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Shielded Herbicide Sprayer for Hardwood Nursery Seedling Beds



Shielded Herbicide Sprayer for Hardwood Nursery Seedling Beds



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Technology and Development Program
Missoula, MT

XE02E69—Shielded Herbicide Hardwood Sprayer

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Introduction



Hardwood seedling production is an important component of nursery management in the Southern United States. Hardwood nurseries are hampered because herbicides that kill weeds also can kill hardwood seedlings. Nursery managers now rely on hand weeding and glyphosate herbicides, such as Roundup, that are sprayed on the leaves of weeds. Hand weeding is expensive and herbicides can damage hardwood seedlings if the chemical is sprayed on any green stems or leaves.

The Missoula Technology and Development Center (MTDC) was asked to develop a herbicide applicator that would apply glyphosate herbicide on the leaves of weeds between rows and along the edges of four- or five-row hardwood seedling beds.

Ken McNabb, director of the Southern Forest Nursery Management Cooperative at Auburn University (the Auburn Nursery Co-op), asked MTDC to develop a machine that would apply herbicide only on the weeds while shielding tender hardwood seedlings from the herbicide. The ideal machine would sense chlorophyll, spraying herbicide only when a weed was present and would be compatible with standard nursery tractors.

Early on, we looked at sophisticated sprayers that would reduce the labor needed, reduce the chemicals used, and protect the persons applying the chemical better than current methods. However, a project review by Auburn Nursery Co-op members told us that what the group really wanted was a simple, inexpensive sprayer with no “bells and whistles.” The project proceeded with that need in mind.

MTDC reviewed several prototypes built by co-op nurseries as well as a couple of high-end commercially available sprayer attachments for mechanical weeders. We incorporated some of the design attributes of the different devices into the prototype that we developed. The MTDC prototype was field tested by the Virginia Department of Forestry’s nurseries at New Kent Forestry Center (Providence Forge, VA) and the Augusta Forestry Center (Crimora, VA).

Based on the centers’ feedback, the prototype’s steering mechanism and herbicide shield were revamped. After receiving positive feedback from a second field test at the Augusta Forestry Center, the design was finalized and shop-quality drawings were prepared. These drawings are available at no charge. Mechanical drawings of some of the other nurseries’ prototypes also are available from MTDC.

Highlights...

- Hardwood seedlings thrive when weeds are controlled. Hand weeding is expensive and herbicides that kill weeds also can kill the seedlings.
- Commercial sprayers are expensive.
- MTDC has developed a prototype for a shielded herbicide sprayer.
- Shop-quality mechanical drawings are available on the MTDC Nurseries Drawings Web site: <http://www.fs.fed.us/t-d/dwf/nurseries> (Username: t-d, Password: t-d).



Market Search

MTDC searched for ways to make the application of herbicides more efficient and safer. We looked at hooded sprayers, roller/wick applicators, brush and other mechanical weeders, ultralow-volume and controlled-droplet-application sprayers, chemical injection systems, and sensors that could identify chlorophyll. Some benefits we sought included reductions in:

- The size of field crews
- The field crew's exposure to chemicals
- Wasted chemicals
- The time needed to clean equipment

Commercially Available Sprayers

The Egedal sprayer is imported from Denmark by Timm Enterprises. The Augusta Forestry Center purchased one of these units as this project was underway. In January 2000, the price of this Type GS Bed Cultivator with eight-row spray system (figure 1) was about \$14,000.



Figure 1—The Egedal sprayer, which is commercially available, also has mechanical weeding attachments.

Roller/Wick Applicators

Roller/wick applicators (figure 2) were considered because they use less herbicide than sprayers and the spray does not drift. However, roller/wick applicators

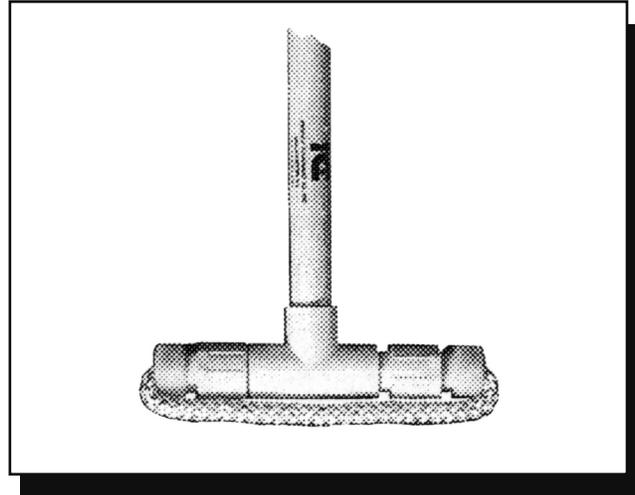


Figure 2—Spray does not drift when it is applied with roller/wick applicators, but the applicators may become gummed up with mud when weeds are close to the ground.—*Courtesy of Reddick Equipment Co., Inc.*

were dropped from further consideration because they might not eradicate low weeds, such as prostrate spurge, and because mud may accumulate on them.

