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# **Evaluation of The Two-Row Timberland Hodag Tree-Planting Machine**



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# **Evaluation of The Two-Row Timberland Hodag Tree-Planting Machine**

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## CONTENTS

|                                           | <u>Page No.</u> |
|-------------------------------------------|-----------------|
| INTRODUCTION .....                        | 1               |
| EQUIPMENT DESCRIPTION AND OPERATION ..... | 1               |
| SITE DESCRIPTION .....                    | 2               |
| DATA COLLECTION .....                     | 4               |
| PERFORMANCE OF HODAG PLANTER .....        | 4               |
| CONCLUSIONS .....                         | 6               |
| RECOMMENDATIONS .....                     | 7               |
| LITERATURE CITED .....                    | 7               |

## ILLUSTRATIONS

| <u>Figure No.</u> |                                                                                                                                                             | <u>Page No.</u> |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1                 | Timberland Equipment Limited HODAG two-row intermittent-furrow tree-planting machine .....                                                                  | 1               |
| 2                 | HODAG intermittent-furrow tree-planting machine .....                                                                                                       | 1               |
| 3                 | Single-row HODAG intermittent-furrow tree-planting machine .....                                                                                            | 1               |
| 4                 | Seedling in nylon planting finger and ejection mechanism .....                                                                                              | 2               |
| 5                 | Tractor pto-driven hydraulic pump which furnishes power to operate the planter .....                                                                        | 2               |
| 6                 | A John Deere 450C crawler tractor was used to pull the Timberland HODAG tree planter. The tractor was equipped with a FESCO Model VB-7 clearing blade. .... | 2               |

## TABLES

| <u>Table No.</u> |                                               | <u>Page No.</u> |
|------------------|-----------------------------------------------|-----------------|
| 1                | HODAG tree-planter specifications .....       | 1               |
| 2                | Summary of tree-planter operation .....       | 3               |
| 3                | Results of tree-planting quality survey ..... | 5               |
| 4                | Field evaluation failure summary .....        | 6               |

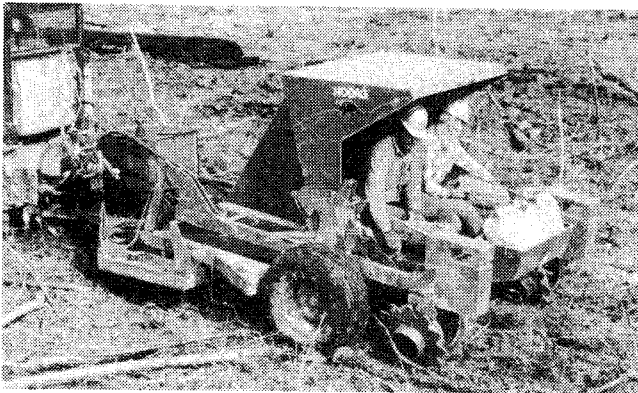
## INTRODUCTION

An evaluation of the Timberland HODAG, two-row, intermittent-furrow tree-planting machine was conducted during January and February 1983 on the Strong River Ranger District, Bienville National Forest, Mississippi. This *Project Record* provides USDA-Forest Service field units with operational characteristics and capabilities of the HODAG.

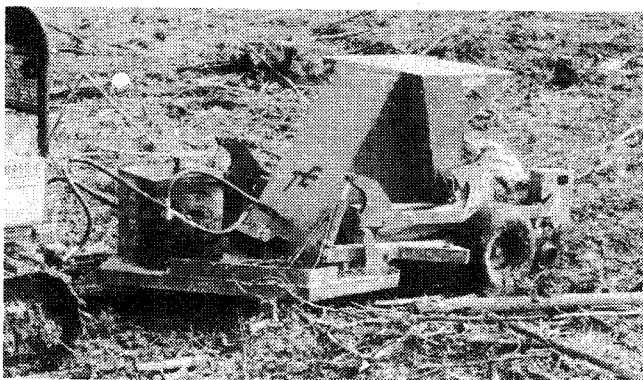
Past experience has shown machine tree planters reduce tree-planting costs and result in more successful and more uniform planting. Intermittent-furrow tree-planting machines should cause less ground disturbance which should reduce erosion and result in a planted site with a more natural, hand-planted look; require less intense site preparation; and require less energy to reforest because there is no continuous furrow.

