be changed due to the container filling, which indicates that the very finest structure of the peat media was unaltered.

Conclusions

It was shown that filling peat medium into containers reduces the proportion of coarse particles (>1 mm) and, correspondingly, increases the proportion of fine particles (<1 mm). This also increases water retention under wet conditions, which may further decrease air-filled porosity so that air diffusion and hence oxygen availability to roots decrease. In nursery management, to preserve the initial favorable structure of light, low-humified peat, container-filling procedures and other mechanical precultivation practices for peat should be as infrequent and gentle as possible.

Literature Cited

Beyer-Ericson, L., E. Damm, and T. Uenestam. 1991. An overview of root dieback and its causes in Swedish forest nurseries. *Eur. J. For. Pathol.* 21:439-443.

Currie, J.A. 1984. The physical properties in the seedbed. *Aspects Applied Biol.* 7:33-54.

Heiskanen, J. 1993a. Favourable water and aeration conditions for growth media used in containerized tree seedling production: A review. *Scand. J. For. Res.* 8:337-358.

Heiskanen, J. 1993b. Variation in water retention characteristics of peat growth media used in tree nurseries. *Silva Fenn.* 27:77-97.

Hillel, D. 1971. Soil and water. Physical principles and processes. Academic, Orlando, Fla.

Landis, T.D., R.W. Tinus, S.E. McDonald, and J.P. Barnett. 1990. Containers and growing media. Vol 2. The container tree nursery manual. Forest Service, USDA, Washington D.C., Agr. Hdbk. 674

Lilja, A., S. Lilja, M. Poteri, and L. Ziren. 1992. Conifer seedling root fungi and root dieback in Finnish nurseries. *Scand. J. For. Res.* 7:547-556.

Puustjärvi, V. 1977. Peat and its use in horticulture. *Turveteollisuussittory.* Publ. 3. Liikekirjapaino, Helsinki, Finland.

Puustjärvi, V. 1982a. Textural classes of horticultural peat. *Peat & Plant Yrbk.* 1981-1982. p. 28-32.

Puustjärvi, V. 1982b. The size distribution of peat particles. *Peat & Plant Yrbk.* 1981-1982. p. 33-47.

Wilson, G.C.S. 1983. The physico-chemical and physical properties of horticultural substrates. *Acta Hort.* 150:19-32.

Potential Utilization of Yardwaste Compost in Virginia: A Survey of Nursery Operators

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Additional index words. municipal landfills, nursery composting

Summary. Registered nursery operators on Virginia were surveyed to determine the potential utilization of yardwaste compost (YWC) from a proposed statewide yardwaste composting system. Respondents reported using 94,000 yd³ of potting medium, 36,000 yd³ of peat in containers, and 9000 yd³ of peat for field soil amendment, and retailing 144,000 yd³ of organic materials per year. Many of the respondents indicated that YWC could be used as a substitute for peat or other organic materials in potting mixes (56%), field-grown nursery crops (54%), and lawn establishment (21%), and more than 30% were interested in selling retail. Nursery operators (30%) expressed interest in contracting with municipalities to do the composting and using or marketing it directly.

Recycling goals have been set by the U.S. Environmental Protection Agency, and several states have mandated recycling goals that are more rigorous than federal

guidelines. In Virginia, landfills were required to reduce the volume of intake 15% by 1993, and 25% by 1995 (Simpson and May, 1990).

A study to determine the feasibility of implementing a yardwaste composting program in Virginia was conducted by Virginia Cooperative Extension (VCE) for the Virginia Dept. of Waste Management (Virginia General Assembly, 1989). A segment of the study focused on the nursery industry and its potential role in producing and using YWC.

Yardwaste, consisting of three types of material—leaves, grass clippings, and brush and prunings—is estimated to comprise an average of 15% to 20% of the municipal solid waste, or 1 million tons, in Virginia (Simpson and May, 1990). Elimination of this material from landfills would allow Virginia to meet a large portion of its 1995 recycling goals. Of the three types of yardwaste, leaves are believed to be the most suitable for municipal composting. Grass clippings are best left on the lawn after mowing or used in backyard composting to avoid the cost of municipal collection and handling. Woody wastes, such as shrub and tree prunings, often are shredded in the collection process and are suitable as mulch.

The tipping fee, or cost assessed by the landfill to receive refuse, varies widely. In Virginia in 1989, this cost was as high as \$150 per ton, with a state average of just under \$20 per ton (Simpson and May, 1990). In 1993, fees had risen on average to \$28 per ton (personal communication, Dept. of Environmental Quality, Richmond, Va.). Fees are projected to rise dramatically in the next few years as landfill space becomes scarcer. Production costs for a ton of finished YWC range from \$12 to \$20 per ton, and can be recovered by a tipping fee paid to the composting facility. For each ton of incoming yardwaste, ≈1 yd³ of finished compost is generated. A cubic yard of finished compost will have a final weight of ≈0.5 ton (Richard and Ferenz, 1988). Compost typically is sold for \$10 to \$20 per yd³, depending on quality. As production costs are covered by the tipping fee, the marketing income would be profit.