Brush Weeders

Several nurseries use the FOBRO Brush Hoe (imported by Baertschi-FOBRO AG, figure 3). Nursery employees



Figure 3—The FOBRO Brush Hoe uses plastic bristles to gently remove weeds. The unit also has an optional sprayer.—*Courtesy of Baertschi-FOBRO AG*



told us that the brush hoe works fairly well in loose soils when weeds are not well established. An optional sprayer attachment is available. The larger of the two models had just 13 inches of clearance for plants, too little for some of the taller hardwood seedlings

can see the weeding devices and keep them away from the plants. These weeders are gentler on the plants than weeders that use sweeps and shanks. The tradeoff is that these weeders may not remove all the weeds.

Other Mechanical Weeders

Spyders, torsion weeders, and spring hoe weeders (figure 4) were investigated. Each requires a specialized weeding tractor that allows the weeding unit to be mounted between its front and rear wheels so the tractor operator

Ultralow-Volume and Controlled-Droplet-Application Sprayers

Ultralow-volume sprayers, such as the Mankar (figure 5), Herbi, and Herbiflex, typically use shrouded spinning discs that are designed for controlled-droplet application of herbicides in narrow bands. Some units like the

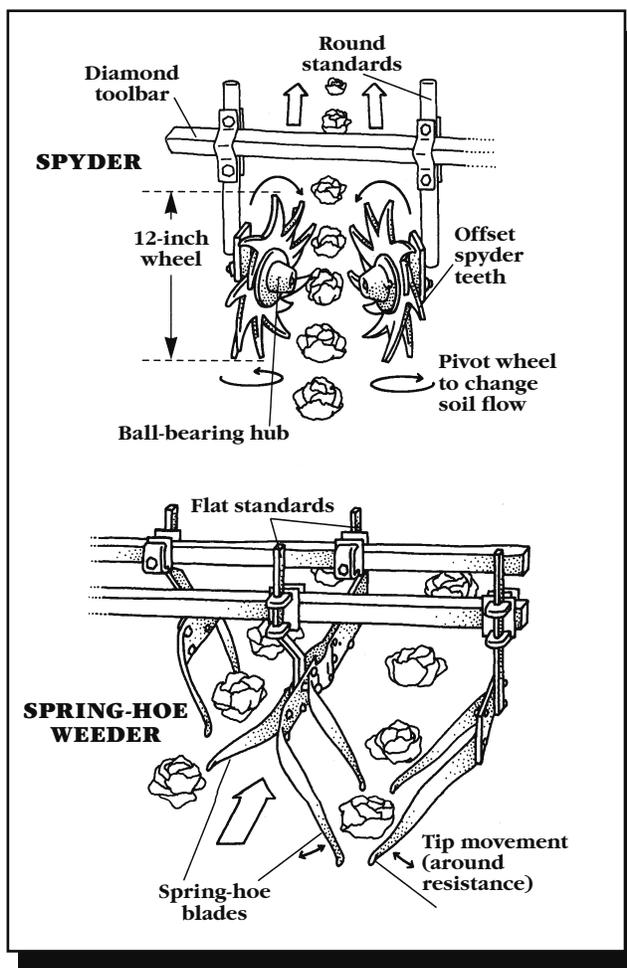


Figure 4—Spyders, torsion weeders, and spring-hoe weeders typically are more aggressive than weeders that use plastic bristles. Their potential to damage the crop is also greater.—Illustration by John Gist. Reprinted from Steel in the Field: A Farmer's Guide to Weed Management Tools with permission from the Sustainable Agriculture Network (<http://www.sare.org>).

