

CHAPTER 7-1

GARDENING: HORTICULTURAL USES



Figure 1. *Sphagnum* species such as this *S. russowii* are commonly used in horticulture as bedding material. Photo by Michael Lüth.

Horticultural Uses

In horticulture, mosses find a niche unparalleled in any other living bryophyte industry (Nelson & Carpenter 1965). Bryophytes, especially peat mosses (Figure 1), have played a major role in horticulture for centuries (Perin 1962; Arzeni 1963; Adderley 1964, 1965). Although their use as part of the landscape has traditionally been mostly an Asian practice, they have commonly been used as soil additives and bedding for greenhouse crops, potted ornamental plants, and seedling beds (Cox & Westing 1963; Sjors 1980). They are stuffed into wire frames to make totem poles to support climbing plants (at the Mossers Lee Plant), topiary (Figure 2, Figure 3), moss-filled wreaths, or baskets (Thomason 1994), or for covering the soil in floral arrangements. One company advertises a birch bark pedestal topped by a moss globe.



Figure 2. A swan topiary exhibited in a pedestrian area of Minneapolis, Minnesota, USA. Photo by David Long.



Figure 3. Dragonfly and toad topiary exhibited in a pedestrian area of Minneapolis, Minnesota, USA. Photos by David Long.

Shipping and Protecting

Sphagnum is almost indispensable for shipping live plants, keeping them moist, yet free from mold. In countries where peat is abundant, the damp peat is burned to produce a smoke screen against frost, hence protecting the plants (Thieret 1954).

Soil Conditioning

As a soil conditioner, coarse-textured mosses increase water storage capacity; fine-textured mosses provide air spaces (Ishikawa 1974; Bernier 1992; Bernier *et al.* 1995). Although supporting experiments seem to be lacking, we assume that mosses improve the nutrient condition of outdoor soils by holding nutrients, especially from dust and rainfall, then releasing them slowly over a much longer period than normal nutrient residency near the soil surface (Stewart 1977; Rieley *et al.* 1979; Scafone unpubl. data).

Their ability to sequester nutrients varies with species and type of nutrient. For most taxa, they do not compete for soil nutrients like phosphorus, but can accumulate from rainfall the potassium, magnesium, and calcium (Timmer 1970). When the mosses later dehydrate, their membranes are damaged, making them leaky. When they rehydrate, nutrients can be dissolved and washed into the soil. It takes a few hours to a day to repair the damaged membranes, giving the roots beneath a chance to retrieve the nutrients that are slowly being washed down from the dusty, leaky mosses. This seems to be especially important for potassium, the most soluble and most easily leached nutrient. (See Nutrient chapter for details.)

Peat, in particular, offers a number of properties important to the growth of plants. To be suitable for most root growth, the peat needs to have about equal proportions of air and water retention. The Peat Research Institute determined that the inclusion of shrubs and cotton grass from the field site could make the peat inconsistent and alter the water-holding capacity and aeration needed for good plant growth. Therefore, they recommended that the proportion of subshrub residues not exceed 3% wet weight, that the proportion of cotton grass and sedge residues not exceed 6%, and that the proportion of *Sphagnum* residues be at least 90% (Puustjarvi 1982).

In England, the Wye College, University of London, and Southern Water have cooperated to develop a compost that takes advantage of sewage, mixed with peat mosses, providing a valuable soil conditioner and slow-release fertilizer that can be used for container-grown plants (Lopez-Real *et al.* 1989). The Shuswap Indians of North America use *Aulacomnium* and *Dicranum* mixed with dirt to make plants healthier (Palmer 1975).

A similar use for the nasty-smelling fish offal takes advantage of the absorptive properties of *Sphagnum* to create a superior compost (Martin & Chintalapati 1990), a real boon for getting rid of fish waste. And, when mixed with fish processing wastes, peat mosses are superior to sawdust and wood shavings in conserving nitrogen, but are a bit more expensive (Liao *et al.* 1995).

