Chapter 3
Equipment for Forest Nurseries

R. G. Hallman

Abstract

Modern machinery and equipment can increase efficiency and productivity in all phases of nursery operations without sacrificing quality or safety. Seed processing is facilitated with kilns, tumblers, separators, dewingers, scalpers, and grinders. Seedbeds are prepared with plows, harrows, rock rakes, packers, bed formers, and levelers; seed is then sown with drills or broadcast seeders. Fertilizers and soil amendments are applied with spreaders, seeders, or soil injectors; weeds are controlled by row or path cultivators. Sprinkler systems not only irrigate seedlings but also spray fertilizers, pesticides, or herbicides and provide frost protection. Saws, pruners, and mowers are used to trim seedling tops and roots. Transplanting and lifting machines allow seedlings to be moved from bed to bed or to processing areas, where they are packaged with balers or bundlers. Both seed and seedlings may be stored in trays, bins, crates, boxes, bags, drums, or tubs on pallets or racks in walk-in refrigerators, freezers, or sheds, or moved from place to place by forklifts, conveyors, carts, trucks, or tractors with attachments. Many machines are commercially available in a variety of types and sizes, but some must be custom built; some are highly specialized, but others, with adaptations, can serve common nursery functions.

3.1 Introduction

Nursery managers realize that maintaining trees as a renewable resource requires highly productive nurseries. Modern machinery and equipment can offer an efficient means of increasing nursery productivity without sacrificing seedling quality or employee safety. But staying abreast of developments in nursery equipment can be difficult.

This chapter informs nursery managers about current developments in nursery equipment and offers ideas about how custom-built and commercial nursery machines and equipment can serve common functions. For details on equipment types and specifications, the Missoula Equipment Development Center (MEDC), Missoula, Montana, has compiled a comprehensive catalog of nursery equipment, including descriptions of equipment typically used for common nursery functions and a list of supply sources; construction drawings of selected machinery are also available.[1]

3.2 Cone Storage and Handling

After harvesting, cones must be properly stored to dry (see chapter 4, this volume). If cones are first partially dried, kiln-drying time is reduced. Ventilating cones in storage also maintains seed fertility and keeps cones from molding.

Cone-storage methods vary with extractory types, volume of cones, and available facilities. Nurseries store cones in sheds, on floors or adjustable racks, on trays, or in ventilated containers like bins. Most nurseries store loose cones in burlap bags or on wooden trays, though aluminum, fiberglass, and plastic trays are also used. Wire-mesh or plastic bins or wooden crates store cones compactly with ventilation. Although storage bins and crates are stacked, air circulates freely around the cones.

Stored cones can be moved by hand or with various kinds of forklifts (Fig. 1) and conveyors, all of which are commercially available.

3.3 Seed Processing, Storage, and Handling

Nurseries use a variety of machines, including kilns, tumblers, scalpers, dewingers (Fig. 2), air-screen cleaners (Fig. 3), and air and gravity separators, to complete cone drying and seed processing (see chapter 4, this volume).

Kilns dry and open cones. Most nurseries use kilns with trays that hold cones dried by circulating hot air; however, some use rotating kilns that hold cones in a drum heated with circulating air. Although nursery kilns are often custom built, some, such as the International Seed Company kiln and the McPherson kiln, are commercially available.

Nurseries use tumblers, air or gravity separators, dewingers, and scalpers to extract seeds from cones, dewing seeds, and

[1]For more information about the catalog and drawings, contact the U.S.D.A. Forest Service, Equipment Development Center, Building #l, Fort Missoula, Missoula, MT 59801; phone 406-329-3157.

In Duryea. Mary L., and Thomas D. Landis (eds.). 1984. Forest Nursery Manual: Production of Bareroot Seedlings. Martinus Nijhoff/Dr W. Junk Publishers. The Hague/Boston/Lancaster, for Forest Research Laboratory, Oregon State University. Corvallis. 386 p.

remove cone bracts. Cone grinders, extractor tumblers, and fanning mill clippers are also commonly used, as are preheated bins and powered conveyors. Once extracted and dewinged, seeds may be sized before storage.

Extracted seeds are tested for moisture content and fertility. Some extractories dry seed in ovens to reduce moisture content before storage. Seed quality and fertility must be maintained because seeds are often stored for years. Therefore, most nurseries store seeds in walk-in freezers (Fig. 4), and many have refrigerator-freezers custom built.