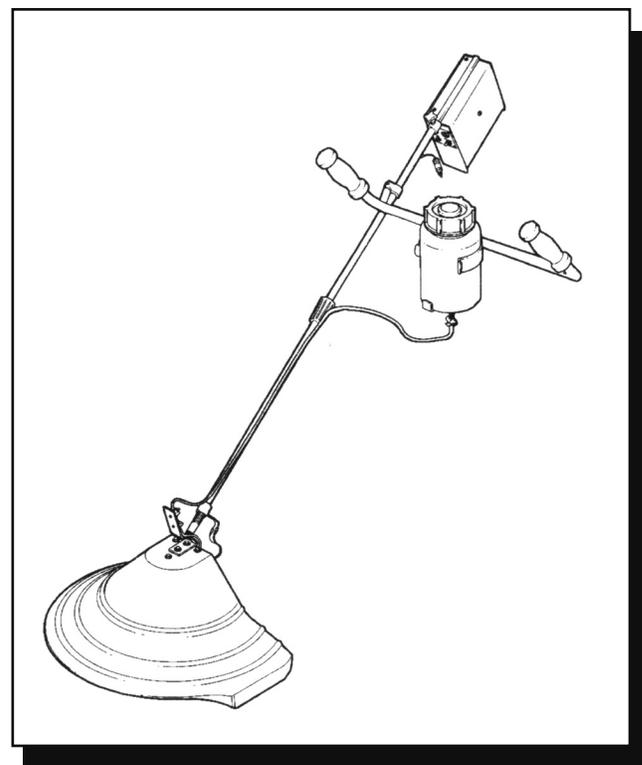


Figure 5—The Mankar ultralow-volume controlled-droplet-application sprayer.—Courtesy of Superb Horticulture/Mankar

Mankar can apply undiluted Roundup. The Vegedome by BUBCO (figure 6) claims to reduce the amount of water used by 80 to 90 percent and to reduce the amount of herbicide used by 50 percent. Commercially available units have been mounted under hoods and used on all-

Market Search



terrain-vehicle sprayers. These sprayers claim to apply herbicide more efficiently.



Figure 6—The controlled-droplet-application system in the Vegedome sprayer by BUBCO uses a spinning-disc rotary atomizer to produce optimum-size spray droplets that are evenly distributed. This system allows low-pressure, low-volume application, minimizing chemical waste and environmental contamination, and extending the time a tank of herbicide can be used between refills.—*Courtesy of BUBCO, Inc.*

Remote Observation

If the tractor operator could view and adjust the sprayer bar remotely, one person could handle the application. Remote camera systems (figure 7) are common. Inexpensive units are used in motor homes to help drivers back up safely. MTDC did not evaluate this type of system because the Auburn Nursery Co-op members thought the tractor operator would quickly become fatigued from steering the tractor while watching the sprayer's position in a monitor.



Figure 7—A remote camera allows the operator to view the sprayer operation. These systems are commonly found on recreational vehicles.

Tractor Toolbar Guidance Systems

Several commercial units are available, including the Navigator (by Automatic Equipment Manufacturing, figure 8), Slide Guide (by Sukup), Buffalo Scout II Shifter guidance system (by Fleischer Manufacturing), and Acura Trak (by Sunco). Some units have several ground sensor options that can provide input to the system.



Figure 8—The guidance system for a sprayer toolbar.—*Courtesy of Automatic Equipment Manufacturing Co.*

Remote Control of Spray Flow

These systems feature basic remote shutoff, pressure control, and speed control to keep the application rate constant. Raven Industries, Inc., and Midwest Technologies, Inc., make this type of equipment (figure 9).



Figure 9—Automated spray control equipment by Raven Industries, Inc.

Herbicide Injection Systems

These systems (figure 10) eliminate the need to mix batches of herbicide in large spray tanks. They eliminate the practice of dumping unused mix and the need to clean the mixing tank. Raven Industries, Inc., and Midwest Technologies, Inc., make this type of equipment.



Figure 10—The SCS Sidekick chemical injection system by Raven Industries, Inc.—*Courtesy of Raven Industries, Inc.*

Sensors To Identify Chlorophyll

NTech Industries makes a system (figures 11a, 11b, and 11c) that uses sensors to recognize plants by the presence of chlorophyll. The company was willing to come up with an appropriate hood configuration for the nurseries. These systems spray only when they sense the presence of chlorophyll.



Figure 11a—The WeedSeeker by NTech Industries can recognize the presence of chlorophyll. The complete system, folded for transport, is shown here.—*Courtesy of NTech Industries*



Figure 11b—One of the WeedSeeker's individual spray hoods.—*Courtesy of NTech Industries*



Figure 11c—The underside of the WeedSeeker's spray hoods.—*Courtesy of NTech Industries*

Costs



The Missoula Technology and Development Center asked nursery managers to estimate how much users would be willing to pay for certain design features. Respondents said they were willing to

pay \$3,000 for a shielded sprayer and \$500 more for an optional attachment that would sense chlorophyll. The cost of various sprayer unit refinements were determined and presented to nursery managers at a concepts review meeting.

The estimated cost users would pay for components of a shielded herbicide sprayer (2001 dollars).

