There is need for a series of experiments for caneberries to take place in a controlled environmental growth chamber, or similar device, to establish the optimum limits of light and humidity at various temperatures, just as experiments have been conducted to establish auxin-cytokinin ratios and nutrients for *in vitro* propagation.

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THE AFTERMATH OF THE TEST TUBE IN TISSUE CULTURE

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Tissue culture at Briggs Nursery has been around for twelve years or more, mainly as a research project and the hope of one man.

There was work done at that time, but until the chemicals and the media were developed, success was minimal. Finally, Dr. Wilbur Anderson, from the Northwest Washington Research and Extension Unit, Mt. Vernon, Washington, was able to start rhododendrons in tissue culture and make them multiply. Afterward, by manipulating chemicals and lights, more and more cultivars were added.

Three years ago our Production Department started to receive plants from the Tissue Culture Department. At first there were only small batches, but the explosion was waiting. In the spring of 1980 we were faced with thousands of tissue culture plantlets to root and grow on.

The first problem we had to face was how to root and grow the new plantlets. The plantlets coming from the test tube were very tender and completely different in character than plant materials normally worked with at Briggs Nursery. This presented new problems for the people in charge of this phase of production.

Soil media had to be developed both for rooting and growing of the new plantlets. The media had to be well drained,

but the particle size had to be fine so the tender plantlets could be planted without damage. This is always hard for a medium to fulfill.

We also learned there was a large difference between summer and winter growing conditions, moreso with the tissue culture plantlets than other plants we work with.

The basic rooting and growing media are made up of the following: sawdust, peat moss, perlite, pumice, and vermiculite, plus fertilizers. We are still searching for the perfect medium for rooting and growing plantlets and, at the same time, transplant in the growing field without showing stress.

Disease was also a problem when we started to get plantlets from tissue culture. The first two years we thought the diseases would win. *Botrytis*, *Pythium*, *Rhizoctonia*, *Phytophthora* and powdery mildew seemed to be the main ones giving us problems.

Many of the fungicides used in the nursery industry showed some toxicity to the young plantlets. We feel this could be due to a lack of cuticle or wax on the leaves. As the plants mature and the leaves thicken, this problem seems to diminish. By using new fungicides and adjusting rates, we are preventing diseases from occurring.

Liverwort and mosses have also given problems in flats and boxes where we grow plantlets. The chemicals used in other parts of the nursery to control these damaged the young plantlets. The heavy metals, i.e. Cu, Zn, Fe, also injured plants so we still do not have the answer to this problem.

Plant size has been a concern of the people in production. The personnel in charge of liners want as many plantlets per square foot of growing space as possible. Crowding plantlets at the start causes die-out and disease problems. The growers want as large a plant as possible for better survival in containers and field.

We have found by experience that a small plant moved out into a field does not respond and grow nearly as well as a larger plant. A plant with a 3″ to 4″ root-ball and a 4″ to 6″ top grows well the first year. It is not affected by the summer heat, and the herbicides that are applied. If we use a small plant we lose that first year's growth.

In containers a much smaller plant can be used. We have had good response from plants with a 1½″ to 2″ root-ball and a 2″ top.

The plants coming from the tissue culture environment seem to show accelerated growth and, given the proper growing conditions, will make a saleable plant 6 to 12 months

before the same size rooted cutting. This is due, in part, because we grow the tissue culture plants at their maximum; lots of feed and more light. This also gives uniformity in size, which is a plus for our nursery and the purchasers of these plants.

In rhododendrons from tissue culture we do not have the growth and rest cycles that are formed in plants from rooted cuttings. The growth in these plants seems to be vertical and, unless they are pinched, the side buds stay dormant. A good example of this is the rhododendron, 'Vulcan'. It gives 12" to 15" growth in one growing season without side breaks. This is not the type of plant we want, so pinching of young plantlets becomes a high cost factor.

Chemical pinching would be a real help to tissue-grown plants. But, there is not any chemical that can do the job. Atrinal at high rates has not been of any help.

There has been a lot of concern in the nursery industry about genetic breakdown of tissue-culture grown plants, both in plant growth and winter-hardiness, plus flower truss. But after growing thousands of plants, both in containers and field, and seeing many of them bloom, we have not seen any signs of genetic variation or off type plants.