Nurseries use various sizes and types of commercially available containers-cloth, paper, or burlap bags, cardboard or wooden boxes, and fiber or metal drums (Fig. 5)—to store seeds. Lining containers with plastic bags helps maintain proper seed moisture.

3.4 Soil Fumigation

Most U.S. nurseries apply methyl bromide gas, frequently using soil injectors with pressurized tanks, to control soil pathogens (see chapters 18 and 19, this volume). After fumigation, the soil must be coveted with tarps or plastic sheets (Fig. 6) to help it retain the gas. However, many nurseries contract fumigation service because it can be dangerous and requires special equipment.

3.5 Ground Preparation

Nurseries prepare seedbeds with common farming equipment, including plows, tillers, harrows, rock pickers, rakes, and packers, all available commercially in a wide variety of sizes and types, and with specialized equipment, including bed formers and levelers (see chapter 5, this volume). The equipment chosen depends on nursery size, soil type, needed tillage depth, availability, and preferences of nursery personnel.

Plows are common primary tillers (Fig. 7). Straight blade plows have curved blades with a flat bottom, disk plows have circular blades, and chisel plows have straight, vertical shanks.

Harrows are common secondary tillers, breaking clods and smoothing plowed soil. Harrows are also available in different sizes with blade styles that range from vertical spiked teeth to disks.

Rock pickers and rakes remove rocks from tilled soil. Rock rakes have adjustable inclining teeth that skim the soil surface to catch rocks and lift them into holders.

Figure 1. Common forklift, useful for moving batches of stored cones as well as numerous other nursery containers.

Before sowing seedbeds, some nurseries form and roll them smooth with mechanical bed formers (Fig. 8) and rollers, most of which are custom built. Such seedbed formers combine light disk-shaped plowshares and rakes with roller packers and leveling bars. Separate soil levelers and packers that use adjustable blades and rakes on rubber-tired frames are also available.

3.6 Sowing

Sowing is a critical nursery operation in which seed density, planting depth, and timing must be carefully controlled (see

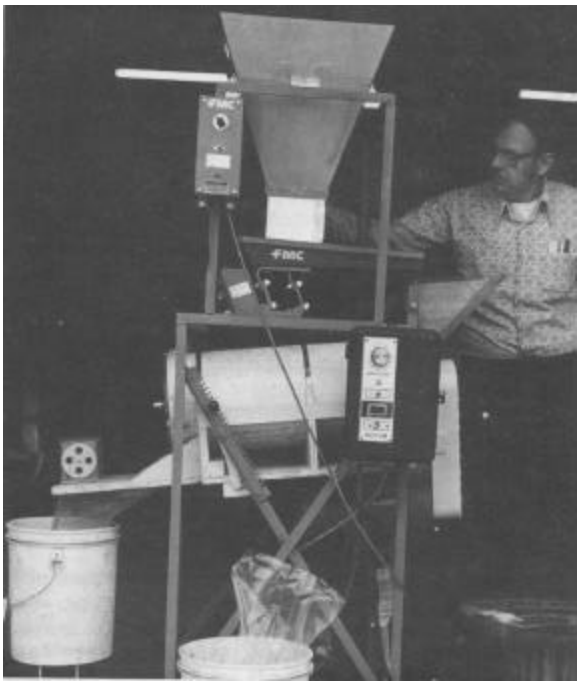

Figure 2. MEDC dewinger.

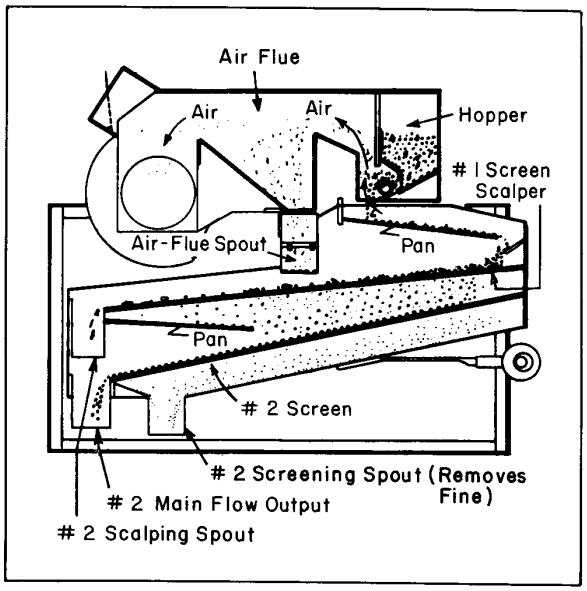

Figure 3. Schematic of air-screen cleaner [adapted from MEDC catalog; see text footnote 1].

chapters 5 and 15, this volume). Most nurseries use agricultural seed drills for sowing, though some prefer broadcast seeders. Seed drills commonly used include the Whitefish Nursery seeder, the Wind River drill seeder (Fig. 9a), and the Love-Øyjörd seeder (Fig. 9b). However, precise seed placement remains a problem for many nurseries.