Component	Cost
Remote camera and monitor	\$500 for black and white and \$1,300 for color
Navigator NV 2000 guidance system	\$2,500
Remote shutoff and pressure check controls	\$400
Remote automatic application rate control.	\$2,500
Injection system	\$3,500 to \$7,000
Controlled droplet application	About \$1,100 per Vegedome (including individual control unit)
Chlorophyll sensors.	\$1,000 per sensor (not including onboard computer and wiring)



Concepts Review Meeting

MTDC presented alternative design philosophies and identified commercially available products at the annual meeting of the Southern Forest Nursery Management Cooperative in 2001. The group was interested in a simple, low-cost design without bells and whistles. They were not especially concerned with conservation of herbicide or reducing the number of personnel required to perform the operation. They said they would only be applying glyphosate, which requires minimal personal protection for the applicator, based on the chemical's label. They wanted the applicator to focus on applying herbicide to the plants rather than having to drive the tractor. Herbicide escaping from the shields

was to be avoided at all cost. The Egedal sprayer met all of the operational requirements, but was too expensive.

Mechanical weeding without herbicides was not desired by the group. They thought a sprayed herbicide was necessary to eliminate the hardier nursery weeds. The FOBRO Brush Hoe was said to work well enough on small weeds in cultivated ground. Some of the more aggressive and efficient mechanical weeders required a special tractor. The roller/wick applicators were ruled out because they might become coated with mud when working on shorter weeds. The other refinements were thought to cost too much.

Nursery Prototypes



In the early stages of this project, a search was conducted for shielded hardwood nursery sprayer prototypes. The six that were identified were from: Southern Weed Science Lab (figure 12); Winona Nursery (figure 13); Pinson Nursery (figure 14); W.W. Ashe Nursery (figure 15); the Texas Forest Service (figure 16); and E.A.

Hauss Nursery (figure 17). Shop-quality mechanical drawings of the prototypes from the Southern Weed Science Lab, and the Winona and Pinson Nurseries are available on the MTDC Nurseries Drawings Web site: <http://www.fs.fed.us/t-d/dwf/nurseries> (Username: t-d, Password: t-d).

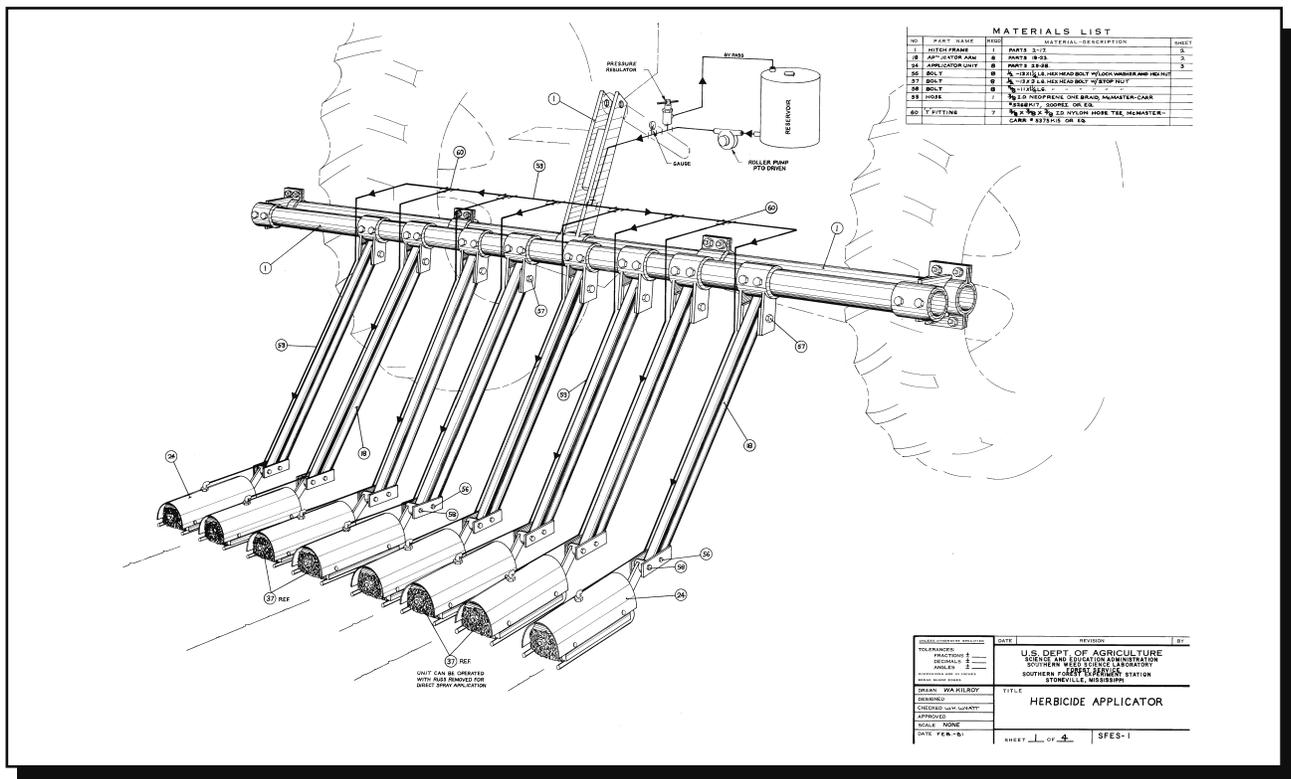
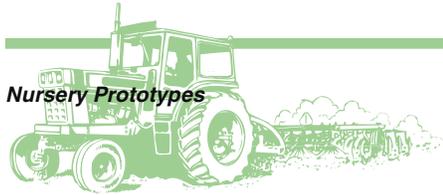


