatments, a lower rate of fumigant may be possible. This would reduce the harmful effects of the fumigant on the environment and on the beneficial organisms within the potting mix. The most likely explanation for this synergistic effect is that the high temperatures generated with solarisation weaken any surviving pathogens, thereby increasing their susceptibility to the fumigant. The integrated approach could be useful in those areas where the effect of solarisation is marginal or during the cooler times of the year when solarisation is not fully effective.

SOLARISATION OF NURSERY POTTING MIXES

With the warm climatic conditions in the Territory, solarisation of nursery potting mix would appear to be an attractive alternative to the currently available methods of steam pasteurisation or soil fumigation. High temperatures, constant sunshine and intense solar radiation are in abundance in the Darwin area and as far south as Katherine for most of the year and down to Alice Springs during the summer months. Investigations in Darwin have shown that solarisation of 25 cm high mounds of potting mix using two layers of clear plastic was far more effective than a single layer of clear plastic at raising the temperature to levels lethal to three commonly found soil-borne pathogens, *Pythium myriotylum*, a tropical pathogen which grows well at 40ºC, *Sclerotium rolfsii* and *Phytophthora nicotianae*. Potting mix was mounded at 25 cm high onto nursery trolleys that had a layer of foam to insulate the mounds from heat loss from the metal base of the trolley.

The temperatures generated during hot sunny days under the two layers of clear plastic from September to mid-May, ranged from the mid 40s to a high of 51ºC, with mean maximum temperatures ranging from 42ºC to about 48ºC. The only exception would be the wet season when overcast rainy weather may reduce temperatures 4-5ºC below those experienced during clear summer days. These temperatures effectively eliminated all three pathogens within three to nine days. The shorter period is applicable to consistent fine hot weather, particularly during the 'build-up' to the wet season. The longer period resulted from overcast rainy weather, as experienced during the wet season and the period at the start of the dry season (May) and the end of the dry season (September).

Solarisation was not completely effective during the dry season period (mid-May through to September), temperatures only reaching as high as 41ºC. However it could still be possible to overcome this by reducing the height of the mound to 10-15 cm. It should then be possible to generate temperatures that are high enough to pasteurise the potting mix. This remains to be further investigated. It may be more appropriate to stockpile treated potting mix in bins or containers for the winter period until the return of ideal solarisation weather.

The solarisation process was designed for the trolley system (see Figure 1) due to its mobility. It would be of most use to the smaller nurseries that only use small volumes of potting mix at any one time. Each trolley can hold approximately ½m^3 of mix and can be solarised within three to nine days depending on the weather. But mounds of potting mix could just as easily be treated on the ground as long as there is an impervious layer of material separating the potting mix from the bare earth. This impervious layer could be heavy-duty plastic, concrete or even bitumen. Larger nurseries with vacant land in full sun could just as easily carry out this process. Perhaps it may not be done on a regular basis due to the small volumes of mix being solarised and the large volumes needed by the nursery, but could be done occasionally during the spring/summer months. This would reduce the reliance on fumigants, reducing nursery costs.

Solarisation of potting mixes in plastic bags under a second layer of plastic could be used as an alternative means of solarisation. This would be appropriate for retail outlets selling potting mix in bags, as is the case with a few local nurseries.

The use of solarisation in field situations in Darwin is also a distinct possibility. Plastic could be laid down in strips to effect solarisation, then the plastic left in place, painted and then the seedlings planted directly through the plastic into the treated soil. A comparison of plant growth and yield could then be conducted in such a situation.

Whatever way it is applied, solarisation can be an attractive alternative. It is relatively cheap, and eliminates or at least reduces the need for pesticides.

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