From experience, we have learned that if we use a good, healthy, single plantlet instead of a clump of plantlets when we come from the test tube, the plants that grow are normal. But, from clumps we sometimes end up with a mossy plant that never grows properly. It is easy to separate this type of plantlet as they grow in the liner stage. We have had a percentage of plants with leaf varigation, but it is not stable and disappears as the plant matures.

CONCLUSION

The benefits of tissue culture plants far out-weigh the problems in growing them. Tissue culture gives increased production by faster manipulation of new plants.

Uniformity of product is another advantage of tissue culture. The plants from the test tube seem to grow at a uniform rate, which is what a grower wants.

MODERATOR BRUCE BRIGGS: We are ready for questions.

VOICE: I heard sawdust mentioned by three of the speakers. I would like to know what type of sawdust, and is it treated in any way other than by sterilization?

STEVE WONG: Most of the sawdust we are using comes from a composted area. It has been through a compost, it is heated up to 140°F. Right now we are using cedar sawdust. We have used both fir and cedar — either one is good.

WILLIAM SMITH: At our operation, we use salt-free hemlock/fir sawdust. When we are direct rooting from the test tube into the propagating medium we sieve the sawdust.

GEORGE MATSON: Are any of you using artificial cuticles, so to speak? You mentioned that as a problem. Can you use anti-transpirants to spray young plants to give them some protection at the transplanting or transferal stage?

VOICE: Yes, we have recently tried using Wilf-Pruf as a bucket soak, also as a spray, but it is too early to tell whether there is any significant improvement over just the mist.

HAROLD TUKEY: Chrysanthemum propagators have been trying the anti-transpirants because initially the chrysanthemums don't have any cuticle — and they found no effect. However, two or three days in the sunlight and the cuticle comes on hard. So they have had no luck with the anti-transpirants — or anything else of this type.

ED LOSELY: I would like to direct a question to Steve Wong relative to the light intensity in your stage II tissue culture just prior to direct sticking from the culture medium. What light intensity do you use?

STEVE WONG: Five hundred foot candles. That is what we aim for. If we have the black plastic on then we have exact control over the light intensity. Without the black plastic and, if you are using sodium lamps as supplemental light then, of course, it is going to vary a bit. But we aim for 500 foot candles. With our sequence we attempt to go directly from the multiplication stage, as opposed to the other people here, directly into the greenhouse, by-passing the pre-rooting charcoal stage in the laboratory. We feel that by this method we can eliminate or reduce costs in the laboratory.

ED LOSELY: What light intensity do you use at the multiplication stage? That was the question.

STEVE WONG: Oh, I see. It is about 250 to 350 foot candles, I would say.

BRUCE BRIGGS: Anyone else want to comment on light? We go less than that ourselves. In fact, for some plants, as rhododendrons, 150 foot candles is enough. There is a difference among the different plants.

ROBERT NORTON: I might just comment on the type of radiation source, whether you are using high pressure sodium, or cool-white fluorescent, or whatever. I really don't think that

it makes any difference what type of light you use, as long as you are applying the proper amount of total radiant energy. We have had best results in terms of fluorescent lamps with regular cool-white, compared to Gro-Lux or other special plant growth lights. You don't need incandescent lamps. Just simple, cool-white fluorescent lamps are perfectly satisfactory. In terms of the comparison between high pressure sodium, metal halide, or any of the others of this type, the high pressure sodium is the most efficient. So, if you need greenhouse supplemental lighting, high pressure sodium is probably the best, with metal halide being second. So I think these three would be the primary light sources to use: cool-white fluorescent, high pressure sodium, and metal halide.

ANN KYTE: In our case, I would add that we had no supplemental lighting in the greenhouse for our berries. For the growing multiplication stage in the laboratory, our lighting runs from 100 to 300 foot candles.

DON DILLON: Question for Steve Wong. In your potting mix, do you incorporate any nutrients into those materials?

STEVE WONG: Yes, we include the usual elements like dolomite lime, gypsum, superphosphate, and Osmocote at 5 pounds per cubic yard, and we liquid feed for the first stage with a 10-52-10 starter solution for about three weeks.

BRUCE BRIGGS: Here again, caution must be used in a lot of these things; it depends upon your light, your water, your mix, and so on. What are you starting with? When you are talking about pounds to use, it depends upon a lot of things, so take a look before you get too far out on a limb; try it on a small scale before you burn your crop up.

