AN ECONOMIC STUDY OF WEED CONTROL WITH FOUR HERBICIDES IN A FOREST NURSERY

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The need for weed control in forest nurseries cannot be questioned. High costs of operation require better means of controlling weeds that compete with tree seedlings for fertilizers and soil moisture. The use of herbicides is often cheaper, more convenient, and less damaging to nursery stock than the conventional methods of machine cultivation, hand weeding, and contact sprays. However, the indiscriminate use of promising herbicides can be dangerous. Some herbicides, such as the s-triazines, (Simazine Propazine) are very insoluble and can cause residual problems in heavy soils, which may build up to toxic levels. Other herbicides are selective against a very narrow spectrum of weed species, and therefore only accomplish a small part of the total weeding job. New herbicides need to be evaluated, first, for their weed control effectiveness, and secondly for any damage to tree seedlings.

Much has appeared in the literature on the evaluation of new herbicides for weed control in forest nurseries. Mader (10) has reported on sixteen chemicals, tested over five years, for weed control in forest nurseries in Massachusetts. Of the 16 tested he recommended only one, Neburon (1•n-buty1-3-(3,4-dichloropheny1)-1 methylurea), be used because of lack of seedling injury and length of effective weed control.

Ahrens (2), working in Connecticut nurseries, found that Simazine (2-chloro-4, 6-bis (ethylamino)-s•triazine), Atrazine (2-chloro-4(ethyl-amino-6-(isopropylamino)-s-triazine) and Diuron (3(3,4 dichloropheny1)-1, l-dimethyl urea) could be used for seasonal weed control on many tree species, while

CIPC (isopropyl N-(3 chlorophenyl) carbamate), Neburon (1-n-buty1-3-(3,4-dichloropheny1)-1 methylurea), DNBP (4,6 dinitro-ortho-secondary butyl pehnol), EPTC (ethyl N, N-di-n-propylthiol carbamate), Sesone (solium 2,4-dichlorophenoxyethyl sulfate), and 2,4-DEP (tris-(2,4-dichlorophenoxy-ethyl) phosphite) give good weed control, but required repeated applications to control weeds for the entire summer.

Aldhous (1), working in English nurseries, found a substantial reduction in weeding time where Simazine was applied at rates of 2-4 lbs. per acre. The reduction in weeding time following an application of 4 lbs. Simazine per acre ranged from as little as 7% (few weeds present) to 68% (numerous annual weeds).

Kuntz and Kozlowski (7,8), Kozlowski and Kuntz (6), Kuntz et al (9), and Winget et al (12, 13) have worked with numerous herbicides in Wisconsin nurseries and have shown the importance of correct application rates, time of application, age of seedlings, and herbicide selectivity. Of the herbicides tested Propazine (2-chloro-4,6•bis (isopropylamino)-s-triazine) and Simazine showed considerable promise for older age coniferous stock (2-0, 2-1) alone with Dacthal (DCPA, dimethyl 2,3,5,6-tetrachloroterephthalate), Vegadex (CDEC, 2--chloroallyl diethyldithio carbamate), and Eptam (EPTC).

The majority of the research done in nursery weed control only evaluates a herbicide for its potential use and makes no attempt at an economic appraisal. Because a chemical gives some degree of weed control does not necessarily mean it may be economically employed. Such factors as price, methods of application, application cost, and rates need to be considered.

Weed control research at the L. T. Nike" Webster Forest Nursery, located near Olympia, Washington, has evaluated potential herbicides for weed control and seedling injury for several years. This evaluation utilizes small plots, with limited replications, and rates weed control and plant damage by a numerical index based on visual observation (4). This type of an evaluation cannot determine the economic value of 'a chemical for weed control. Because of this, the following experiment was established to test four promising herbicides on an operational basis for their economic weed control value.

METHODS AND PROCEDURES

Plot Layout and Herbicide Application

Four herbicides, Dowpon (2-2-dichloroproprionic acid), Simazine (2-chloro-4,6-bis(ethylamino)-s-triazine), Propazine (2-chloro-4,6-bis (isopropylamino)-s-triazine), and Kloben (1-n-butyl-3-(3,4•dichloropheny1)-1-methylurea) were used as pre•emergence sprays on 2-1 Douglas fir (Pseudotsuga menziesii (Mirb.) Franco) transplants in plots 1/4 acre in size (three 600-foot transplant beds), during the early summer of 1962. Transplant beds were sprayed by two men using a conventional nursery sprayer. Five treatments (four herbicides and a control) were randomly assigned locations within each block, and four such blocks were selected across a transplant field. This then gave a total of one acre sprayed per herbicide and a one acre control.