Figure 12—The drawing for a sprayer designed by the Southern Weed Science Lab in Stoneville, MS. The hoods are made of sectioned PVC pipe. The tractor driver operates the sprayer.



Figure 13—A prototype sprayer developed by the Winona Nursery (Winona, MS). The sprayer assembly is raised and lowered by a hydraulic cylinder actuated by the operator. The spray tank is mounted in front of the tractor.



Nursery Prototypes



Figure 14—A prototype sprayer developed by the Pinson Nursery (Pinson, TN). The entire sprayer tilts up and back when the tractor is not being used for spray operations.—*Courtesy of Tom Strickland/Mike Sbery!*



Figure 16—A Texas Forest Service prototype sprayer.—*Courtesy of Harry Vanderveer*



Figure 15—A prototype sprayer developed by the W.W. Ashe Nursery (Brooklyn, MS).—*Courtesy of Chuck Grambling*



Figure 17—A prototype sprayer developed by the E.A. Hauss Nursery (Atmore, AL). The tractor driver operates the sprayer. The nursery seems very pleased with this machine.—*Courtesy of Craig Frazier*

Features of MTDC's Design



MTDC's shielded herbicide sprayer was designed to be used on nursery beds. The tires are on 6-foot centers to treat beds about 4 feet wide. The sprayer was specifically designed for use with glyphosate. The use of any other chemical may not be compatible with the pump and valve seals and may present a health hazard to the operator on the back of the machine. The design of the machine permits tree seedlings shorter than 18 inches to pass under the toolbar without striking it.

Sprayer hoods can be added or taken off the toolbar to accommodate up to eight rows on a 4-foot-wide bed. The width of the in-row sprayer hoods can be adjusted. The sprayer hoods are mounted on a parallel linkage, which permits the hoods to follow the contours of the nursery bed independently. The angles of the two outside sprayer hoods are adjustable to ensure that spray does not escape, whether the sprayer is used on raised beds or flat beds.

The sprayer is intended to be mounted on a category II three-point hitch (it may work on other hitches with appropriate adapters), while the sprayer's pump needs to be attached to a 540-revolutions-per-minute power takeoff shaft on the tractor. The tractor operator controls the vertical position of the sprayer's toolbar. The sprayer operator uses a tiller bar to control the horizontal position of the sprayer's toolbar. The sprayer operator controls flow volume and pressure.

The sprayer's tank holds up to 85 gallons of chemical mixture that is pumped with a roller pump mounted on the end of the tractor's power takeoff shaft.

A bank of see-through control meters helps the operator keep track of clogged nozzles. The spray nozzles have inline check valves to keep chemical from leaking when the unit is moved from bed to bed. An operator's manual is available to help the tractor and sprayer operators adjust and maintain the sprayer.



Initial Field Test

The first MTDC sprayer prototype (figure 18) was tested at the New Kent and Augusta Forestry Centers in Virginia. The original machine featured a steering wheel guidance system and sprayer hoods with sled runners. Two sets of sprayer hoods were sent out for evaluation—one set with fixed width and one set that could be adjusted in the field to vary the spacing between rows.

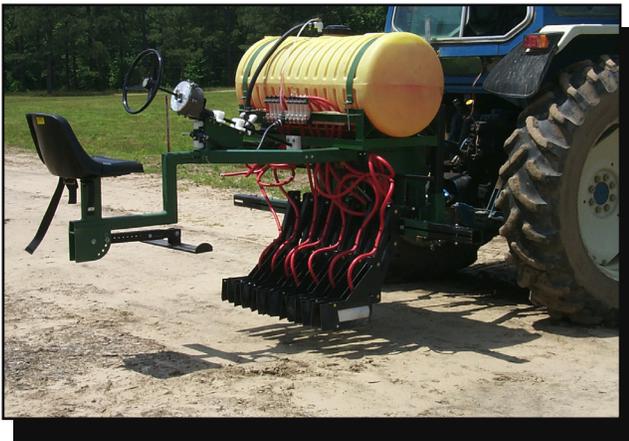


Figure 18—The first-generation MTDC sprayer prototype with fixed-width spray hoods and the original steering wheel.