## EQUIPMENT DESCRIPTION AND OPERATION

The HODAG is a towed, two-row, intermittent-furrow tree-planting machine (see fig. 1 and 2 and table 1),



**Figure 1. Timberland Equipment Limited HODAG two-row intermittent-furrow tree-planting machine.**



**Figure 2. HODAG intermittent-furrow tree-planting machine.**

**Table 1. HODAG tree-planter specifications**

### Dimensions

Overall length . . . . . 150 in (381 cm)  
Height . . . . . 62 in (157.5 cm)  
Width (5-ft row center setting) . . . . . 94 in (238.8 cm)

Wheels . . . . . 15 x 8 rims  
Tires (farm service) . . . . . 11.6-15

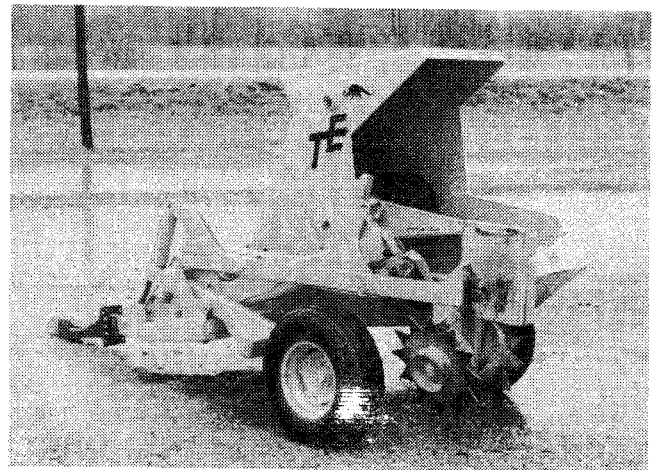
Weight . . . . . 6,200 lb (2808 kg)

Hydraulics recommended . . . . . 20-25 gpm @ 2,000 psi  
(75-95 l/m @ 13,800 kPa)

Tree spacing within rows . . . . . 5 ft (1.52 m)  
5½ ft (1.67 m)  
6 ft (1.82 m)

manufactured by Timberland Equipment, Ltd.,  
Woodstock, Ontario, Canada.

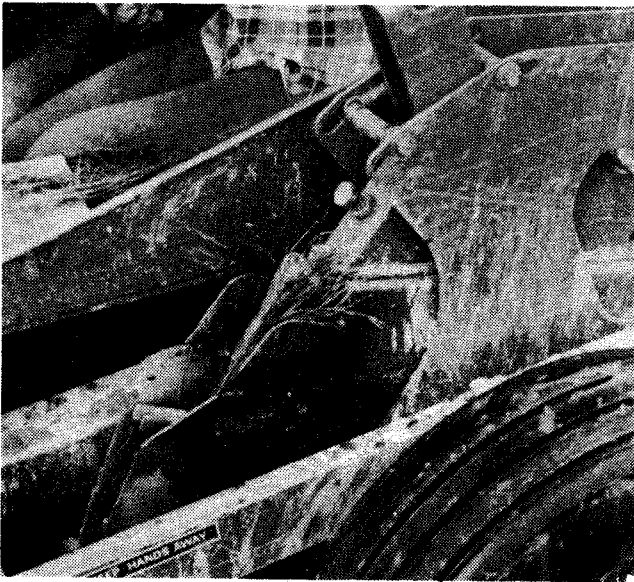
The row spacing of the planting arms can be adjusted to three spacing positions, 5 ft (1.52 m), 5½ ft (1.67 m), and 6 ft (1.82 m). A single-row model of the HODAG is also available (fig. 3).



**Figure 3. Single-row HODAG intermittent-furrow tree-planting machine.**

The planting arms (with the planting dibbles) are hydraulically actuated, and the seedling ejection mechanism is mechanically actuated by a plate contacting the ground when the planting dibbles reach the desired depth. Two operators are required, one for each planting arm or side. They sit side-by-side, facing backwards. Each planting arm

is controlled separately by a foot pedal. The operator manually loads a seedling into nylon planting fingers (fig. 4) and depresses the foot pedal causing the planting arm and dibble to be powered down. When the dibble reaches planting depth, the plate on the bottom of the planting arm is pushed up, operating the ejection mechanism. After the operator observes that the seedling has been ejected, the foot pedal is released resulting in the planting arm and dibble returning to the load position.