Dowpon was applied at 10 lbs. active material per acre (11 3/4 lbs. total) and Simazine, Propazine, and Kloben were applied at the rate of 4 lbs-active material per acre (5 lbs. total, except 8 lbs. for Kloben). Herbicides

were applied in 60 gallons of water and a six-foot strip was sprayed for each bed. Contents of the spray tank were kept in constant agitation, and the spray was applied to the beds at 100 lbs. pressure.

Plot Measurement and Analysis

All plots were hand weeded three times during the summer of 1962 and the time taken to hand weed individual plots was recorded.

The weeding time per acre was subjected to the analysis of variance, and the "J.S.D." test (Just Significant Difference) was applied to the significant parts of the analysis. Weeding costs per acre were determined for the summer and comparisons of the total costs and cost per M were made for each treatment.

RESULTS AND DISCUSSION

The analysis of variance for weeding time/acre (Table I and II) showed blocks, weeding date, and treatments to be highly significant. Of the five treatments (four herbicides and control) Simazine significantly reduced the weeding time per acre for each weeding date over all other treatments (Figure 1). All four herbicides were significantly better than the control in reducing the average weeding time at each weeding date (Figure 1) and for the entire summer (Figure 2).

The degree of weed control for the herbicides was influenced by weeding date and blocks. As the summer progressed, the average weeding time per acre increased (Figure 3). This is probably due to weeds going to seed adjacent to the nursery area and blowing into the transplant beds. As the length of weeding time increased during the summer, the effects of Simazine became even more pronounced. At the first weeding (July 27), Simazine reduced weeding time about 6 hours per acre over the control. At the last weeding (Sept. 17), Simazine reduced the weeding time per acre 21 hours over the control.

Propazine, Simazine and Kloben maintained acceptable weed control up to the last weeding date, approximately 3 months after application, indicating their residual properties. Burnside et al (5) found that under optimum conditions original doses of Simazine can be reduced up to 90% in a 10-month period, while Aldhous (1) found the "half-life" of Simazine was about 10-16 weeks. To determine what amounts of these herbicides remained in the Webster Forest Nursery soil, soil samples were collected six months after application and subjected to a bio-assay technique using oats as an indicator plant (3). Based on preliminary results, it would appear that both Simazine and Propazine disappear rapidly in the Webster Forest Nursery's light, sandy soil. The level of both herbicides dropped from an original dosage of 4 lbs. active material per acre to less than 1/2 pound active material per acre in the six month period of time. This is in close agreement with both Burnside and Aldhous.

The bio-assay results with Kloben were inconclusive; however this material probably dissipates from the soil as rapidly as the two triazines.

The effectiveness of Dowpon decreased with time and, although still significantly better than the control at the last weeding date, required almost twice as much hand weeding as the next best herbicide, Kloben. This indicates that the effectiveness of Dowpon is short-term and that repeated applications would be necessary for acceptable weed control.

TABLE I Weeding Time per Acre for four herbicides and a control in four blocks at three weeding dates, for 2-1 Douglas fir transplant beds at the Webster State Forest Nursery.

Treatment	Weeding Date	BLOCKS[1] 1	2	3	4	Sum
DOWPON	July 27, 1962	4.4	4.1	7.0	11.3	26.8
	Aug. 20, 1962	10.9	9.4	14.9	18.2	53.4
	Sept. 17, 1962	16.0	18.9	19.8	32.7	87.4
	Sum	31.3	32.4	41.7	62.2	167.6
SIMAZINE	July 27, 1962	4.1	4.7	3.4	3.2	15.4
	Aug. 20, 1962	7.8	7.2	5.5	6.6	27.1
	Sept. 17, 1962	6.9	5.1	6.2	3.6	21.8
	Sum	18.8	17.0	15.1	13.4	64.3
PROPAZINE	July 27, 1962	4.1	5.3	5.3	4.8	19.5
	Aug. 20, 1962	6.5	10.1	15.3	7.8	39.7
	Sept. 17, 1962	8.7	7.2	12.0	6.4	34.3
	Sum	19.3	22.6	32.6	19.0	93.5
KLOBEN	July 27, 1962	3.8	5.4	6.0	8.0	23.2
	Aug. 20, 1962	5.6	9.2	12.8	13.6	41.2
	Sept. 17, 1962	10.5	10.3	11.5	13.0	45.3
	Sum	19.9	24.9	30.3	34.6	109.7
CONTROL	July 27, 1962	4.2	5.4	11.3	14.8	35.7
	Aug. 20, 1962	10.2	15.7	27.4	44.2	97.5
	Sept. 17, 1962	20.7	21.0	30.5	33.2	105.4
	Sum	35.1	42.1	69.2	92.2	238.6
	SUM	124.4	139.0	188.9	221.4	673.7

