SEEDLING NET-SPREADING AID

R. Don Langmo and James Washburn

ABSTRACT: Time studies of labor required to spread protective net over newly sown conifer seed beds led to construction of a cart to carry the roll of netting. Field tests showed that labor cost savings through use of the cart will pay for the equipment within one season.

INTRODUCTION

During the 1983 planting season, work sampling time studies were made of the labor required at the Bend Pine Nursery to spread protective net over newly sown beds of pine seed. The netspreading operation was selected for study because, though it is seasonal, it occurs every year and is relatively high in labor use and cost.

Management at the Bend nursery justifies use of the net because it prevents the destruction of seeds and sprouting seedlings by birds and rodents. There is special concern to avoid the substantial or complete destruction of a seed lot for which there is no replacement stock and, hence, the potential of complete disruption of a regeneration schedule.

Results of the 1983 net-spreading study were reported in a paper (Langmo 1983) presented at the Pacific Northwest Regional combined meeting of the American Society of Agricultural Engineers and the Canadian Society of Agricultural Engineers. That study showed a high proportion of delay time in the work of the net-spreading crew. The study also led to the objective of developing a cart to hold and carry the roll of net being spread in order to reduce nonproductive delays of labor. During the spring of 1984, the cart was built and comparative studies were made between manual and machine-assisted net laying.

The analysis of net-spreading and subsequent development of an alternative method was promoted through an Oregon State University Agricultural Experiment Station project administered by the Department of Agricultural and Resource Economics.

Paper presented at the combined meeting of the Western Forest Nursery Council and Intermountain Nurseryman's Association, Coeur d'Alene, ID, August 14-16, 1984.

R. Don Langmo is Associate Professor and Industrial Engineer, Department of Agricultural and Resource Economics, Oregon State University, Corvallis, Oregon; James Washburn is Wage Leader, Bend Pine Nursery, USDA Forest Service, Bend, Oregon.

A working environment for the study was provided by the Forest Service Bend Pine Nursery. The nursery provided the necessary field facilities, the assistance of administrative staff and work crews, cost and production data, and ultimately the building of the prototype net carrier.

It should be kept in mind that the net-spreading methods and research results of this report are characteristic of the Bend Pine Nursery. Adaptation of the results to other nurseries must be evaluated in terms of the particular local conditions.

PROCEDURE

Bed Unit Characteristics

At the Bend Pine Nursery one complete net-covered bed unit consists of an area four bed-rows wide and is usually 400-feet (122-m) long. Wood stakes are driven into the ground at 15-foot (4.6-m) intervals along all the rows of the four bed-row unit. Nails are driven partially into the tops of all the stakes along the two outside edges and the longitudinal center of the four bedrow unit. The nails provide hooks for the net covering. Stake distribution for support of the net is shown in figures 1, 2 and 4. The width of

Figure 1.--Present method of spreading precut net. Three workers holding the net are near the end of the bed-row. Two workers following them stretch and hook the net to stakes.

the four beds and the walk lanes between them are covered by two strips of net each 12-feet (3.66-m) wide requiring a total net length per unit of

800 feet (244m). Where the center edges of the two lengths of net meet, they are slightly overlapped and hooked over the nails in the stakes in the center of the bed unit. Enough of the 24foot (7.32-m) width of the net extends over the stakes on the outside rows to allow the net to drape to the ground. A short length of net resting on the ground is covered with soil, making a complete seal to prevent animal entry and restrain the net from lifting by wind. Rodents and birds capable of damaging the seeded beds are too large to get through the 5/8- by 3/4-inch (16-mm x 19-mm) mesh size of the net.

Net-Spreading Techniques

Approximately two-thirds of the net installed each season has been used previously and cut to match the bed length. It is spread by a fiveperson team consisting of two crews. One crew of three workers holds the roll of net weighing about 17 pounds (7.7kg), with one person on each end and one person in the middle. The three workers slowly back down the lanes between the beds unrolling the net as they move. A second crew of two workers stretches the unrolled net flat across two bed-rows and hooks it to previously driven wood stakes that hold the net about one foot (0.3m) off the ground. The relative position of the three net unrollers and two spreaders is shown in figure 1.