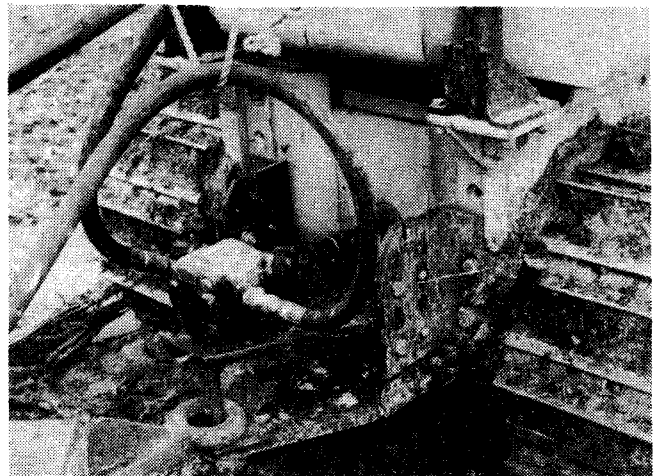


**Figure 4. Seedling in nylon planting finger and ejection mechanism.**

The packing wheels are in contact with the ground when the planter is in planting position. After the seedling is ejected, the packing wheels roll on both sides of the seedling, packing it. When the tree planter is raised to a roading position, the packing wheels are also raised.

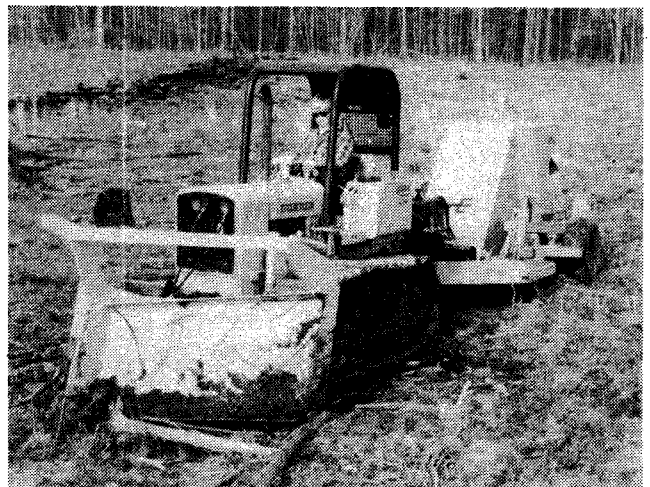
The HODAG is designed so that the prime mover furnishes hydraulic power to operate the planting arms by driving a separate hydraulic pump, generally by the prime mover's pto. The planter hydraulic system has an accumulator and unloader valve. When the accumulator is fully charged, the unloader valve allows hydraulic oil to freely circulate, eliminating heat buildup and energy waste.

For this evaluation, a 22-gpm (83 L/min) pump was mounted on and driven by the prime mover's pto (fig. 5). A 50-gal (190-L) hydraulic reservoir was mounted on the front section of the planter (fig. 2). With this arrangement, the planter's hydraulic system is separate and completely independent of the prime mover's hydraulic system.



**Figure 5. Tractor pto-driven hydraulic pump which furnishes power to operate the planter.**

A John Deere 450C crawler tractor, equipped with a FESCO (Forestry Equipment Specialist Company of Starkville, Miss.) Model VB-7 debris-clearing reforestation blade (fig. 6), was used as the prime mover. The tractor has a net flywheel horsepower of 65 hp (48.5 kW), and is powered by a John Deere, 4-cylinder, diesel engine driving a high-low range, four-speed transmission. The John Deere 450C has an operating weight of 14,500 lb (6576 kg).