3.7 Irrigation

Most nurseries supply and control the water in seedbeds with commonly available agricultural irrigation systems that use impulse sprinklers attached to movable sections of pipe (Fig. 10) (see chapter 11, this volume). The pressure of water pumping through the pipes rotates sprinkler heads; water trajectory and patterns of rotation at each sprinkler head are adjustable. Some nurseries use injector pumps to apply fertilizers, pesticides, and herbicides through irrigation systems.

Figure 4. Nurseries commonly use walk-in freezers to store seeds.

Figure 5. Fiber drums are widely used for seed storage.

Figure 6. Plastic layer helps trap methyl bromide gas in newly fumigated soil.

Figure 7. Tractor-drawn plow used to prepare ground for seedbeds.

Figure 8. Rototiller bed former shapes and smooths plowed ground into raised beds.

3.8 Fertilization and Soil Amendments

Applied at nurseries to replenish soil nutrients, fertilizers may be either organic or chemical. Though both types are commercially available, specific crop and soil requirements will determine which type a nursery needs (see chapters 7 and 8, this volume).

Figure 9. Drill seeders like the (a) Wind River and (b) Love-Øyjörd are commonly used to sow nursery seed.

Figure 10. Impulse sprinkler systems (sprinkler head shown in inset) have adjustable water trajectories and rotation patterns.

Nurseries apply organic fertilizers—manure or mulch, for example-with commercial manure spreaders (Fig. 11) or mulchers. Chemical fertilizers may be either solid (usually granular) or liquid; granular chemicals are spread with granular applicators, broadcast seeders (Fig. 12), or spreaders and liquid chemicals by soil injectors, sprayers, or irrigation injector systems.

Soil amendments-commonly, sand, sawdust, or mulch—modify soil texture, add organic matter to the soil, and increase the soil's capacity for moisture (see chapters 9 and 10, this volume). Nurseries apply amendments with a variety of machines, all of which must adjust to control application density and width. Sand spreaders (Fig. 13) come in various sizes and types. Manure spreaders can effectively spread sawdust if modified to increase their holding capacity and decrease their spreading density. Manure spreaders or broadcast seeders also can apply mulch. Some nurseries mix water with mulch and spray it on newly sown seedbeds with hydromulchers (Fig. 14).

3.9 Seedbed Cultivation

Weeds rob seedlings of moisture and nutrients. Most nurseries periodically control weeds mechanically with various row and path cultivators, but some still weed by hand.

Many types and sizes of row cultivators, like the Buddingh wheel hoe (Fig. 15a), are commercially available. Path cultivators (Fig. 15b) include large row cultivators, rototillers, and custom-built weeders.

3.10 Root and Top Pruning

Root pruning reduces top growth and encourages full root development in nursery stock, although the timing and frequency of pruning depend on species, desired size and type of

Figure 11. Tractor-drawn manure spreader applies organic fertilizer to soil.

Figure 12. Broadcast seeder may be used to spread granular (solid) chemical fertilizer.

stock, and growth stage (see chapter 15, this volume). Two different models of mechanical pruners—either to cut tap roots or to trim lateral roots—are used. Reciprocating and fixed-bottom pruners (Fig. 16a), fixed and disk side pruners, and root wrenchers are available in both models. Most root pruners are tractor mounted.

Top pruning removes new top growth from seedlings. Seedlings are top-pruned regularly before lifting to produce short sturdy seedlings, obtain favorable root-to-top ratios, and reduce transpiration surface; these effects make seedlings hardier against drought. Nurseries use adjustable tractor-mounted sickle-bar, flail, or rotary mowers (Fig. 16b) to prune seedling tops.

3.11 Pesticide Spraying

Nurseries apply pesticides for weed, insect, and disease control with a variety of sprayers (see chapters 18 and 19, this volume). Because chemical treatment may leave toxic residue in soil, however, nursery personnel must consider the possible consequences of different compounds when chosing pesticides.