The remaining one-third of the net installed is new material and comes on rolls of 4400 linear feet (1341m) that weigh about 187 pounds (85 kg) each. Spreading net from new rolls requires a team of 11 people. A pipe inserted through the center core of the net is set on rollers held by racks positioned at the end of the bed-rows. A worker with the end of the net in hand starts down the bed-row. At every interval of about 50 feet (15m) another worker steps in to help extend the net to the full length of the row. Two persons, starting at the far end of the row, stretch the net over two bed-rows simultaneously hooking it to the stakes along the rows. As the hooking progresses the workers that carry the net along the row length are released to return to the starting point to wait for completion of the hooking process. Workers are shown in figure 2 holding the net after the leading end has been carried the full length of a 400-foot (122-m) bed-row. After the net is spread and hooked on stakes over the length of the row, the net is cut. Then the roll and its supports are moved to the next two bed-rows to be covered.

When working with the prototype cart, the two person crew that stretches and hooks the net to stakes follows the same operating practice used by the stretchers in the five-member team. The net unrolling crew, however, is reduced from three people to one person who guides the cart along the bed-rows. Details of the development and physical nature of the cart are described in the Results section.

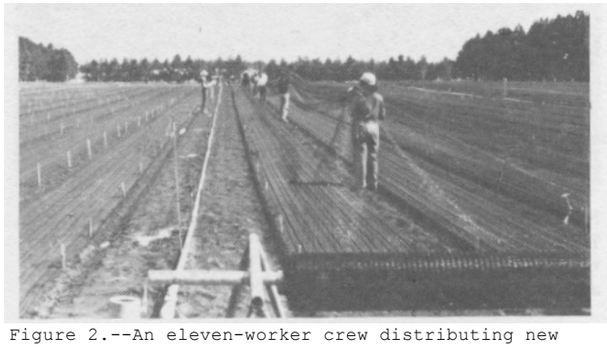

Figure 2.--An eleven-worker crew distributing new net along the length of a bed-row. After being stretched and hooked to stakes the net will be cut to fit the bed length.

Time Study Method

In both the manual and cart assisted methods of net-spreading, only the time required by crews to spread net was measured. Material distribution, travel to and from the planting area, work interruptions, and rest breaks were not timed. Work sampling was used to determine the times for activities and delays required by the five-worker team to cover manually one unit of seed bed with precut net. Five observations per minute were made of each of the team members. The same work sampling frequency also was used to establish working and delay times for the three-person team distributing net with the aid of the prototype cart.

Only the total elapsed time was recorded during the few opportunities to observe the large team involved in manually spreading new net from uncut rolls. Though substantial delay time was not isolated, only the total worker time was needed for subsequent cost comparisons.

Comparative costs of the manual and machine-assisted methods of net application were based on the quantity of seed bed planting and the cost figures provided by the Bend Pine Nursery.

RESULTS

Manual Net-Spreading Time

Time studies revealed that a five-person team took 20 minutes to complete laying 800 feet (244m) of precut net over four bed-rows each being 400-feet (122-m) long. The two-person crew that stretched and hooked the net had work delays of about 13 percent. Their activity controlled the slow pace for the crew of three workers unrolling the net. In contrast, the unrollers accumulated delay time of 38 percent. Their work time consisted of holding and unrolling the net while slowly backing down the lane.

To spread new net from a roll located at the end of the bed-row, the eleven-worker team required a cycle of 21.4 minutes. Even while working during this cycle, nine members of the crew were simply holding the net (fig. 2). Though not isolated by measurement, much of each worker's time was spent

in an empty-handed return to the starting point of the row and waiting for the next turn to carry the net. Reflecting upon such unchallenging activity, (Barnes 1980) emphasizes that the activity "hold" is the least effective among the uses of human capability and it should be reduced or eliminated through work design or use of mechanical devices.

Mechanical Net-Spreading Aid

The need to reduce the ineffective delay and holding time identified with the manual work of unrolling net, suggested the potential use of a mechanical aid to hold the net. Initial sketches and ideas concerning design of a net-handling cart were expressed and adjusted at Oregon State University by building and modifying the three dimensional model shown in figure 3. Several features anticipated as desirable on a prototype

Figure 3.--An Oregon State University model was the pattern for building the labor saving cart to assist workers placing new or precut net over seeded bed-rows.

machine were developed on the model. These included:

1. Open bearing blocks to permit fast positioning and removal of the tubing on which the net was rolled.
2. Lateral adjustment of the bearing blocks to accommodate net widths from 12 to 14 feet (3.7 to 4.3 m).
3. Wheel adjustment to allow for some variation in bed and lane widths.
4. Safety pads supported by brackets attached to the main frame and located behind the wheels. In case the machine tipped backwards the pads would stop the tilt before the net roll could drop on and disturb the seeded bed.
5. A front stabilizer bar shown near the right hand of the model operator in figure 3 that could be moved to the vertical position to give level support to the cart when it was unattended.
6. Adjustable components that locked and released through the use of screw clamps.

