benches as we were. Others, like bedding plant growers, and some who were propagating with fast-germinating native seeds, were able to avoid the accumulation of salts in their propagation trays.

We still water our tubed plants with normal mains water—the *problem was in the propagation area.*

Figure 1 gives details of the de-salination plant.

LITERATURE CITED

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HYGIENE AND THE USE OF TISSUE CULTURES IN THE NURSERY INDUSTRY

ANGELA COOPER

Phytotech Australia Pty. Ltd.
12 Konando Tce.
Edwardstown, South Australia 5039

I would briefly like to examine the importance of hygiene in the preparation of stock plants for tissue culture and in the planting out of tissue cultures. These are the two areas where the nursery propagator and the tissue culture laboratory interact, and for the relationship to be effective and trouble free there must be communication and understanding between the two spheres of activity. I think these two areas are worth exploring at an I.P.P.S. meeting.

Research is expanding the range of products which can be produced by commercial laboratories and tissue culture is going to become a more routine feature of propagation. Therefore theorists and practioners from both areas urgently need to come to grips with each other's requirements.

A combination of higher capital costs, higher labour costs, rising taxes and on-costs must cause the nurseryman to examine his/her nursery turnover in terms of dollars per square metre of floor space. The true cost of producing cuttings should include a calculation of the worth of the floor space occupied by the stock plants in terms of what that space could generate if turned over to straight production. In the not too distant future floorspace may become so valuable that the only stock plants you can afford to hold are those expensive lines which cannot be satisfactorily produced by tissue culture.

Obviously there are a number of equally important aspects of stock plant preparation and planting out which could be examined

(e.g. nutrition, seasonality, environmental control, water quality, root formation), but I have chosen hygiene because it is often neglected and can be the cause of severe problems between nurseries and laboratories. This paper concentrates more on what the grower can do to optimize the process than on what the laboratory can do.

Much of the information presented here is a result of experience and observation. I have no doubt that many of these things have been said before, but I think there is no better time than now to bring these issues into sharper focus.

PREPARATION OF STOCK PLANTS

There are two common scenarios encountered when initiating plants into culture:

(a) The laboratory has extreme difficulty in getting the material into culture due to recurring heavy infections. This can cause the lab to go through large amounts of stock material before achieving success, or to not achieve success at all.

(b) The plant is put into culture with some low level infection which causes progressively greater problems as production builds.

The overall result is often very long lead times, unreliable production, and difficulty in planting out at the nursery. Although the initiation of material into culture is largely dependent on the skill of the laboratory, there is a good deal that the grower can do to minimize infection problems and so give the laboratory the best possible chance of getting the material cleanly into culture.

Initiation of plant tissue cultures can be achieved from a number of parts of the plant—shoot tips, lateral buds, stem tissue, leaf tissue, petioles, floral buds, roots, rhizomes, etc. The organ chosen depends on the plant in question. In order to grow any of these in culture the surface contamination must be removed, and this is done by treating the piece of tissue with a sterilant such as sodium hypochlorite. A balance must be struck between treating the material harshly enough to remove all surface contamination and not so harshly that the plant tissue is killed or suffers debilitating damage. The disinfestation process is a numbers game—strength of sterilant vs. number of microbes on the surface of the piece of tissue. The propagator can greatly assist this process by hygienic preparation of the stock plants, and taking the following precautions:

(a) *Stock quality*—Use only vigorous, mature plants with no symptoms or history of disease. Mature plants have not only had time to show their best characteristics, they have also had time to show up any slowly developing diseases they might be harbouring.

(b) *Potting mix*—A clean, preferably pasteurized potting mix helps to keep down the level of contamination immediately around

the plant. This is particularly important where underground parts of the plant must be used. Experiment with potting mixes to get the best combination of growth and cleanliness. Rich, untreated, organic mixes should be avoided at this stage if possible, because they are usually heavily contaminated with soil bacteria.

(c) *Pots and tools*—These must be totally clean at all times. Used pots should be scrubbed out with bleach or some other disinfectant and tools dipped in bleach before being used for mother plants.

(d) *Environment*—In a final preparation phase a few weeks before culture initiation, plants should be shifted out of the greenhouse where humidity and contamination is high and placed in a clean, dry, well-ventilated environment. In conjunction with clean potting mix, this can substantially lower the surface contamination of the plant.

(e) *Water*—In the final preparation phase the plants should be hand watered to avoid wetting the foliage and splashing soil onto the plant.

(f) *Field specimens*—For initiation of cultures from field specimens such as trees, plastic sheeting can be used as splash barriers to prevent rain from splashing soil on the foliage to be used, and pests and diseases should be treated around the immediate area.