Most nurseries apply chemical pesticides with tractor-mounted boom sprayers (Fig. 17) or spraying kits mounted on tractor-drawn tilling equipment. Hand sprayers or portable mist blowers facilitate applications for small treatments. Many sizes and models of pesticide sprayers are commercially available.

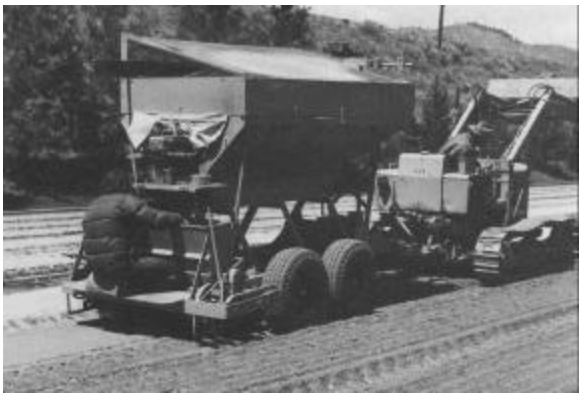

Figure 13. Sand spreader useful for adding mulches to soil.

Figure 14. Hydromulcher spraying a mulch-water mixture on prepared beds.

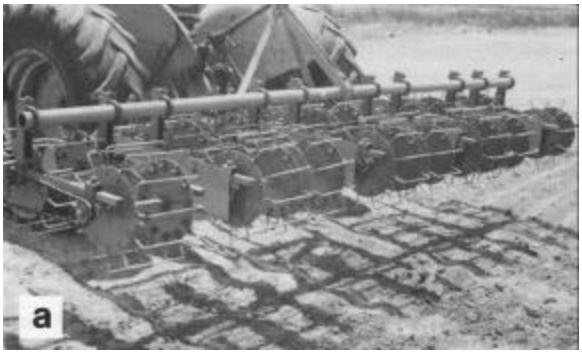

Figure 15. (a) Buddingh wheel hoe row cultivator and (b) Coeur d'Alene path cultivator keep nursery beds weed free.

Figure 16. (a) MEDC reciprocating root pruner and (b) tractor-drawn rotary mower used for top mowing both control seedling growth.

3.12 Frost Protection

Seedlings must be protected against frost, which can damage immature seedlings at nurseries located in valley bottoms or where surface winds are restricted, until they harden and become dormant (see chapters 12, 14, and 15, this volume). Encouraging early dormancy by restricting water can reduce frost damage. Sprinkler systems are often used to protect seedlings that have not yet hardened from frost (see Fig. 10) by keeping frost from settling on young trees.

3.13 Transplanting

Nursery stock is often grown in one seedbed for 1 to 3 years and then transplanted, either manually or mechanically, to another seedbed. Transplanting generally produces large, sturdy seedlings, but the extra handling increases production costs.

Most nurseries use tractor-drawn transplanters (Fig. 18); some use hand-transplanting boards for small jobs. Although commercially available transplanters are often unsuited to nursery work, many can be modified to perform satisfactorily.

3.14 Field Lifting, Handling, and Transportation

Field lifting describes the removal of trees from nursery seedbeds (see chapters 21 and 22, this volume). Most nurseries use tractors with rigid undercutting blades and agitators (Fig. 19) to disturb seedlings and loosen seedbed soil so that seedlings can then be lifted manually. Manual field-lifting equipment includes pickup belts, conveyors, and forklifts.

Figure 17. Boom sprayers efficiently apply pesticides to large acreages of nursery beds.

Figure 18. Tractor-drawn transplanter.

In recent years, mechanical seedling lifters have been introduced and widely used. These tractor-drawn machines have hydraulic undercutting blades, conveyors, and spaces for seedling containers. Mechanical lifters like the Grayco Harvester (Fig. 20) are sometimes modified to accommodate individual nursery needs.

After trees have been lifted, they must be placed in containers before being moved to the packing area. Nurseries commonly use boxes, bins, and tubs as field containers: custom-made fabric slings, which are usually handled manually, also may be used. Mechanical seedling harvesters have racks for carrying boxes and tubs. Equipment needs for field handling depend on field lifting and transportation methods, nursery size, istance to packing area, and volume of seedlings handled.

Most nurseries move seedlings from fields to packing sheds with tractor-drawn trailers. But trailers are difficult to turn in the field, slow to load and unload, and too light for rigorous use. Nurseries also use flatbed trucks, pickups, tractor attachments, and forklifts. A wide variety of equipment suitable for transporting seedlings is commercially available.