The complete cart, built at the Bend Pine Nursery, is illustrated in figure 4. It was pulled by one operator who moved along the bed 30 to 40 feet (9 to 12m) ahead of the two workers stretching and hooking net. Features developed on the model were utilized on the prototype. During construction of the cart specific dimensions were determined and design refinements for practicality were added. This included:

1. A 13-foot (4.0-m) frame width when the machine was adjusted to carry 12-foot (3.7-m) wide net.
2. Height from the ground to the center of the net roll was 4 feet (1.2m).
3. Unattended, the cart could rest in a horizontal position with the handle bar 3 feet (.9m) above the ground. A steel leg hinged to the center of the front reinforcement bar was held horizontally to the bar with a pin lock. By pulling the pin, the leg could be dropped to the vertical position to support the cart at rest.
4. The reinforcement bar located behind the handle (fig. 4) was 3 feet, 2 inches (1.0m) ahead of the main frame.
5. The distance between the main frame and handle bar was adjustable from 7 feet, 5 inches (2.3m) to 8 feet, 6 inches (2.6m). This allows some control by individual operators to balance the cart to fit their comfort preference.
6. The bicycle wheels were 26 inches x 1.75 inches (66.0 x 4.4cm).
7. The detail in figure 5 shows the sliding support that allows for minor changes in the distance between wheels. At the Bend Pine Nursery, the normal distance between wheels to straddle two bed-rows is about 10 feet (3m).

Figure 4.--During testing one worker guides the cart along the bed while two workers stretch and hook the net to stakes.

Figure 5.--There are several adjustable components on the machine. The one shown permits change in the distance between wheels to fit variations in bed width.

Cart Assisted Net-Spreading Time

The only change in the net-spreading activity was the substitution of the cart for two persons carrying net. If there were no change in the cycle time of 20 minutes to cover one seed-bed unit with precut net, then the reduction of the crew to three members would result in a 40 percent savings in labor time.

However, the average time for the studies of the three-worker team unfamiliar with the cart was 27.4 minutes per unit. Delay time for the worker pulling the cart was 37.4 percent in contrast to 2.6 percent delay for the two workers spreading and hooking the net. Once again, these two workers set the pace for the operation.

Comparative Costs

A change in the net-spreading method should provide a quality of performance equal to or better than a current system. Also, an operating cost advantage should develop that would pay for the cost of change to the new method in a reasonable time.

Production and cost data pertinent to a comparison of net-spreading alternatives for conditions experienced at the Bend Pine Nursery was provided as follows:

1. Bed-row length planted in 1984 = 86,320 feet (26,310m) or 108 units.
2. Used precut net to cover two-thirds of bed-rows = 57,550 feet (17 540m).
3. New net to cover one-third of bed-rows = 28,770 feet (8 770m).
4. Rolls of new 4,400-foot (1 341m) net used per season = 6.5 rolls.

The last 400 feet (122m) of each of the six new rolls of net used was spread by the five-operator team, the same as for precut net. This added 2,400 feet (731m) to the 57,550 feet (17 541m) of precut net totalling 59,950 feet (18 273m) of bed-row coverage by the five-operator team.

In turn, 2,400 feet (731m) of new net was not spread by the eleven-operator team, thus, reducing their production to 26,374 feet (8 039m).

In terms of time study units for cost purposes, the two teams spread the following amounts of net:

1. Precut net spread by five-operator team was 75 bed-row units of 800 feet.
2. New net spread by eleven-operator team was 33 bed-row units of 800 feet.

Labor costs for spreading net by the manual method included the cost of the five-operator team to cover 75 units plus the cost of the eleven-operator team covering 33 units. The cycle time in minutes per unit was converted to worker hours in each case. The stated labor rate per person at the Bend Pine Nursery was $10 per hour including benefits.

Only one cost determination was needed for the cart assisted method since both precut and new rolls of net were handled by the machine and a three-operator team. This system, however, must account for the cost of the machine.