The addition of *Sphagnum fuscum* peat to hog manure reduced the volatile loss of ammonia, a primary source of nitrogen, by 75%, mainly due to lowered pH, making it a more suitable fertilizer (Al-Kanani *et al.* 1992a). It offers the added advantage of preventing release of offensive odors caused by 1,2-ethanediamine, methyl hydrazine, N-methyl methanamine, 3-methyl 2-butanamine, ethanethioic acid, and methanethiol (Al-Kanani *et al.* 1992b).

Rao and Burns (1990) found yet another way of providing nitrogen in the culture of oil-seed rape. They provide Cyanobacteria (nitrogen fixers) and bryophytes in the growing medium. Bryophytes are well known for their ability to harbor Cyanobacteria.

Miller (1981) found that bryophytes can even increase the buffering capacity of the soil, surprisingly even against the abrupt changes resulting from fertilizer. And as a mulch, the slow decomposition of peat mosses makes them much more long lasting than leaf litter and compost.

Mosses such as *Sphagnum* retain moisture and prevent weed growth, while at the same time discouraging damping-off fungi (Miller & Miller 1979).

Culturing

Some mosses, for example the epiphytic *Octoblepharum albidum*, are especially suitable for growing hard-to-grow epiphytic ferns (Arzeni 1963). In the Philippines, *Leucophanes octoblepharioides* and other members of the family are used by gardeners and plant growers instead of peat moss in potting new plants (B. C. Tan, pers. comm.). *Leucobryum* (Figure 4) is a suitable medium for inducing good root sprouts on orchid cuttings, sold at U.S. \$0.50 per kilo. The most popular moss medium for growing orchids, most of which are likewise epiphytes, is *Sphagnum*, but mosses like *Camptothecium arenarium*, *Hypnum imponens*, *Leucobryum* spp., *Rhytidiopsis robusta*, and *Thuidium delicatulum* are also

useful (Perin 1962; Adderley 1964, 1965). Chen and Chang (2000a, b) had almost 100% survival success when growing the orchid *Oncidium* from callus explants on *Sphagnum* peat. Whereas most of their culture media produced abnormal shoots, both embryo- and shoot-bud-derived regenerants developed into healthy plantlets when potted in *Sphagnum* and acclimatized in the greenhouse.



Figure 4. This epiphytic species of *Leucobryum* demonstrates its suitability for supporting root growth by hosting an epiphytic fern. Photo by Janice Glime.

Air Layering

Horticulturists may have learned some lessons from nature. Mosses in nature provide suitable media for air layering of plants like the heath shrub *Calluna* (Scandrett & Gimingham 1991; Macdonald *et al.* 1995) and even some tropical trees, so it is no surprise that they are used almost exclusively for air layering as a means of propagation of plants. The moss is wrapped around the area where roots are to be encouraged, often held in place with cloth mesh, wire, or dark plastic. The moss provides a continuous supply of moisture and encourages the development of adventitious roots while discouraging fungi. Once the roots have formed, the stem can be cut below that point and the explant grown into a new individual. Pant (1989) reports similar use for grafting fruit trees.

Pot Culture

Mosses can also encourage potted plants. Pant (1989) reports that *Begonia* and *Fuchsia* bud and flower more profusely in pots where mosses are used to separate the humus-rich top soil from the bottom soil. Members of the Ericaceae, in particular, benefit from the acid of peat mosses. But in Japan, *Hypnum plumaeforme*, *Leucobryum bowringii*, *L. neilgherrense*, and occasionally *L. scabrum* fragments are used, mixed with sand or soil, to cultivate *Rhododendron* shrubs (Ando 1957).

The forestry industry likewise finds peat invaluable for culturing young seedlings. Heiskanen and Rikala (2000) found *Sphagnum* peat to be superior to fine sand or peat with perlite, the latter resulting in more weakened seedlings as a consequence of the lower water retention of the medium. However, peat is not always readily available. Israeli researchers found that composted cattle manure mixed with grape marc were good substitutes for peat in that country where peat must be imported; the substitutes were likewise effective at suppressing plant pathogens (Chen *et al.* 1992).