**Figure 6. A John Deere 450C crawler tractor was used to pull the Timberland HODAG tree planter. The tractor was equipped with a FESCO Model VB-7 clearing blade.**

## SITE DESCRIPTION

The HODAG was operated on two sites totaling 72 acres (29 ha) on which 41,000 seedlings were planted (table 2). The first site of 52 acres (21 ha) was commercially harvested for pine pulpwood and pine sawtimber in the spring and

Table 2. Summary of tree-planter operations

| Date                          | Trees<br>planted<br>(attempts) | Planting<br>time    | Planting<br>rate<br>seedlings<br>(attempts/hr) | Number of<br>breakdowns or<br>adjustments<br>over 10 min | Repair or<br>adjustment<br>time over<br>10 min | Number of<br>times<br>stuck over<br>10 min | Time<br>stuck      |
|-------------------------------|--------------------------------|---------------------|------------------------------------------------|----------------------------------------------------------|------------------------------------------------|--------------------------------------------|--------------------|
| <b>First site (52 acres)</b>  |                                |                     |                                                |                                                          |                                                |                                            |                    |
| 1/28/83<br>Friday             | 3,500                          | 3 hr 25 min         | 1,024                                          | 1                                                        | 35 min                                         | 1                                          | 14 min             |
| 1/31/83<br>Monday             | 3,500                          | 2 hr 47 min         | 1,257                                          | 1                                                        | 15 min                                         | 1                                          | 14 min             |
| 2/2/83<br>Wednesday           | 2,558                          | 2 hr 45 min         | 930                                            |                                                          |                                                |                                            |                    |
| 2/3/83<br>Thursday            | 5,899                          | 5 hr 40 min         | 1,041                                          | 1                                                        | 30 min                                         |                                            |                    |
| 2/4/83<br>Friday              | 3,891                          | 3 hr 45 min         | 1,037                                          | 6                                                        | 4 hr 35 min                                    |                                            |                    |
| 2/7/83<br>Monday              | 4,108                          | 4 hr 35 min         | 896                                            |                                                          |                                                |                                            |                    |
| 2/8/83<br>Tuesday             | 4,042                          | 4 hr 30 min         | 898                                            | 1                                                        | 15 min                                         | 1                                          | 30 min             |
| <b>Second site (20 acres)</b> |                                |                     |                                                |                                                          |                                                |                                            |                    |
| 2/11/83<br>Friday             | 3,920                          | 3 hr 30 min         | 1,120                                          |                                                          |                                                | 2                                          | 1 hr 20 min        |
| 2/14/83<br>Monday             | 6,361                          | 5 hr                | 1,272                                          | 2                                                        | 1 hr 30 min                                    | 1                                          | 30 min             |
| 2/15/83<br>Tuesday            | 3,319                          | 3 hr 15 min         | 1,021                                          |                                                          |                                                |                                            |                    |
| <b>TOTAL</b>                  | <b>41,098</b>                  | <b>39 hr 12 min</b> | <b>1,048</b>                                   | <b>12</b>                                                | <b>7 hr 40 min</b>                             | <b>5</b>                                   | <b>2 hr 34 min</b> |
| <b>TOTAL ACRES: 72</b>        |                                |                     |                                                |                                                          |                                                |                                            |                    |

summer of 1981 and site prepared for reforestation by shearing and windrowing in June 1982. This was nearly a level site with the maximum slope being 3 percent. The surface soil was sandy loam 3- to 16-in (8- to 40-cm) thick with an underlying clay loam 60- to 80-in (150- to 200-cm) thick. During the time of planting, soil moisture was at field capacity (100 percent saturated) resulting in muddy conditions.

The second site of 20 acres (8 ha) was also commercially harvested for pine pulpwood and pine sawtimber in the fall of 1981. It was sheared and windrowed in July 1982. This site also was nearly level with a maximum slope of 5 percent. The soil surface was sandy loam and the subsurface was clay loam. Soil moisture was also near or at field capacity, resulting in muddy conditions. Both sites were opened as public fuelwood areas in the fall of 1981. On both sites, stumps

16 in or less in diameter were sheared at ground level and all material 6 ft long and 2-in in diameter was windrowed.

## DATA COLLECTION

Planting time, planting quality, repair time, other downtime, and number of seedlings planted were collected for each of the 10 days the HODAG was operated. A visual inspection of a very large number of seedlings was made on two different planting days by the District silviculturist.

## PERFORMANCE OF HODAG PLANTER

Each performance criterion is stated, followed by a discussion of the degree the HODAG meets the criterion.

1. Ability to plant both bare-root and most containerized stock, one or two rows at a time. When bare-root stock is planted, protection from roots drying out must be provided.