Feedback from Donald Hixson (at the New Kent center) and Tommy Frazier (at the Augusta center) was that the sled runners were leaving shallow ruts in nursery beds with sandy soils. This did not happen in beds with clay-based soils. The steering also seemed awkward and counterintuitive. The adjustment mechanism for the hoods needed refinements. They shipped the machine back to MTDC and asked for a:

- New steering system
- Height gauge wheel for the individual sprayer hoods
- Positive sprayer width adjustment mechanism for the individual in-the-row sprayer units
- Shade umbrella for the sprayer operator

Second Field Test

MTDC redesigned the steering system of the shielded herbicide sprayer (figure 19) with a tiller bar (figure 20) that actuates a wheel assembly. A mechanism was added to allow the width of the sprayer hood to be adjusted (figure 21). A gauge wheel was added to the back side of the individual in-row sprayer hoods and a gauge wheel was added to the front side of the wheel-row sprayer hoods. A mist barrier was added to the bottom of the sprayer hoods to reduce the chance that herbicide mist would escape (figure 22).

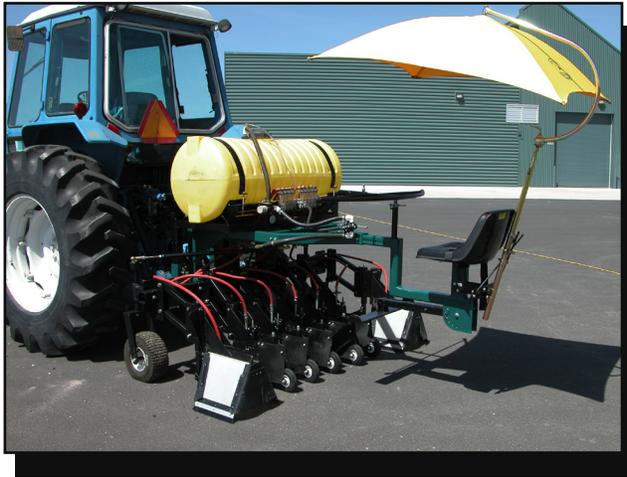


Figure 19—The second-generation MTDC Shielded Herbicide Sprayer has adjustable spray hoods, a tiller steering system, and a sun shade.



Figure 20—A closeup of the tiller bar used to steer the MTDC Shielded Herbicide Sprayer.



Figure 21—The mechanism used to adjust the width of a sprayer hood on the MTDC Shielded Herbicide Sprayer.

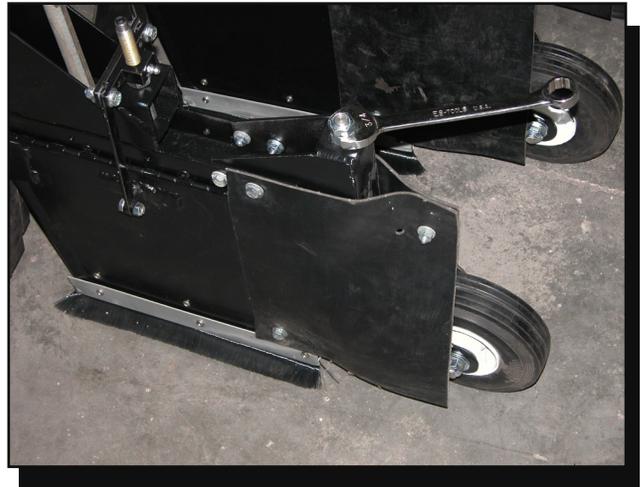


Figure 22—An adjustable spray hood with the height gauge wheel and bristle mist guard on the MTDC Shielded Herbicide Sprayer.

The second MTDC prototype was evaluated during field tests at the Augusta Forestry Center. According to Joshua McLaughlin, the unit was used for 6 days. It was used to apply Roundup Pro on five-row crops including white oak, northern red oak, bald cypress, sawtooth oak, and hazelnut. The seedbeds were about 4 feet wide. The chemical mixtures tested were 1 ounce per gallon or 2 ounces per gallon of Roundup Pro. A surfactant, *Induce*, was also added at a rate of 1 percent to quickly wet the plants and spread a uniform spray. Evaluators said they



could not tell the difference in weed mortality between the 1- and 2-ounce mixtures. The tractor was operated at $1\frac{1}{2}$ or $1\frac{3}{4}$ miles per hour. Even at the higher speed, enough herbicide was being applied.