Manual net-spreading costs per season - Five-worker team spreading net over 75 units:

1.67 worker hours per unit x
$10 per hour x 75 units = $1,253

Eleven-worker team spreading net over 33 units:
3.94 worker hours per unit x
$10 per hour x 33 units = $1,300

Total cost per season for 108 units = $2,553.

Machine assisted net-spreading cost per season - Three-worker team spreading net over 108 units:
1.37 worker hours per unit x
$10 per hour x 108 units = $1,480

Labor cost difference between manual and machine assisted methods -

Manual method	=	$2,553
Less machine assisted method	= -	$1,480
Savings per season	=	$1,073

Machine construction cost -

Materials	=	$124
Fabrication labor		385
Overhead at 20% of material and labor	=	102
Interest on capital at 15%	=	92
Total machine cost		$703

CONCLUSIONS AND DISCUSSION

The limits of the experience available indicate that the machine cost of $703 will be paid by the $1,073 savings projected for the cart assisted net-spreading system in .66 of a season. This estimate is conservative since it is based on the labor savings for three instead of five workers only during actual net-spreading time. It does not include other terminated and currently paid time for preparation, rest periods, and travel of the two released workers that would be charged normally to the net application.

A further safety margin in the cost analysis resulted from using the average performance time for the team unfamiliar with the mechanical netspreading aid. Though the team of three with the cart did not match the 20 minute cycle time per bed-row unit of the five-worker team, analysis showed that the time per cycle for the cart team diminished with each sequential cycle. This is characteristic of performance as the learning process accommodates to a change in practice. Payment for the change of method would be accomplished in .57 of a season providing that the three-worker cart team with added experience could reduce its cycle time per bed-row unit to the 20.0 minutes cycle time of the present fiveworker manual team.

Since the operating time to pay for the net-spreading aid is much less than one year, the 15 percent interest charge for capital for the machine likely would be necessary. This would reduce the payment period by an additional 14 percent.

In this study there was a cost advantage to the machine in that it was built by the user. Undoubtedly, its cost would have been considerably higher if the profit margin of a private fabricator was included.

More intensive use of the net spreading aid is needed to gain a more comprehensive understanding of its advantages and limitations. However, the brief experience this season has led to several suggestions concerning use of the cart and a few considerations for modifications in its design.

There was a high delay time, 37.4 percent, for the cart handler in contrast to the low delay, 2.6 percent, for the two stretchers. This extreme variance suggests that difficulties other than lack of training influenced the cycle time of the crew stretching the net. Two deterrents to the stretchers following the machine were related to (1) the quality of the net, and (2) roll condition. The large roll of new net was delivered with an oblique mesh. This made it difficult and time consuming for the operators to stretch the net evenly across the supporting stakes. In addition, sometime during storage the net had been laid on an uneven surface which caused the fiberboard core to warp. As a result, the net would tend to flop off the roll causing surges in tension when it unrolled rather than flowing uniformly as the machine was moved along the bed-row.

Adjusting the design of the main frame of the cart to place the weight of the net roll closer to the top of the wheels would reduce forces at the handle bar when the wheels move over an uneven surface. Also, lowering the net roll would improve the visual contact and coordination between the cart handler and the net stretchers.

Use of wider tires would ease the work of moving the cart over soft or irregular soil. Tires with a 2.25-inch (57.15-mm) diameter cost about $3 more than the 1.75-inch (44.45-mm) tires used.

It may be feasible to extend the usefulness and reduce the cost of a mechanical net-spreading aid by sharing it with other nurseries in the area that have different planting schedules.

Another means of increasing the function of the basic machine would result from modifying it to aid with the retrieval of net after the seedlings no longer need protection. A retrieval feature that could be installed and removed easily from the basic cart would have to serve the purposes of improving the efficiency of the retrieval operation and making the task easier for the workers involved.

Scheduling at the Bend Pine Nursery did not permit fabrication of the machine until the planting season was ended. The cart was tested on several units of one planting block. Since the opportunity for studies was limited, more extensive testing is recommended for next year.

REFERENCLS

Langmo, R. Don. Nursery Work Improvement Through Work Measurement. Paper No. PNR 83-502; Pacific Northwest Regional meeting; American Society of Agricultural Engineers; Victoria, B.C., Canada; 1983. 13 p.

Barnes, Ralph M. Motion and Time Study Designs and Measurements of Work. Seventh Edition; John Wiley and Sons; 1980. 689 p.