RALPH SHUGERT: Bill, in getting the fall 1980 tissue-cultured rhododendron liners to the field, compared to the normally produced fall-planted rhododendron liners, which broke earlier in the spring, or was there any difference? That is, in the spring of 1981?

WILLIAM SMITH: The tissue-cultured rhododendrons broke quite a lot earlier. They really never stopped growing. During the winter they may rest a little bit, but the minute it warms up they start out. One of my slides showed regular cuttings on one side and tissue-cultured plants on the other; they were two different cultivars. One was 'Jean-Marie' and one was 'Crest'. But you could see the comparison in the field — both produced about the same sized plants.

KEITH TURNER: On your lighting studies, Bob, what kind of plant material are you working with — strawberries, foliage plants, or deciduous plants?

ROBERT NORTON: Strawberries, raspberries, and rhododendrons, primarily.

KEITH TURNER: If I could ask another question while I am on the subject. Speaking of high pressure sodium lamps, are you familiar with their wave length pattern?

ROBERT NORTON: Yes.

KEITH TURNER: I have studied them and, according to the graphs of photosynthesis in plants, their peak is in between the two peaks of the high pressure sodium. And I am wondering, if in fact, in terms of the energy that is put in and the light quantum that you get out, they are not that efficient, because the best spectrum for plants is not supplied by those lights.

ROBERT NORTON: I think we have been placing too much emphasis on the spectral qualities of lamps in the past. If you look at Marc Cathy's recent article in the Journal of the American Society for Horticultural Science you will see reference to this. Of course, this was expressed many years ago by the Dutch workers. I think there is a misimpression that light in wavelengths other than red and blue is inefficient for photosynthesis — this is not the case. What you are really talking about is the total energy — the total quantum energy from 400 to 700 nanometers that is effective for plant growth. It has been demonstrated time and time again in our facility and in other facilities with high pressure sodium and with low pressure sodium, which is absolutely monochromatic, as you know, that the total growth per micro-einstein of energy is really greater with some types of efficient lamps that have a very poor spectral output. The Sylvania people developed the Gro-Lux lamp, which had high radiant energy output in both red and blue and yet many, many tests have been conducted against cool-white, with cool-white being found to give superior plant growth, in most cases, than Gro-Lux lamps. So, if you manipulate the spectrum too much in a fluorescent lamp it costs money because it reduces the light output. So that is why I mention that high pressure sodium is probably the most efficient lamp to use for supplemental lighting.

RICHARD BUSH: My question is on tissue culture of Malling apple and Mazzard cherry rootstocks. What degree of virus testing has been done and what certification are you able to get?

DAVID DUNSTAN: The material that we place into culture is virus certified from the local plant quarantine station. All the techniques that we use in tissue culture are under sterile conditions — sterile manipulations. We get a plant quarantine certification at the end from the plant quarantine

officer provided he is assure of the cleanliness of all our facilities and all the techniques that we have used. He comes often to inspect our facilities and our growing on areas.

VEGETATIVE PROPAGATION TECHNIQUES — CURRENT IDEAS IN BRITAIN

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The last decade has seen many innovations in the production of hardy nursery stock within the British Isles, many of which have been directed to a number of aspects relating to plant propagation. The objective of this paper is to itemize some of the technical developments that have taken place within the last three years, in addition to those currently being used.

Before looking at some individual topics, it will first be helpful to summarize some of the current trends in British plant propagation:

(1) Nurseries specializing in individual crops, such as *Clematis*, are developing specialized growing systems — for example, liner production. This has been particularly noticeable with the formation of newer businesses and also in the rationalization that has occurred within some established companies.

(2) The production of crops if Britain that are traditionally imported from abroad, for example, rose rootstock and tree seedling rootstocks.

(3) Techniques to reduce fuel costs in propagation, which, in turn, have led in a number of instances to a simplification of plant propagation facilities.

(4) The use of polyethylene film for rooting cuttings in the winter as an alternative to mist propagation. Nurserymen have experienced problems with mist over the winter, in particular, due to excess water application leading to leaf drop on cuttings, increased fungal disease, and excess water in the rooting media.

(5) The interest by nurserymen in the growing of new plant introductions. This has been particularly evident in the plant lists of some of the more recent formulated nurseries.