PROPAGATION OF TREE FERNS FROM SPORES

RUTH F. ELLIOTT

Plant Diseases Division,
Department of Scientific &
Industrial Research
Auckland, New Zealand

The beauty of tree ferns and the ease with which they will grow make them very desirable garden plants.

At present, most commercial plants are being collected from the wild but it would be better if tree ferns could be grown from spores.

Several species are sold commercially. They are all attractive, but vary in their ability to withstand exposure. The black tree fern or mamaku *(Cyathea medullaris* Swartz) is usually considered to be the best species for cultivation, and so most of my studies have been with theis species. Other species that I have used are *Dicksonia squarrosa* Swartz and *D. fibrosa* Col. By using sterile culture techniques, I have been able to find out some of the requirements for "normal" growth of tree fern spores into new fern plants.

Collecting spores. The spores of tree ferns are found in sporangia grouped together in sori found on the back of older fronds. The sori open when mature, shedding sporangia which, in turn, split and release the spores.

To collect spores, I choose fronds with abundant mature but unopened sori. Then, I place the fronds over clean thick paper in a draft free place so that sporangia and spores fall onto the paper as they dry. Spores can be separated from sporangia by sloping the paper and tapping it gently whereupon the heavier sporangia slide down the paper leaving the powder-like spores behind. A single frond of *C. medullaris* can yield about 20 g of spores.

The colour of the spores is a useful indication of their maturity in the case of *C. medullaris* and *D. squarrosa*. Their immature spores are grey or yellow. Mature spores of *C. medullaris* are dark brown and of *D. squarrosa* are light brown (tan). On the other hand, mature spores of *D. fibrosa* are bright yellow. Mature spores have high germination rates (80-100%) and remain viable for over 12 months if stored in tightly stoppered tubes in a refrigerator. Immature spores do not have high germination rates and do not retain their viability.

Conditions for spore germination. Germination of spores requires moisture and light (4).

My tests showed that the optimal temperature range for spore germination is 20-29°C for *C. medullaris,* 18-28°C for *D. squarrosa* and 16-22°C for *D. fibrosa*. It is interesting that *D. fibrosa* does not

germinate as well as the other species at the higher temperatures. This species does not occur naturally north of latitude 37° 30'.

Structure and development of the gametophyte. In ferns, the spore does not grow directly into a typical fern plant but forms first a small, delicate, green, heart-shaped structure rarely more than 2-3 cm in diameter. This separate little plant is called the gametophyte because it produces the male and female gametes. In fertilization the gametes fuse to form an embryo which grows into the new fern plant or sporophyte. The structure and development of tree fern gametophytes have been described previously (1, 5, 6).

In order to understand the factors limiting the production of young tree ferns, it is necessary to delve into this life cycle in more detail. When the spore germinates, the young gametophyte grows as a short filament 6-10 cells in length. This one-dimensional phase is followed by a two-dimensional phase when the cells further divide to form a plate-like structure one cell thick and about 0.5 cm in diameter.

The male sex organs or antheridia are usually formed by the gametophyte at this stage. If unfavourable conditions limit the growth of the gametophyte, it may not proceed beyond these early stages so that filamentous, sterile or male gametophytes are formed. With favourable conditions, on the other hand, the gametophyte continues to grow to about 2-3 cm in diameter and becomes more or less heart-shaped with a thickened centre. The female sex organs or archegonia are formed on the thickened centre, on the under surface behind the apical growing point. In many ferns, these larger "female" gametophytes are known to secrete chemicals or hormones which induce antheridia formation in adjoining smaller gametophytes.

In *C. medullaris* I found that antheridia were formed in cultures about 6-8 weeks after germination and archegonia in about 12-16 weeks after germination. Both "male," "female" and "bisexual" gametophytes were observed.

It is well known that the development of the gametophytes of some ferns can be altered readily by cultural conditions (2, 3). I found that *C. medullaris* gametophytes are very sensitive to external growth conditions being more plastic than those of *D. squarrosa* and *D. fibrosa*. Factors which influence their development are as follows.

1. *Density of spores.* If pores are sown too thickly the developing gametophytes become crowded, and under these conditions most of them remain sterile or male. If spores are sown more sparsely some larger "female" gametophytes bearing archegonia are formed intermingled with the smaller male gametophytes. The mature "female" gametophyte of *C. medullaris* is 2-3 cm in width and to attain this size it needs ample space.

2. *Temperature.* In experiments where cultures were grown under a light intensity of 120-220 foot- candles at 25°C or 20°C, gametophytes grew very slowly at 25°C and many did not develop past the filamentous stage. Growth was more "normal" at 20°C, where "typical" expanded gametophytes were formed. After three months, 80% of the gametophytes grown at 25°C were male and 20% were female, while at 20°C, 20% were male and 80% were female.
3. *Light intensity.* In experiments where cultures were grown at 20°C under varying light intensities, it was found that both high light intensities (800-1400 foot-candles) and very low light intensities (60 foot-candles) reduced growth and produced gametophytes which were predominantly filamentous and thus sterile or male. The optimal light intensities for producing gametophytes with archegonia are 120-220 foot-candles. (This is about 2-5% of full daylight).
4. *Moisture.* Free water is needed to insure the release of the male gametes and to provide an adequate film of moisture for the motile male gametes to swim to the immobile eggs. Fertilization only occurred in cultures which were regularly flooded with sterile tap water or nutrient solution.

Production of sporophytes. In theory the gametophytes of *Cyathea* and *Dicksonia* are bisexual, but in practice they tend to be unisexual as the conditions which favour the production of male sex organs do not favour the production of female sex organs. This ovbiously limits the formation of sporophytes.

I was able to induce sporophyte formation in several different ways, as long as the steps taken resulted in both male and female gametophytes being present in the same culture at the same time.

Thus, when large female gametophytes were taken from three month old cultures grown at 20°C under 120 foot-candles of light intensity, and mixed with smaller male gametophytes taken from similar but younger cultures (two months old) sporophytes appeared in another 4-6 weeks. Sporophytes were also produced by sowing a second lot of spores into two month old cultures. In a third experiment, cultures were grown first at 20°C for three months and then transferrred to 23°C in order to encourage male gametophyte formation in the slower growing gametophytes intermingled with the larger female gametophytes. Again sporophytes were formed.

In conclusion, my studies suggest that tree ferns could be grown from spores if the following procedure was followed:

Choose mature spores and sow them thinly on a loose potting mix similar to that used for orchids. Grow the gametophytes under low light intensities in a cool place not above 20°C and water them frequently to ensure free water for fertilization.

The minimum time for sporophytes to appear is 3 to 4 months and for plants 10-30 cm high, one to 2 years.

LITERATURE CITED

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Question — Is the use of distilled water beneficial when working with fern spores?

Answer — If available, use is recommended.