Similarly, as nursery size and labor costs tend to increase, it becomes important to move workers around the nursery as efficiently as possible. In recent years, a variety of homemade and commercial crew carriers has appeared. Scooters also are popular, sometimes replacing light trucks and buses: some nurseries even use bicycles.

3.15 Sorting, Grading, and Counting

After seedlings are lifted and moved to packing sheds, they must be sorted, graded, and counted. Even though these operations are manual, efficiency is increased with commercially available counters, scales, custom-built conveyors, and

Figure 19. Seedling lifters loosen soil so that seedlings can be manually extracted.

Figure 20. Grayco Harvester, which lifts seedlings mechanically rather than manually.

sorting tables. Most nurseries use moving belt systems for sorting, grading, and counting. MEDC has developed a new stacked, three-belt system that is more efficient in grading and counting in less space than other systems (Fig. 21).

Packing-shed workers often trim seedling roots uniformly when sorting, commonly using various custom-built electric pruning saws (Fig. 22), fabric saws, and paper cutters. A variety of equipment that trims roots is commercially available.

3.16 Packaging, Storage, and Handling

Once seedlings have been sorted, graded, counted, and pruned, they are packaged for shipping or storage. Many nurseries use mechanical bundling machines, which wrap seedlings in burlap and other bags, to package seedlings; a packing medium like sphagnum moss or "shingle toe" (cellulose fiber) is often included to keep seedlings moist (see chapter 22, this volume). Most nurseries, however, pack seedlings manually in boxes or bags. Commercially available mechanical devices that package seedlings include balers, bag closers, staplers, and strapping equipment.

Packaged seedlings may be stored for months before shipping. Seedlings can be lifted and processed and then refrigerated at the nursery until needed. Most nurseries store seedlings in large, walk-in refrigerators, usually custom built, but others store them in sheds or on permanent racks or pallets. Because controlling the temperature and relative humidity of stored seedlings is crucial, nurseries often monitor these conditions with sensors that trigger alarm systems if damaging temperature fluctuations occur.

A variety of commercially available equipment, including forklifts, roller conveyors, skids, belt conveyors, and carts, is most commonly used to help employees move seedlings from storage to trucks (Fig. 23). In general, good scheduling and good equipment are the key components of designed flow patterns for all seed and seedling handling.

3.17 Shipping for Outplanting

Customers must receive seedlings promptly and in good condition. Therefore, nurseries often deliver seedlings in refrigerated trucks (Fig. 24) either owned by the nurseries themselves or contracted specifically for seedling hauling. Planned deliveries and refrigerated equipment allow nurseries to control the temperature and humidity of seedlings to ensure vigor.

Figure 21. Three-tiered belt system, which improves processing efficiency.

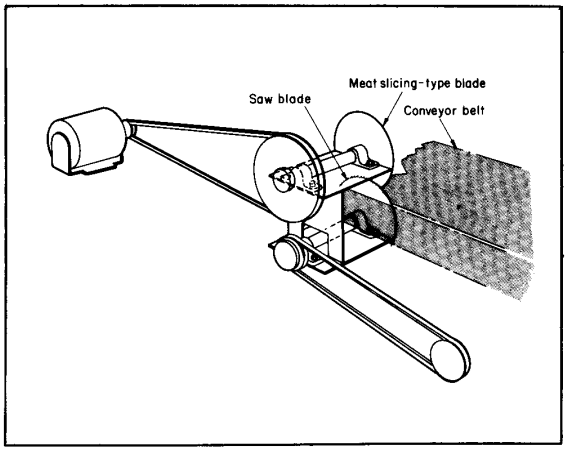

Figure 22. Schematic of root-pruning saw.

Figure 23. Trailer used to move containers of seedlings from one area of the nursery to another.

Figure 24. Seedlings are often transported to the field for outplanting in refrigerated trucks.

3.18 Conclusions

Proper equipment in good working condition is essential for high-quality nursery operations. Some machinery must be custom built and tailored to specific nursery needs, but other equipment is commercially available in a range of types and sizes and readily adaptable to nursery needs. Tractors, for example, are indispensable. Large tractors are used for lifting, plowing, and disking: small tractors for seeding, cultivating, and towing. All sizes accept attachments that increase versatility. Special features sometimes make particular tractors the best choice: for instance, hydrostatic-drive tractors are ideal for operations that require steady, slow speeds.

The right choice of equipment, in combination with manual operations, will facilitate all phases of seedling production, from cone storage and handling through outplanting.