There are drawbacks to using mosses in culturing of some plants. In containers of conifer seedlings, they can choke young seedlings, compete for nutrients, and repel water (Haglund *et al.* 1981).

Mushrooms & Other Fungi

Sphagnum peat is the substrate of choice as casing medium for cultivating the common grocery store mushroom, *Agaricus bisporus* (Eicker & van Greuning 1989). (Casing is the process in which a non-nutritious layer, in this case peat, is applied over the colonized substrate so that the mycelium has access to more moisture, thereby increasing the size and number of growths.) Sungrow had a multi-million-dollar contract from Campbell (of Campbell soup fame) to improve mushroom culturing using a *Sphagnum* mix (Vitt, pers. comm.; Miller 1981). However, in places such as South Africa, where there is no peat, substitutes are necessary. The need for peat substitutes led Eicker and van Greuning (1989) to test other substrata and compare, but peat still gave the highest yields compared to eight other materials, with only weathered, spent compost offering similar results.

In an attempt to make further improvements in mushroom success, Beyer (1997) sought ways to reduce the effect of accumulated substances on late mushroom crops. Surprisingly, he found that the addition of *Hypnum* peat to the compost improved later break yield, but the addition of *Sphagnum* did not. One of the concerns is that the peat becomes infested with nematodes and may carry *Pseudomonas tolaasii*, the cause of bacterial blotch, both of which cause serious diseases to the mushrooms (Nikandrow *et al.* 1982).

Martin and Bailey (1983) succeeded in using peat as a fermentation medium in which acclimated fungi could be grown. They were more successful with the common mushroom *Agaricus campestris* than with the morel *Morchella esculenta* (Martin 1982; Figure 5). They considered that growth inhibitors might be present in peat. Using sulfuric acid hydrolysates with autoclaved peat released a liquid that, when supplemented with nutrients, would enhance growth and crude protein content of these two edible fungi. Nutrient-supplemented peat hydrolysates enhance growth & crude protein content of fungal biomass.



Figure 5. *Morchella esculenta*, the common morel, can be cultured in a bed of peat. Photo by Janice Glime.

A mixture of *Sphagnum* with fish offal promises to be a suitable substrate for culturing the acid-tolerant fungus *Scybalidium acidophilum*, which is considered to be a promising source of microbial protein (Martin & Chintalapati 1990). However, not all fungal cultures seem to benefit from peat mixtures. In one commercial operation, the yield of mushrooms improved when the peat was omitted from the cultivation medium (Smith 1983).

Container Gardens

Mosses are commonly used in container gardens with bonsai and bonkei (Figure 6), where they help to stabilize the soil and retain moisture for the shallow roots. When the mosses appear dry, you can be sure your bonsai needs water. However, they are not always the friend of the bonsai. The continuous moisture of the mosses can inhibit root growth and promote sudden fungal attacks. The experts advise removing the mosses each autumn to reduce fungal damage (Bland 1971).



Figure 6. Outdoor bonkei in a Japanese private garden. *Selaginella* is used to represent a tree, with mosses growing on the rocks that form the basin for a small "lake." Photo by Janice Glime.

Designers select the species of mosses to serve particular functions in the container landscapes. Large, upright mosses such as *Atrichum*, *Climacium*, *Dicranum*, *Polytrichum*, and *Rhodobryum* simulate forests. *Bryum argenteum* has a silvery, compact look that can simulate grasslands, and *Leucobryum* usually has the role of a mountain. For snow-capped mountains, *Racomitrium canescens* provides a frosted look. *Physcomitrium*, often a volunteer in greenhouse flower pots, is so miniature as to appear like a moss, or maybe a grass, in a landscape of *Leucobryum* mountains. *Barbula unguiculata*, *Funaria hygrometrica*, and *Weissia controversa* can contribute to needs of intermediate size. In Mexico, some mosses are even used for fake bonsai: *Campylopus*, *Dendropogonella rufescens*, *Hypnum*, and *Thuidium* (C. Delgadillo, pers. comm.). In the Pacific Northwest of North America, *Leptobryum pyriforme*, known as Kyoto moss, is sold for bonsai trays (J. Christy, pers. comm.).