The HODAG planted two rows at a time. Only 1-0 bare-root loblolly pine (*Pinus taeda*) was planted. Spacing was 5 ft (1.52 m) (between-row spacing), by 10 ft (3.04 m) (between trees within rows); and 9 ft (2.74 m) between tractor rows. These seedlings ranged in size between 6 and 12 in (15 and 30 cm); roots were 6 to 10 in (15 to 26 cm).

Timberland Equipment Limited can supply a dibble for planting containerized tree stock. This dibble was not used in this evaluation because no containerized planting was done.

The HODAG can be equipped with an optional seedling storage bin attached to the rear of the planter. During this evaluation, seedlings still in the nursery bag were carried in this storage bin. Nursery seedling bags carried in the storage bin were exposed to direct sunlight; however, at the rate of planting of the HODAG, this was usually for a short time only (30 to 60 min). In the operation, small bundles of seedlings were removed from the nursery seedling bag and placed into a small, wet canvas bag from which the operator withdrew seedlings for planting. With the HODAG, as with most other planting machines, the method used to prevent the seedling roots from drying out is the responsibility of the operator(s).

2. Capable of planting from 700 to 1,800 seedlings/hr in hilly, rocky terrain that is strewn with logging debris where intensive site preparation has not been done. In addition, the planter must be able to operate in muddy conditions. Also, tree spacing as close as 5 ft (1.52 m) is desired.

The average production rate of the HODAG over the 10 days of use was 1,048 seedlings/hr of planting time. Instantaneous production rates were measured at 1,575 and 1,909 seedlings/hr. Also, when attempting to plant as close as 5 ft (1.52 m), the instantaneous rate was measured at 2,329 seedlings/hr with most of the seedlings planted approximately 5-ft (1.52-m) apart. Travel speed was measured at an average of  $1.45 \pm .01$  mph ( $2.33 \pm .02$  km/hr) when measuring instantaneous production rates.

The area planted had been sheared and raked and, as a result, was fairly level and smooth with little logging debris. The sites were very wet and, as a result, the tractor and planter became stuck five different times taking longer than 10 min to free. Ground clearance of the planter in planting position was a problem because there was not enough clearance to clear unsheared stumps. For the planter weight, the tires are small as compared to other planters in use. Perhaps larger tires and/or lower tire pressure would reduce the tendency to become stuck. Sometimes the dibble did not penetrate the heavy hardpan of area 2. The HODAG dibble is very blunt and perhaps a sharper dibble would have penetrated better. A sharper point would help penetration regardless of soil type or condition.

3. Consistently plants the seedling 10-in (25-cm) deep with 75 percent of the seedling's root collar between ground level and 1 in (2.5 cm) between the ground; when planting bare-root stock, the seedling should be inserted vertically (not more than 30-degree lean, 25 percent of the time) with no "J" roots (25 percent or less). There should not be more than 20 percent skips (no seedling planted where there should have been) or no-plant. Overall successful planting should be 75 percent or greater.

The HODAG dibble penetrates the ground 10 in. In a survey of 433 attempts to plant, 258 seedlings were considered satisfactorily planted (60 percent). Of the 433 attempts, 11 percent root-collar depth was incorrect and 9 percent had a lean greater than 30 degrees. In a sample of 47 seedlings that were dug up, only three were found to have "L" or "J" roots (6 percent).

4. Should close the planting hole with adequate packing (no air pockets), but not overcompact the soil and thereby restrict water infiltration inhibiting root growth.

In the survey of the 433 attempts to plant, inadequate packing was found to be a cause or contributing cause

51 percent of the time a seedling was not successfully planted. Inadequate packing had the highest percent of any cause or contributing cause to unsatisfactorily planted seedlings (table 3).