In general, a soil-spattered plant presented in a damp earthenware pot filled with compost and blood and bone and carrying a few crawling insects and a spot of two of fungus won't be received with enthusiasm by a laboratory. However, a clean, pest-free plant presented in a clean, dry, plastic pot filled with pasteurized soil mix containing few organics will be met with great appreciation.

PLANTING OUT

The successful planting out of tissue cultures involves cooperation between the laboratory and the nursery, and each has their areas of responsibility with respect to hygiene.

The laboratory has the responsibility to deliver healthy cultures displaying good colour, good vigour, no blemishes—and they must be pathogen-free. If they arrive in this state, then it is reasonable to assume that you will have a trouble-free plant-out, all other factors being equal. Occasionally there are low levels of visible infections in tissue cultures, and these cultures should be planted-out in consultation with the laboratory. If cultures are very visibly contaminated, then the laboratory should give prior warning and advice on handling. These infections are seldom plant pathogens, but by their very presence in the cultures they are competing with the plant for nutrients. It is reasonable to assume that they could possibly interfere with the planting-out process. Our present knowl-

edge of these microbes is so poor that we cannot become dogmatic about whether or not they cause harm. Clearly, some nurseries have consistent success with cultures, both clean and infected, while other nurseries produce poor results with the best quality cultures.

The responsibility of the nursery is to plant out the cultures under the best possible conditions. The following points should be noted:

(a) *Use a pasteurized potting mix*—Tissue cultures come from an aseptic environment. We know very little about the microbes which normally live in association with plants in open cultivation, and in tissue-culturing the plant we may have removed not only antagonistic organisms but also any which may have afforded protection or conferred an advantage to the plant when encountering pathogens. A clean soil mix with a low population of microbes must ease the transition for the plant back into open cultivation.

(b) *Use sterilized tools*—Always be scrupulously clean with implements when planting out. Tools should be washed in sodium hypochlorite or equivalent to ensure that pathogens are not transmitted.

(c) *Salinity and pH*—High salinity and pH can cause severe damage to tissue cultures and can bring about heavy losses from damping-off at any time.

(d) *Fungicide*—Spraying with a fungicide is a matter of judgement for a given nursery working with a given product, but preventative spraying is usually a good idea.

(e) *Time*—Tissue cultures should be inspected immediately upon delivery and planted out within a few days. The cultures should have been delivered in their optimum growth phase, and substantial delay in planting out will only cause them to deteriorate, both for physiological and hygienic reasons. Delivery containers for tissue cultures are not air-tight, and air has moved in and out of the containers with changes in temperature and air pressure, especially if the cultures were air-freighted. Thus when they reach the nursery, they have probably taken in some fungal and bacterial spores from the air. These may develop if the cultures are left to sit for any length of time at the nursery. Also, cultures left sitting on a floor or bench for a week or more invariably attract very small mites which enter the jars and spread spores among the plants. This may not become apparent until the cultures have been planted out and suddenly exhibit signs of the infection.

CONCLUSIONS

This paper represents a practical attempt to help the nurseryman overcome some of the hygiene problems associated with the development and use of tissue cultures. I would encourage all

nurseries using or contemplating the use of tissue cultures to experiment extensively with their propagating facilities to optimize their success. Those nurseries which have established good success rates with cultures should be analysing very carefully the factors responsible for that success, just as those who have not had success need to experiment to find out the source of their problems. I believe that in a short time tissue culture will become a conventional technique in the nursery industry in Australia and we must begin now to take the guesswork out of preparation of stock plants and planting out of tissue cultures.

SELECTION AND GRAFTING STUDIES OF *BANKSIA COCCINEA* AND *BANKSIA MENZIESII*

GAIL BARTH

South Australian Department of Agriculture, Adelaide

MIKE BENNELL

Black Hill Native Flora Nursery
Athelstone, South Australia

INTRODUCTION

Banksia species are showing great promise as a plantation-grown cut flower crop in South Australia where currently 56 ha are under cultivation. Two species with outstanding flowers and high export potential are *Banksia coccinea* (the scarlet banksia) and *Banksia menziesii* (raspberry frost banksia). *Banksia coccinea* has a reputation of being difficult to grow and is currently grown commercially only in well-drained acid sands in South Australia and Victoria. The flower is recognized in overseas markets from the export of bush-harvested blooms from Western Australia. There has been little success in cultivation overseas.

In addition to the striking appearance of the bloom, *B. coccinea* is suitable for export due to its small to medium size, relatively fine straight stems, compact leaves, and terminal flowering habit without side breaks. Considerable variation exists in populations in relation to flowering period (May to December) and color of blooms (yellow, orange to deep scarlet). A selection program for this species should concentrate on the following criteria:

1) Selections to extend the bloom season to provide for continuity of supply in export markets.
2) Identification of colour variants.
3) Identification of an outstanding high yielding true red cul-