A little herbicide escaped, damaging some trees. Evaluators were unsure whether the escape was human error or whether mist leaked from the hoods. The applicators did not notice herbicide leaking out. McLaughlin wondered whether the mixture might have been too concentrated. Some of the sprayer's tips and strainers were plugged, but evaluators attributed these problems to storage over the winter. When the sprayer was in full operation, there were no problems. The check valves did not leak. The flow-control gauges could not be evaluated because none of the spray units became clogged.

Evaluators started the spraying using the original nozzle tips (8001E and TR80-02) and worked some days with 8006 nozzle tips. Although the 8006 tips allowed more product to be applied, evaluators wonder whether these tips might have allowed a little herbicide to escape, damaging some trees.

Evaluators discovered that the steering wheels were not durable enough for their uses of the machine. Evaluators installed a sturdier wheel assembly (figure 23).

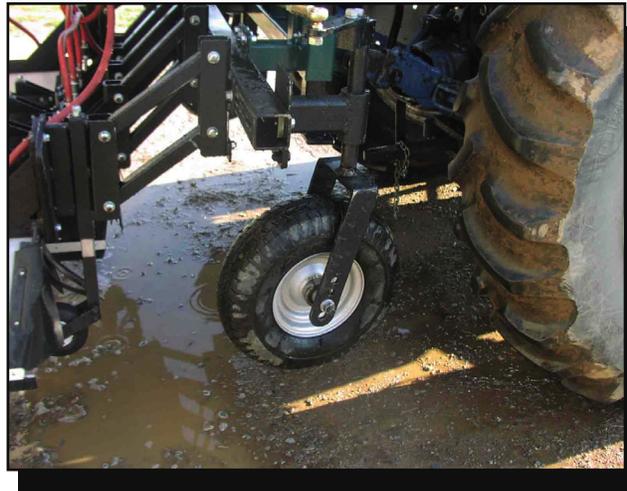
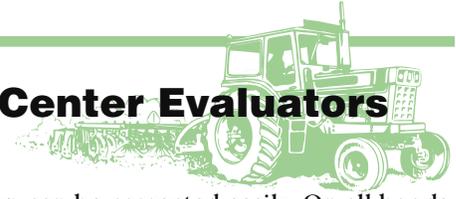


Figure 23—The improved version of the steering guide wheel on the MTDC Shielded Herbicide Sprayer.—*Courtesy of the Virginia Department of Forestry*

The new wheel assembly made it much easier to guide the sprayer unit. MTDC has incorporated this modification into the final design. The brushes on the bottom of each hood were seen as a plus, but the wheels on the back of each hood were installed too close to the hoods. Under wet conditions, mud built up between the wheels and the back of the sprayer hoods. Also, these gauging wheels were difficult to clean. The gauge wheels will be positioned farther back to correct the problem.

Comments from the Augusta Forestry Center Evaluators



A lton Dean felt there was no difference between the Egedal sprayer and the MTDC prototype. He was concerned by the weight of the MTDC sprayer (about 1,300 pounds for a five-row system), compared to just 1,072 pounds for the Egedal system. He thought weight could play an important role in mobility.

Tommy Frazier felt there was no difference between the effectiveness of the MTDC and Egedal machines. His only concern was the bulkiness of the hoods on the MTDC machine; it is easier to treat eight rows with the Egedal machine than with the MTDC prototype, because the sprayer operator can see between the hoods.

Both machines can apply herbicide at the same rate. Evaluators liked the larger spray tank on the MTDC prototype. The operator's control of the machines was the same.

The mud buildup can be corrected easily. On all hoods (including the outside sprayers) the distance between the wheel and the hood should be increased to prevent buildup.

Joshua McLaughlin said he would recommend the MTDC prototype sprayer to others. He said it was easy to use, tips were easy to change, and the machine was more durable than the Egedal machine. Frazier said he would recommend the MTDC prototype for the same reasons.

For additional information on the field trials, contact Joshua McLaughlin, Larry Estes, or Tommy Frazier at the Virginia Department of Forestry, Augusta Forestry Center (phone: 540-363-5732) or Dwight Stallard at the Garland Gray Forestry Center (phone: 804-834-2855). It may be possible to make arrangements with these individuals to watch the machine in use (varies with time of year) or to borrow it for your own evaluations.



Based on the results of the field tests, shop-quality drawings have been completed for the MTDC Shielded Herbicide Sprayer. You can obtain a copy of these drawings online by going to the MTDC Nurseries Drawings Web site: <http://www.fs.fed.us/t-d/duf/nurseries> (Username: t-d, Password: t-d).