**Table 3. Results from tree-planting quality survey**

|                            |     |
|----------------------------|-----|
| Attempts .....             | 433 |
| Successful .....           | 258 |
| Percent successful .....   | 60  |
| Unsuccessful .....         | 175 |
| Percent unsuccessful ..... | 40  |

**Cause(s) or contributing cause(s) of unsuccessful attempts:**

| <u>Cause</u>           | <u>Percent of<br/>total attempts<br/>with this<br/>cause</u> | <u>Percent of<br/>unsuccessful<br/>attempts with<br/>this cause</u> |
|------------------------|--------------------------------------------------------------|---------------------------------------------------------------------|
| Inadequate packing     | 21                                                           | 51                                                                  |
| Lean                   | 9                                                            | 21                                                                  |
| Depth                  | 11                                                           | 27                                                                  |
| Skip (no tree planted) | 13                                                           | 31                                                                  |
| Mud                    | 11                                                           | 27                                                                  |
| Light slash            | 7                                                            | 18                                                                  |
| Medium slash           | 5                                                            | 13                                                                  |
| Heavy slash            | 2                                                            | 5                                                                   |

5. Should attach to and be operated by a "small" prime mover—preferably a crawler tractor in the 10,000- to 15,000-lb (4536- to 6804-kg) range and require only two operators (one on the tractor and one on the planter)—or, if cost effective, have an automatic feed system so the planter operator is not needed. Also, if cost effective, the unit could be an integral, self-propelled, special-design machine. If the tree-planting machine plants two rows at a time (which is desirable for increased production), the tree planter may require (and probably will require) two tree-planter operators.

The HODAG was pulled satisfactorily with a John Deere 450C crawler tractor with an operating weight of 14,500 lb (6576 kg). In the opinion of the operator, the John Deere 450C is the smallest tractor that could satisfactorily pull the HODAG. Drawbar pull was measured with the following results.

- With both dibbles out of the ground, a pull of 1,000 to 3,500 lb (4.5 to 15.5 kN) was

observed, with a pull in the area of 2,000 lb (8.9 kN) being the most common. The 3,500-lb (15.5-kN) pull was in a very muddy area.

- With one dibble in the ground, a pull of 3,000 to 4,000 lb (13.3 to 17.8 kN) was observed with an average pull of 3,500 lb (15.5 kN).
- With two dibbles in the ground, a pull of 3,500 to 4,500 lb (15.5 to 20 kN) was the most frequent. Pulls of 8,000 to 9,000 lb (36 to 40 kN) were observed, with a pull of 5,000 lb (22 kN) being common.

To operate the HODAG, a tractor operator and two tree-planter operators are required. However, with two operators on the planter, two rows are planted. This results in almost double the production of a single-row machine with only the added cost of a tree-planter operator.

6. The tree planter must be affordable. That is, the planter must be able to be operated on a sound, economical basis when operated by force account, and at a profit when operated by a contractor. The purchase price that will allow the planter to be affordable is very much dependent on production rate.

From the methodology developed in an economic analysis (1) the maximum purchase price you can afford to pay for a tree-planting machine can be found by the following equation:

$$X = -118,700 + 1,560 (\text{HPC}) (\text{MPR})$$

When:

X = Maximum economical purchase price of a tree planter

HPC = Hand-planting cost per seedling in dollars

MPR = Machine production rate in seedlings per hour.

This equation has been adjusted for the labor (one tractor operator and three tree-planter operators) and tractor rates found on the Strong River District.

Using FY 83 hand-planting costs in Mississippi and

average production rates of the HODAG, the maximum affordable planter cost is:

$$X = -\$118,700 + 1560 \text{ (HPC) (MPR)}$$

$$X = -\$118,700 + 1560 \text{ ($.10) (1048)}$$

$$= \$44,800$$

The production rate of 1,048 seedlings/hr is based on a 10-ft (3.04-m) spacing between seedlings within rows. If a closer spacing had been used, the production rate would have been higher and the affordable purchase price would have been much higher.

The purchase price of the HODAG is \$25,000. Therefore, this machine is affordable providing it meets reliability, availability, maintainability, and tree-planting quality criteria and is able to be operated at the assumed field efficiency of 80 percent. Data indicates actual field efficiency of about 60 percent.

7. Have high system reliability, with a minimum mean-cycles-between-failures (MCBF) of 12,000, and a minimum inherent availability of 85 percent, which will require a high degree of maintainability.

Reliability (2)—MCBF was 3,424, which is far below the desired 12,000.

Inherent availability (2)—Percent of uptime as compared to uptime plus active repair time was 83 percent.

Maintainability (2)—Mean-time-to-repair was 38 min.