Miniature tray landscapes (bonkei, bankei, saikei in Japan) use mosses to provide appropriate texture and color with little danger of damage due to drying (Kawamoto 1980; Oishi 1981). Such trays can delight the bed-ridden. Gerritson (1928) arranged sixteen species of mosses in various stages of maturity to provide a changing landscape for a hospitalized friend: "Each day the mosses had changed appearance; so each day added a new joy. The

nurses came from time to time to see and admire. Other patients shared its freshness and beauty. Visitors, too were invited to see the charm of a 'platter of mosses.'"

For making these miniature landscapes, Schenk (1997) recommends the usual potting mix of humus, including peat moss, ground-up tree bark, or rotted sawdust. He cautions that sand, vermiculite, or perlite can be used, but that they must be kept moist because they tend to have larger spaces and dry quickly near the surface, leaving the moss with no source of moisture.

Even in this seemingly harmless occupation, one must use caution against allergens. Tray gardens and other forms of bonsai and dish gardens may use *Sphagnum* peat as a medium. This moss is well known for its ability to harbor the fungus that causes sporotrichosis (Dong *et al.* 1995).

Hanging Baskets

Mosses are often used in the construction of hanging baskets for flowers (Smith 1996). In California, USA, meter-long "strips" 8-10 cm wide are used to make hundreds of baskets per week!

Usually a wire frame is used to give support, with mosses wound among the wires or laid within to provide the structure. Not only do they make an attractive, natural-looking basket, but they reduce the need for frequent watering (Lohr & Pearson-Mims 2001). Species of *Hypnum* and *Sphagnum* are commonly used for this purpose.

The long, stiff stems of *Polytrichum* permitted the early Romans to weave it into baskets (Bland 1971), but these most likely did not have a horticultural purpose.

Terraria

The terrarium, a drier plant version of the aquarium, is often arranged like an enclosed garden, a miniature garden like the container gardens. Because of its small size, bryophytes are often used to give the look of mountains; dry brooks made of pebbles ramble between clumps of various hues of green. But bryophytes are not easy to grow in such conditions. If the container is fully open, mosses soon dry out and become crispy. If it is sealed, as many terraria are, fungi can easily grow. The best choice is to leave the top partially open to permit air circulation.

Choice of mosses depends in part on how moist you intend to keep it and in part on the effect you want to achieve. *Polytrichum* can survive in a somewhat dry terrarium but will easily be covered with mold when it is too damp. Likewise, *Leucobryum* likes it airy with good circulation. *Ceratodon purpureus* is sometimes successful, again requiring at least some air circulation. Schenk (1997) states, "I must tell the whole truth by identifying the great enemy of terrarium gardening with native woodlanders, for there is one: mold." He admonishes that most terraria have a short life due to this problem. My own experience certainly agrees.

Funaria hygrometrica can be encouraged in more moist conditions, but it still needs circulation. With a little luck it will even produce capsules.

Schenk suggests that a container the size of an aquarium is best, smaller ones being more subject to mold. Air space is of the essence, and it needs to circulate.

Schenk considers a potting mix to be suitable, whereas it does not tend to work well in open-air gardens. On the

other hand, if the bryophytes have their own deep brown portions, no substrate is necessary. Charcoal may be added to the substrate to absorb excessive acidity and gases produced by decay.