If you encounter technical difficulties using the Web site or would prefer a paper copy of the drawings, you can call Deb Mucci at 406-329-3999.

Sprayer design	Drawing name	Drawing number
MTDC.....	Hardwood Shielded Herbicide Sprayer	MTDC-1031
Southern Weed Science Lab ...	Herbicide Applicator	SFES-1
Winona Nursery	Mississippi Forest Commission, Winona Nursery	
	Hardwood Shielded Herbicide Sprayer	WIN-1
Pinson Nursery	Tennessee Department of Agriculture	
	Hardwood Shielded Herbicide Sprayer	TDA-1

Appendix—Vendor Contact Information



Acura Trak guidance control

Sunco
P.O. Box 2036
North Platte, NE 69103
Phone: 308-532-2146
Web site: <http://www.suncomarketing.com>

Buffalo Scout II Shifter guidance system

Hanke Buffalo
2281 16th Ave.
P.O. Box 848
Columbus, NE 68602
Phone: 402-564-3244

Chemical flow and injection systems

Midwest Technologies, Inc.
2864 Old Rochester Rd.
Springfield, IL 62703
Phone: 217-753-8424
Web site: <http://www.mid-tech.com>

Egedal Sprayer

Timm Enterprises, Ltd.
5204 Trafalgar Rd.
Milton, ON, Canada L0P 1E0
Phone: 905-878-4244
Web site: <http://www.timmerprises.com>

FOBRO Brush Hoe

Baertschi-FOBRO AG
1715 Airpark Dr.
Grand Haven, MI 49417
Phone: 616-847-0300
Web site (Switzerland): <http://www.fobro.com>

Herbi, Herbiflex, Vegedome

BUBCO, Inc.
816 "B" Black Diamond Way
Lodi, CA 95240
Phone: 209-367-3885
Web site: <http://www.bubco.com>

Mankar ultralow-volume and controlled-droplet-application sprayer

Agtec Crop Sprayers
5720 Smetana Dr.
Minnetonka, MN 55343
Phone: 952-935-0468
Web site: <http://www.agtecsprayers.com>

Navigator row crop guidance system

Automatic Equipment Manufacturing Co.
One Mill Rd., Industrial Park
Pender, NE 68047
Phone: 800-228-9289
Web site: <http://www.automaticag.com>

SCS Sidekick

Raven Industries, Inc.
P.O. Box 5107
Sioux Falls, SD 57117-5107
Phone: 800-243-5435
Web site: <http://www.ravenprecision.com>

Slide Guide guidance system

Sukup Manufacturing Co.
P.O. Box 677, 1555 255th St.
Sheffield, IA 50475-0677
Phone: 641-892-4222
Web site: <http://www.sukup.com>

WeedSeeker

NTech Industries, Inc.
740 South State St.
Ukiah, CA 95482
Phone: 707-467-3747
Web site: <http://www.weedseeker.com>



Notes

About the Author

Keith Windell is a project leader for reforestation, fire, and residues projects. He has a bachelor's degree in mechanical engineering from Montana State University. He has worked for the California Department of Forestry, USDI Bureau of Land Management, and the USDA Forest Service.

Library Card

Windell, Keith. 2006. Shielded herbicide sprayer for hardwood nursery seedling beds. Tech. Rep. 0624-2827-MTDC. Missoula, MT: U.S. Department of Agriculture Forest Service, Missoula Technology and Development Center. 18 p.

Describes a prototype for a shielded herbicide sprayer developed by the Missoula Technology and Development Center. Market research found no commercial sprayer

that was inexpensive and met all operational requirements. Shop-quality drawings are available on the MTDC Nurseries Drawings Web site: <http://www.fs.fed.us/t-d/dwf/nurseries> (Username: t-d, Password: t-d).

Keywords: chemicals, chlorophyll, glyphosate, herbicides, injection systems, mechanical drawings, remote cameras, safety at work, sensors, spray nozzles, weeds

Single copies of this document may be ordered from:

USDA Forest Service, MTDC
5785 Hwy. 10 West
Missoula, MT 59808-9361
Phone: 406-329-3978
Fax: 406-329-3719
E-mail: wo_mtdc_pubs@fs.fed.us

Electronic copies of MTDC's documents are available on the Internet at: <http://www.fs.fed.us/eng/t-d.php>.

For additional information about the shielded herbicide sprayer for hardwoods, contact Keith Windell at MTDC.

Phone: 406-329-3956
Fax: 406-329-3719
E-mail: kwindell@fs.fed.us

Forest Service and Bureau of Land Management employees can search a more complete collection of MTDC's documents, videos, and CDs on their internal computer networks at: <http://fsweb.mtdc.wo.fs.fed.us/search/>.