YWC is a dark, crumbly material with many physical and chemical properties similar to peatmoss that make it suitable for use by the nursery industry as a soil amendment for beds and field-

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grown crops, and as a partial or complete substitute for peatmoss in potting mixes. Due to its low nutrient value, it is not considered a fertilizer, but only a soil conditioner used to increase the soil's water-holding capacity, cation exchange capacity, and tilth. A cubic yard of peatmoss can cost more than \$50; thus, YWC is economically competitive as a peat substitute.

Private-sector businesses, particularly nurseries or landscaping firms with a ready market for the finished product, are presently composting yardwaste for municipalities in New Jersey, Oregon, Washington, and Minnesota (Schaver, 1986). Portland, Ore., has contracted with two large private firms to accept yardwaste for composting and resale (Metro Portland, 1989). Middlebush Compost, Inc., in New Jersey, is a private company with a facility capable of handling >100,000 yd³ (25,000 tons) of yardwaste annually. The finished material is marketed to nurseries and landscape contractors (M. Vastano, personal communication).

To determine the potential need, knowledge, and interest of the nursery industry in municipal composting, a survey was developed and mailed to all registered nursery operators (including landscape contractors) in Virginia following the Total Design Method survey guidelines (Dillman, 1978). The survey asked: 1) the types and amounts of organic materials currently in use; 2) the types and amounts of organic materials currently offered for sale; 3) the operators' interest in using or selling composted yardwaste and their perceived use and value of YWC; and 4) their interest in operating a compost facility. While responses were confidential, an optional section was included for respondents to request additional information.

The 476 surveys were sent by first-class mail on 28 July 1989. One week later, a follow-up postcard was mailed to remind those who had not yet returned their completed survey to do so, and to thank those who had responded. No other reminders were sent. One-hundred-forty-seven responses (31%) received in the first 5 weeks were used in data compilation.

Results and discussion

The respondents indicated that a number of organic materials were used that potentially could be replaced by

YWC. Fifty-six percent of the respondents indicated YWC potential use as a component in potting soil mixes. A major component of most potting mixes is peatmoss. More than 94,000 yd³ of potting mixes and 36,000 yd³ of peatmoss were used by the respondents annually. Replacement of these materials with YWC would represent a large potential market. Fifty-four percent of the respondents indicated YWC potential use as a soil amendment for field-grown crops. More than 9000 yd³ of organic materials are reported as used by the respondents annually for this purpose. Twenty-one percent responded that YWC could be used as a substitute for other organic materials in lawn establishment and renovation.

The respondents sold >144,400 yd³ of organic materials per year. One-third of the respondents were interested in selling bulk compost, and 39% were interested in selling bagged or baled YWC. More than two-thirds (67%) of the respondents were interested in using YWC if prices were below comparable materials, and 61% stated that travel up to 30 miles to obtain YWC was acceptable.

Based on survey results, there may not be enough demand by the nursery industry for the projected production of 800,000 yd³ of YWC annually. However, experiences in other states indicate action can be taken to broaden the market for YWC. State agencies could be required and local government agencies encouraged to use YWC in landscaping and maintenance when available and competitively priced. In an attempt to implement this, House Joint Resolution No. 170 recommended such action (Virginia General Assembly, 1990), but has not yet passed.

As a result of the feasibility study by VCE, the Dept. of Waste Management (now DEQ) authorized publication of the *Virginia Yardwaste Management Manual*. This hands-on guide for local government officials, extension agents, and the private sector is intended to lead them through the steps necessary to site, design, and operate a yardwaste management program (May and Simpson, 1990).

In addition, a public education program has been implemented on privatization of compost facility operation that included establishment of a pilot program. Field days for nursery operators and farmers have been con-

ducted. Nursery operators and landscape contractors are seen as primary private-sector producers and users of YWC. Education of the nursery industry is therefore essential to implementation of a statewide YWC program. Extension agents have established demonstration sites to educate the nurseries' customers on home uses of compost.

Some survey responses indicated a lack of understanding regarding the physical and chemical properties of YWC, as well as potential uses for the product. When partially decomposed, YWC makes an excellent mulch. The grinding and screening usually involved in producing the finished YWC on a large scale often results in a texture resembling peatmoss, which may be too fine for use as a mulch. However, 48% of respondents listed this as a potential use. This misperception may have occurred because they lack experience with YWC, as there are only a few large-scale YWC operations in Virginia.

There is interest in yardwaste composting among the nursery operators surveyed, with 67% of respondents asking to be placed on a mailing list to receive additional information as it becomes available. Thirty percent of the respondents were interested in operating a compost facility if satisfactory contracts could be arranged with nearby localities or solid-waste management firms. They indicated that low-interest loans for private yardwaste composting would encourage involvement.