Little water is needed as it will recycle within the nearly sealed container. Mosses that are collected wet generally do not need additional water and may even need to be dried by leaving the terrarium open wide for a day or two. Slightly dry mosses can be moistened with 30-35 ml (2-3 tablespoons) of water; totally dry ones may require up to 70 ml (1/4 cup) (Schenk 1997).

Maintenance for the first few days after planting is essential to avoid an immediate mold attack. If a heavy dew appears on the walls of the container, open it and dry the walls. This should be repeated daily until morning brings only a light condensation on the upper half of the walls of the container. When you discover, probably in a few weeks, that there is no longer any morning dew, it is time to add water, but not much.

After all this care, Schenk warns that the terrarium will most likely last only three weeks! (I have had better success than that with larger aquaria.) That can be extended by providing fluorescent lights to avoid the etiolated growth so noticeable in low light. Nevertheless, a mold garden is most likely to ensue within this short time, and great care and luck are needed to find the right wetting and drying cycle.

Within those first few weeks, a moss garden terrarium can be full of surprises, with mushrooms appearing, capsules extending, and the somewhat rapid but unnatural elongation of the moss stems in low light.

One of the contributors to the demise of the moss terrarium indoors is the warm temperatures night and day indoors. If there is a cool location for the terrarium, it might survive a longer display, and surely in the refrigerator it would last, but would be of little use, not to mention suffering from lack of light.

One last caution I would insert is that lichens are to be avoided if one wishes to maintain a moss terrarium for any length of time. In the moist conditions of confinement, they will soon spread their fungi broadly and overtake the moss, albeit no longer as lichens, but nevertheless encroaching rapidly upon the surfaces of green. If lichens are to be enjoyed in this terrarium, it must by all means be kept open and the mosses provided with water occasionally as needed, perhaps with dry periods, but not too often.

I was relieved to read this moss gardener's treatment of the terrarium. If such an expert as Schenk was able to maintain such a terrarium garden for only three weeks, I felt elated that I, too, had succeeded on occasion to maintain one for so long! In short, if you wish to maintain a terrarium of bryophytes for a lengthy period of time, my best advice to you is Good Luck!

Summary

Peat mosses have been widely used in horticulture as soil additives, and for bedding, as well as forming the foundation for topiary, wreaths, and hanging baskets. Their ability to add moisture makes them ideal as a shipping medium for plants.

Peat mosses are used as soil conditioners, providing a holding medium for nutrients, releasing them slowly following drying. They provide good

compost, especially when mixed with such waste products as fish offal or sewage. Some peat mosses provide additional fixed nitrogen through their Cyanobacteria flora. Their antibiotic properties discourage damping-off fungal growth while maintaining moisture. These same properties make them good for air layering. All of these properties make peat mosses good culture media and potting mixes, but other relatively dense mosses work well also.

Peat mosses have been used in forestry to culture young seedlings and in the food industry to culture mushrooms and morels.

Small mosses work well in container gardens such as bonsai and bonkei, where various species are used to simulate different aspects of miniature landscapes. Terraria are more difficult, with mold being a frequent problem. Aeration is important, as is the choice of mosses.