The majority of the failures were related to the hydraulic system and the ejector mechanism (table 4). The hydraulic related failures were hydraulic leaks and one broken hose. The leaks may be a one-time occurrence, and once corrected should not occur again.

**Table 4. Field evaluation failure summary**

|                               | <u>No. of failures</u> | <u>Repair time (hr)</u> |
|-------------------------------|------------------------|-------------------------|
| Hydraulic                     | 3                      | 2.42                    |
| Ejector                       | 8                      | 4.95                    |
| Foot pedal linkage adjustment | 1                      | .25                     |

The large number (eight) of failures related to the ejector mechanism seem to point toward a design of very short life and to correct will require changes in the design of the ejector mechanism.

8. The tree planter shall be energy efficient.

The John Deere 450C crawler tractor used approximately 2 gallons of fuel per planting hour of operation which is about 1.1 gallons per acre (11 L/ha).

The hydraulic oil temperature during operation ranged between 130° F (57° C) to 165° F (74° C), which is good. The HODAG's hydraulic system does not have a cooler; therefore, this oil temperature indicates that energy is not being wasted in the hydraulic system.

9. The tree planter must be safe to operate. If no automatic feed, a safe and comfortable operator station and rollover protection must be provided.

A tree-planter operator was struck on the hand by a standing sapling while placing a seedling in the dibble finger. This injury did not result in a lost time accident, but it could have been a serious injury. Also, a planter operator looks outside the planter cab to see the fingers to place the seedlings in, and to see if the seedling has been ejected. When in this position, not only the hand, but the head could be hit or poked by a standing sapling or other slash.

Also, when the tree-planter operator is leaning out of the cab to see if a seedling has been planted, his/her head is very close to the top edge of the cab and if a bump is hit, his/her head could strike the top edge of the cab. This has been known to happen. This situation could be improved if the top of the cab was made wider and wrapped around so as to protect the arm and hand when placing seedlings in the fingers.

## CONCLUSIONS

Based on the performance criteria, the Timberland HODAG tree planter performed adequately in the following areas:

- Stock Type—The planter was able to plant bare-root stock, two rows at a time.
- Production Factors—The overall production rate was 1,048 seedlings/hr. The HODAG can plant seedlings 5-ft (1.52-m) apart. Few seedlings that were dug out were found to have "L" or "J" roots.

- Planter configuration—The planter could be pulled adequately with a 14,500-lb (6576-kg) crawler tractor.
- Affordable—At the production rate observed, 1,048 seedlings/hr, and list price of \$25,000, the HODAG is an affordable tree-planting machine—providing that tree-planting quality, reliability, availability, and maintainability are also acceptable.
- Energy Requirements—With a fuel use of 1.1 gal/acre (11 L/ha), the HODAG tree-planting system is considered energy efficient. Hydraulic oil temperature during operation indicates that energy is not being wasted in the planter's hydraulic system.

The HODAG performed unsatisfactorily in the following areas:

- Site Characteristics—The HODAG had difficulty operating on the muddy sites that are typical of central Mississippi. Only 60 percent of the attempts to plant were judged to be successful.
- Planting Factors—Approximately 40 percent of the attempts to plant were unsuccessful or judged to be unsuccessful. The cause(s) or contributing cause(s) of the unsuccessful planting are listed in table 3.
- Reliability, Availability, and Maintainability—

Reliability was far below the desired reliability mean-cycles-between-failures (MCBF); desired being 12,000 MCBF and demonstrated being 3,424 MCBF. Inherent availability was close to the desired 85 percent, even though reliability was low because many of the failures only required a short time to repair.

- Safety—The HODAG needs more protection for the planter operators from unsevered saplings and slash.

Overall the HODAG's performance must be judged unsatisfactory for the following reasons:

- Only 60 percent successful planting
- Low reliability of the ejector mechanism
- Improper or insufficient planter operator protection.

## RECOMMENDATIONS

Even though the HODAG is judged unsatisfactory, the design appears to have very high potential. If the causes of unsuccessful planting attempts can be reduced (particularly the packing problem), ejector mechanism reliability improved through design changes, and improvements in operator protection made, the HODAG should be reevaluated. The manufacturer reports that since this evaluation test, the ejector mechanism has been redesigned and operator protection has been improved.

## LITERATURE CITED

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