Seventy-two percent of those interested in operating a compost facility indicated that they had adequate land available for a facility, and 74% had tractors or front-end loaders to turn the compost windrows. Seventy-eight percent of the respondents noted that regulations might influence their interest, while 30% responded regulations would definitely influence their interest in operating a facility. Regulations governing composting vary from state to state, and, in Virginia, yardwaste composting facility regulations (VR-672-20-32) were introduced in 1990 as emergency regulations and finalized in 1992 (Virginia Dept. of Waste Management, 1992). These regulations allow "agricultural operators" (farmers, nursery operators, and landscapers) to accept an unlimited amount of yardwaste from municipalities for a

tipping fee and require minimal permitting paper work. Guidelines to protect ground and surface waters are included in the regulations. A copy of the regulations may be obtained by calling the DEQ in Richmond, Va.

Organic matter is required in most horticultural enterprises. YWC is an economical soil amendment that can be produced and marketed for less cost than comparable organic materials. Nurseries and landscape businesses are natural locations for compost facilities because much of the finished product could be used "in-house" for potting mixes, in field-grown nursery crops as a soil amendment, and in turf establishment and renovation. Operating a facility would allow nurseries to supplement their income by accepting organic materials from municipalities for a tipping fee, and, in cooperation with municipalities, the nursery industry could play a major private sector role in the implementation of a statewide YWC program.

Literature Cited

Dillman, D.A. 1978. Mail and telephone surveys, the total design method. Wiley, New York.

May, J.H. and T.W. Simpson. 1990. The Virginia yard waste management manual. Virginia Cooperative Extension, Blacksburg. Publ. 452-055

Metro Portland. 1989. A users guide to yard debris compost. Portland, Ore.

Richard, T. and G. Ferenz. 1988. Composting landscape wastes. Grounds Maintenance 9:40-45.

Schaver, D. 1986. Solid waste recycling aided by state initiatives. Biocycle, J. of Waste Recycling 27(4):44-48.

Simpson, T.W. and J.H. May. 1990. The feasibility of a yardwaste composting program for Virginia. Virginia General Assembly. House Doc. 34. Jan. Richmond.

Virginia Department of Waste Management (now DEQ). 1992. Yard waste composting facility regulations. VR 672-20-32. Blacksburg, Va.

Virginia General Assembly. 1990. House Joint Resolution 170. Jan. Richmond.

Virginia General Assembly. 1989. House Joint Resolution 395. Jan. Richmond.

Physical and Chemical Characteristics of Apples in European Markets

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Additional index words. *Malus domestica* Borkh., shape, external defects, internal defects, water core, bruises, firmness, color, soluble solids, acid, starch, vitamin C

Summary. Comparisons were made of the major physical and chemical characteristics of seven cultivars of apples (*Malus domestica* Borkh.) produced and imported into Western Europe from 13 origins. During the 1990-91 marketing season, 'Delicious', 'Golden Delicious', 'Granny Smith', 'Elstar', 'Jonagold', 'Gala', and 'Fuji' apples were included in the study. Physical characteristics evaluated were length-to-diameter ratio, shape, external defects, internal defects, water core, bruises, firmness, blush surface, and color. Chemical characteristics evaluated were starch, juice content, soluble solids, acids, and ascorbic acid. Significant differences in some of these quality characteristics were found between the different origins. Apples produced in the United States, particularly 'Delicious', had some superior quality characteristics compared to fruit from other origins.

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The European Union (EU) is one of the world's major producers of apples. However, the EU also imports apples from many sources. The largest producers within the EU are Italy, France, Germany, and Spain. Major exporters to the EU are Chile, South Africa, New Zealand, Argentina, and the United States.

Most of the published data on chemical composition and physical characteristics of apple quality are found in miscellaneous reports that describe the direct effects of either the cultivar, mineral nutrition, climate, maturity, or time of storage (Olsen, 1969; Pattee, 1985; Watada et al., 1980, 1981). These reports are concerned with aspects of fruit quality as influenced by the environment of relatively small areas of production. There are no reports that clearly describe the difference in quality of different apple cultivars from the major producer countries in the world when the apples are available to the consumer. In this study, selected apple cultivars from various countries were compared for the principal physical and chemical characteristics related to condition and quality.

Materials and methods

Apple samples were collected at 12 monthly intervals from lots arriving on the wholesale markets or importers' warehouses in Rotterdam, the Netherlands; Cologne, Germany; Paris, France; and 1 month in London, England, over a period of one marketing season (1990-1991). A total of 1066 samples of apples from 13 different origins were collected during the survey. The following cultivars were sampled: 'Delicious', 'Golden Delicious', 'Granny Smith', 'Elstar', 'Jonagold', 'Gala', and 'Fuji'. Samples of 'Empire' were also taken; however, not enough samples were collected for analyses. One standard package of median-size apples was selected from each new lot that had arrived during the monthly periods. Lots were separated according to brand or packer/grower. A 10-fruit sample was selected at random from the package and returned to the laboratory. The 10-fruit sample was divided in two subsamples of five fruit for further evaluation of all factors. For statistical analysis, the average value of the five fruit was used as one sample.

Size. Size was determined by measuring the diameter of the fruit to the nearest millimeter at the equator. Length of the fruit was determined by