Literature Cited

- Adderley, L. 1964. Two species of moss as culture media for orchids. *Amer. Orchid Soc. Bull.* 34: 967-968.
- Adderley, L. 1965. Two species of moss as culture medium for orchids. *Gard. J. New York Bot. Gard.* 15(3): 105-106, 120.
- Al-Kanani, T., Akochi, E., MacKenzie, A. F., Alli, I., and Barrington, S. 1992a. Organic and inorganic amendments to reduce ammonia losses from liquid hog manure. *J. Environ. Qual.* 21: 709-715.
- Al-Kanani, T., Akochi, E., MacKenzie, A. F., Alli, I., and Barrington, S. 1992b. Odor control in liquid hog manure by added amendments and aeration. *J. Environ. Qual.* 21: 704-708.
- Ando, H. 1957. Notes on useful bryophytes. *Bull. Biol. Soc. Hiroshima Univ.* 7(2): 23-26.
- Arzeni, C. B. 1963. *Octoblepharum* as a seedling medium. *Econ. Bot.* 17: 10-15.
- Bernier, P. Y. 1992. Soil texture influences seedling water stress in more ways than one. *Tree Planter's Notes* 43: 39-42.
- Bernier, P. Y., Stewart, J. D., and Gonzalez, A. 1995. Effects of the physical properties of *Sphagnum* peat on water stress in containerized *Picea mariana* seedlings under simulated field conditions. *Scand. J. Forest Res.* 10: 184-189.
- Beyer, D. M. 1997. The effect of chelating agents on the later break yields of *Agaricus bisporus*. *Can. J. Bot.* 75: 402-407.
- Bland, J. 1971. *Forests of Lilliput*. Prentice-Hall, Englewood Cliffs, N. J., 210 pp.
- Chen, J. T. and Chang, W. C. 2000a. Efficient plant regeneration through somatic embryogenesis from callus cultures of *Oncidium* (Orchidaceae). *Plant Sci.* 160(1): 87-93.
- Chen, J. T. and Chang, W. C. 2000b. Plant regeneration via embryo and shoot bud formation from flower-stalk explants of *Oncidium Sweet Sugar*. *Plant Cell, Tissue Organ Culture* 62(2): 95-100.
- Chen, Y., Inbar, Y., and Hadar, Y. 1992. Composted residues reduce peat and pesticide use. *Biocycle* 33(6): 48-51.
- Cox, R. L. and Westing, A. H. 1963. The effect of peat-moss extracts on seed germination. *Proc. Indiana Acad. Sci.* 73: 113-115.
- Dong, J. A., Chren, M.-M., and Elewski, B. E. 1995. Bonsai tree: Risk factor for disseminated sporotrichosis. *J. Amer. Acad. Dermatol.* 33(5 part 1): 839-840.

- Eicker, A. and Greuning, M. van. 1989. Economical alternatives for topogenous peat as casing material in the cultivation of *Agaricus bisporus* in South Africa. S. Afr. J. Plant Soil/S.-Afr. Tydsk. Plant Grond. 6(2): 129-135.
- Gerritson, W. 1928. A platter of mosses. Bryologist 31: 106-107.
- Haglund, W. A., Russell, K. W., and Holland, R. C. 1981. Moss control in container grown conifer seedlings. Tree Planter's Notes, summer: 27-29.
- Heiskanen, J. and Rikala, R. 2000. Effect of peat-based container media on establishment of Scots pine, Norway spruce and silver birch seedlings after transplanting in contrasting water conditions. Scand. J. Forest Res. 15(1): 49-57.
- Ishikawa, I. 1974. Bryophyta in Japanese gardens (2). Hikobia 7: 65-78.
- Kawamoto, T. 1980. Saikei: Living landscapes in miniature. Tokyo. 133 pp.
- Liao, P. H., Vizcarra, A. T., Chen, A., and Lo, K. V. 1995. A comparison of different bulking agents for the composting of fish offal. Compost Sci. Utilization, spring: 80-86.
- Lohr, V. I. and Pearson-Mims, C. H. 2001. Mulching reduces water use of containerized plants. Horttechnology 11(2): 277-278.
- Lopez-Real, J. M., Witter, E., Midmer, F. N., and Hewett, B. A. O. 1989. Evaluation of composted sewage sludge/straw mixture for horticultural utilization. Water Sci. Technol. 21: 889-897.
- Macdonald, A. J., Kirkpatrick, A. H., Hester, A. J., and Sydes, C. 1995. Regeneration by natural layering of heather (*Calluna vulgaris*): Frequency and characteristics in upland Britain. J. Appl. Ecol. 32(1): 85-99.
- Martin, A. M. 1982. Submerged growth of *Morchella esculenta* in peat hydrolysates. Biotech. Lett. 4(1): 13-18.
- Martin, A. M. and Bailey, V. I. 1983. Production of fungal biomass in peat acid hydrolysates. In: Fuchsman, C. H. and Spigarelli, S. A. (eds.). Proceedings of the International Symposium on Peat Utilization, Bemidji, MN, USA, 10-13 Oct 1983, pp. 301-309.
- Martin, A. M. and Chintalapati, S. P. 1990. Composting of fish offal with peat and its use in the production of microbial biomass. 34. Atlantic Fisheries Technological Conf. and Seafood Biotechnology Workshop, St. John's, Nfld., Canada, 27 Aug-1 Sep, 1989. In: Voigt, M. N. and Botta, J. R. (eds.). Advances in Fisheries Technology and Biotechnology for Increased Profitability, pp. 387-394.
- Miller, N. G. 1981. Bogs, bales, and BTU's: A primer on peat. Horticulture 59(4): 38-45.
- Miller, N. G. and Miller, H. 1979. Make ye the bryophytes. Horticulture 57(1): 40-47.
- Nelson, T. C. and Carpenter, I. W. Jr. 1965. The use of moss in the decorative industry. Econ. Bot. 19: 70.
- Nikandrow, A., Nair, N. G., and McLeod, R. W. 1982. Effects of ethylene oxide on organisms contaminating peat moss. Mushroom J. 11: 100-101.
- Oishi, T. 1981. Koke-zukuri-koke-bankei kara koke-hiwa made. [Moss horticulture-moss landscape trays and moss gardens.]. Osaka, Japan, 96 pp.
- Palmer, G. 1975. Shuswap Indian Ethnobotany. Sysis 8: 29-51.
- Pant, G. 1989. Exploration of the bryophytic vegetation of Districts Almora and Pithoragarh (Kumaon Himalaya), Project Completion Report: 1985-1989. DST Ref. No. 1/3/1984 - STP III: 105-113.
- Perin, F. 1962. Woodland mosses – A little-used growing medium. Amer. Orchid Soc. Bull. 31: 988.
- Puustjarvi, V. 1982. Main properties of horticultural peat. Proceedings of the Symposium on Peat Lands Below Sea Level August 24-28, 1981, the Netherlands. IRLI Publication No. 30. pp. 260-266.
- Rao, D. L. N. and Burns, R. G. 1990. Use of blue-green algae and bryophyte biomass as a source of nitrogen for oil-seed rape. Biol. Fert. Soils 10(1): 61-64.
- Rieley, J. O., Richards, P. W., and Bebbington, A. D. L. 1979. The ecological role of bryophytes in a North Wales woodland. J. Ecol. 67: 497-527.
- Scandrett, E. and Gimingham, C. H. 1991. The effect of heather beetle *Lochmaea sutralis* on vegetation in a wet heath in NE Scotland. Holarct. Ecol. 14: 24-30.
- Schenk, G. 1997. Moss Gardening: Including Lichens, Liverworts, and Other Miniatures. Timber Press, Portland, OR, 261 pp.
- Sjors, H. 1980. Peat on earth: Multiple use or conservation? Ambio 9: 303-308.
- Smith, C. 1996. Mosses for sale? Bryonet email.
- Smith, J. F. 1983. The formulation of mixtures suitable for economic, short-duration mushroom composts. Scientia Horticulturae (Amsterdam) 19(1-2): 65-78.
- Stewart, J. M. 1977. Canadian muskegs and their agricultural utilization. In: Radforth, N. W. and Brawner, C. O. (eds.). Muskeg and the Northern Environment in Canada. Toronto, pp. 208-220.
- Thieret, J. W. 1954. Mosses and liverworts: Old and new uses. Chicago Nat. Hist. Mus. Bull.: pp. 4, 8.
- Thomason, J. H. 1994. Mossy containers. Southern Living, February: 58-59.
- Timmer, V. R. 1970. Observations on the mineral nutrition of feather mosses under black spruce. Forest Research Laboratory. Canad. Forest. Serv., Report N-62.