[1] Hours per acre

TABLE II Analysis of variance of weeding time per acre (hours) for four herbicides and a control on 2-1 Douglas fir transplant beds at the Webster Forest Nursery

Degrees of Freedom	Source of Variation	Sum Squares	Mean Squares	F Ratio	F 1/ Table	Significance
59	Total	4,179.64				
3	Blocks	401.97	133.99	14.95	4.72	**
2	Weeding Date	841.83	420.92	46.98	5.61	**
4	Treatments	1,596.35	399.09	44.54	4.22	**
6	B X W	58.79	9.80	1.09	2.51	NS
12	B X T	576.94	48.08	5.37	3.03	**
8	W X T	488.76	61.10	6.82	3.36	**
24	Error	215.00	8.96			

** Significant at the 1% level.

NS Non-significant.

1/ Tabular values of F from Snedecor (11) pp. 246-249, pp. 276-279.

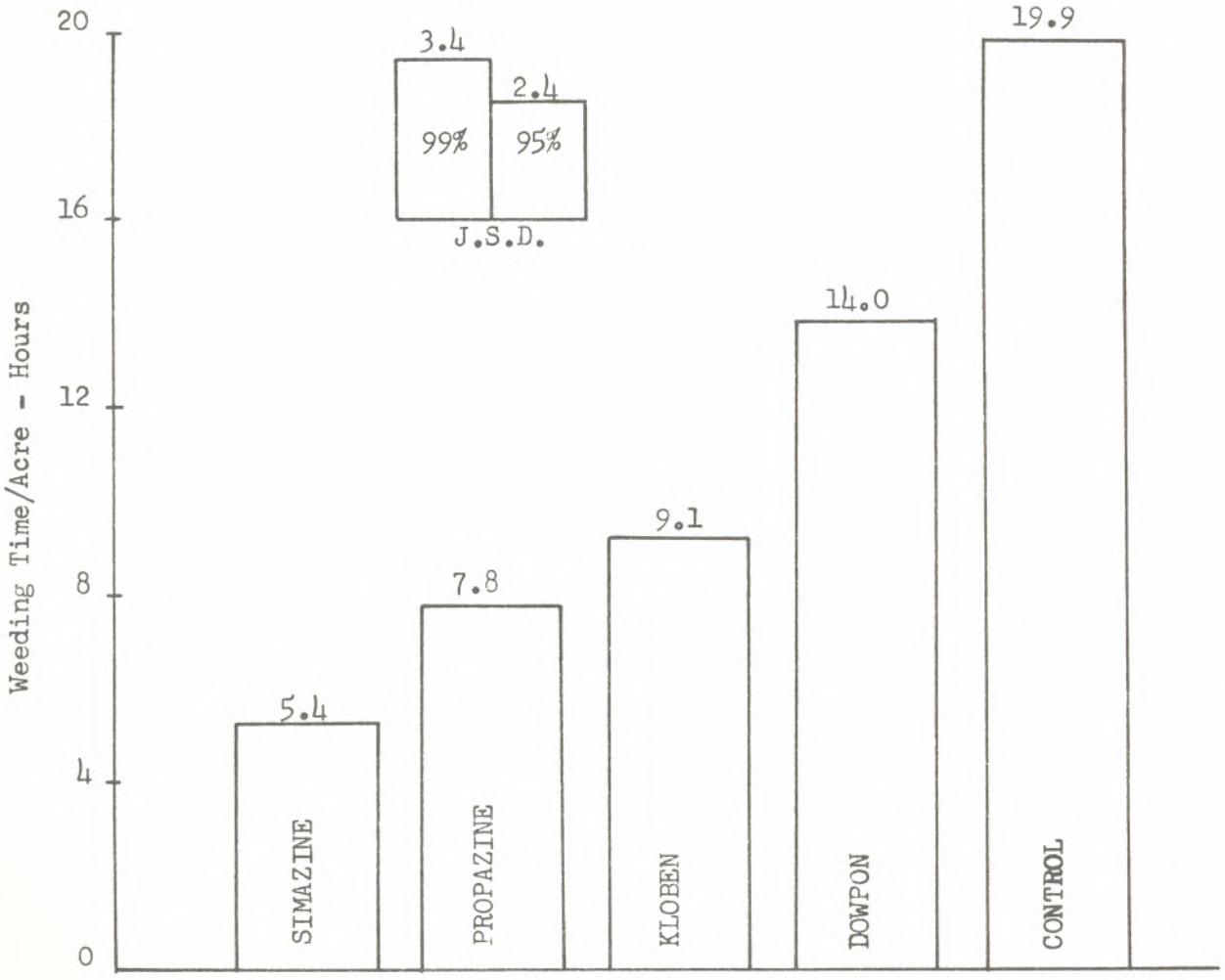
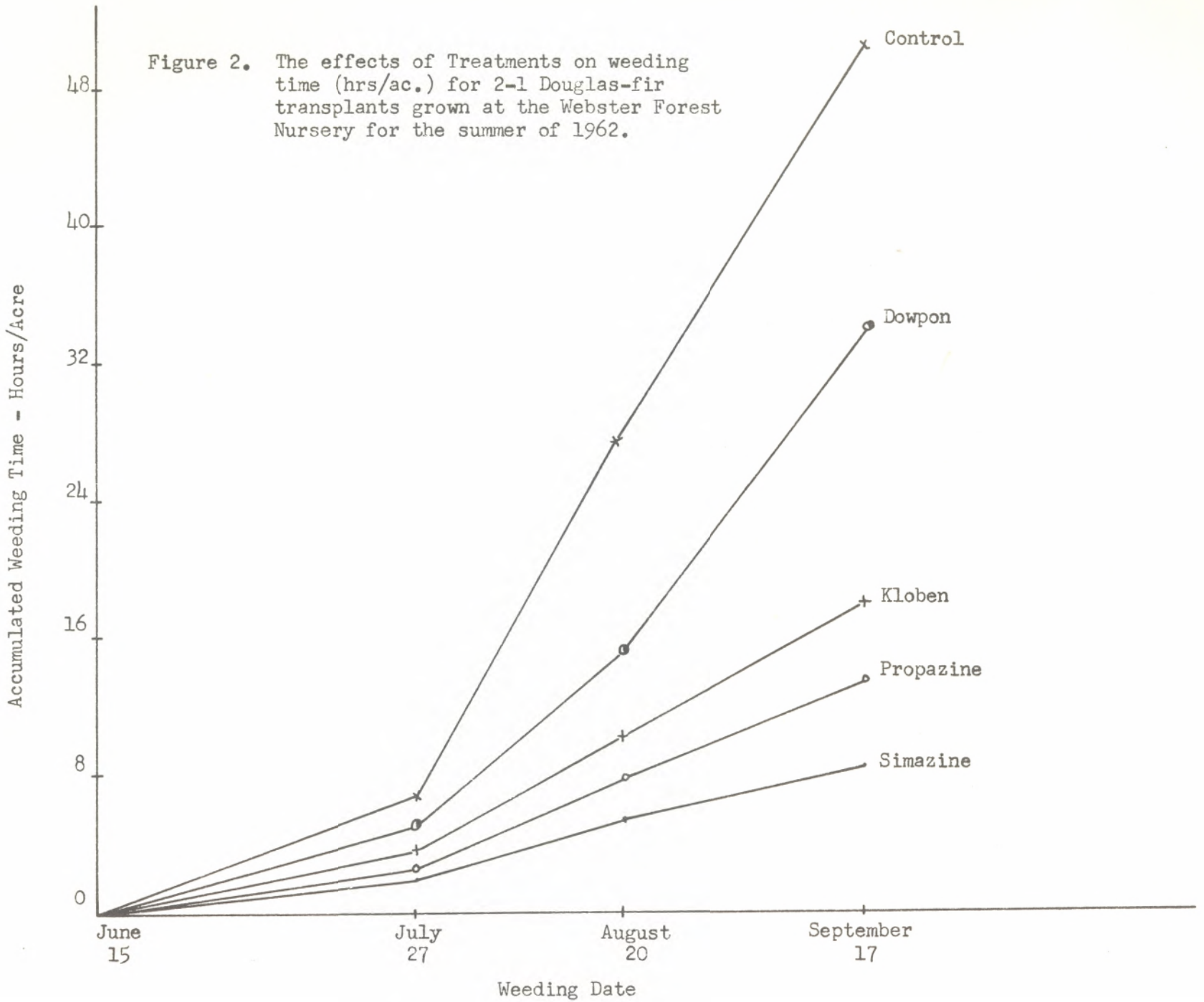


Figure 1. The effects of Treatments on the weeding time per acre, averaging out Blocks and Weeding Date, for 2-1 Douglas-fir transplants grown at the Webster Forest Nursery.

Figure 2. The effects of Treatments on weeding time (hrs/ac.) for 2-1 Douglas-fir transplants grown at the Webster Forest Nursery for the summer of 1962.



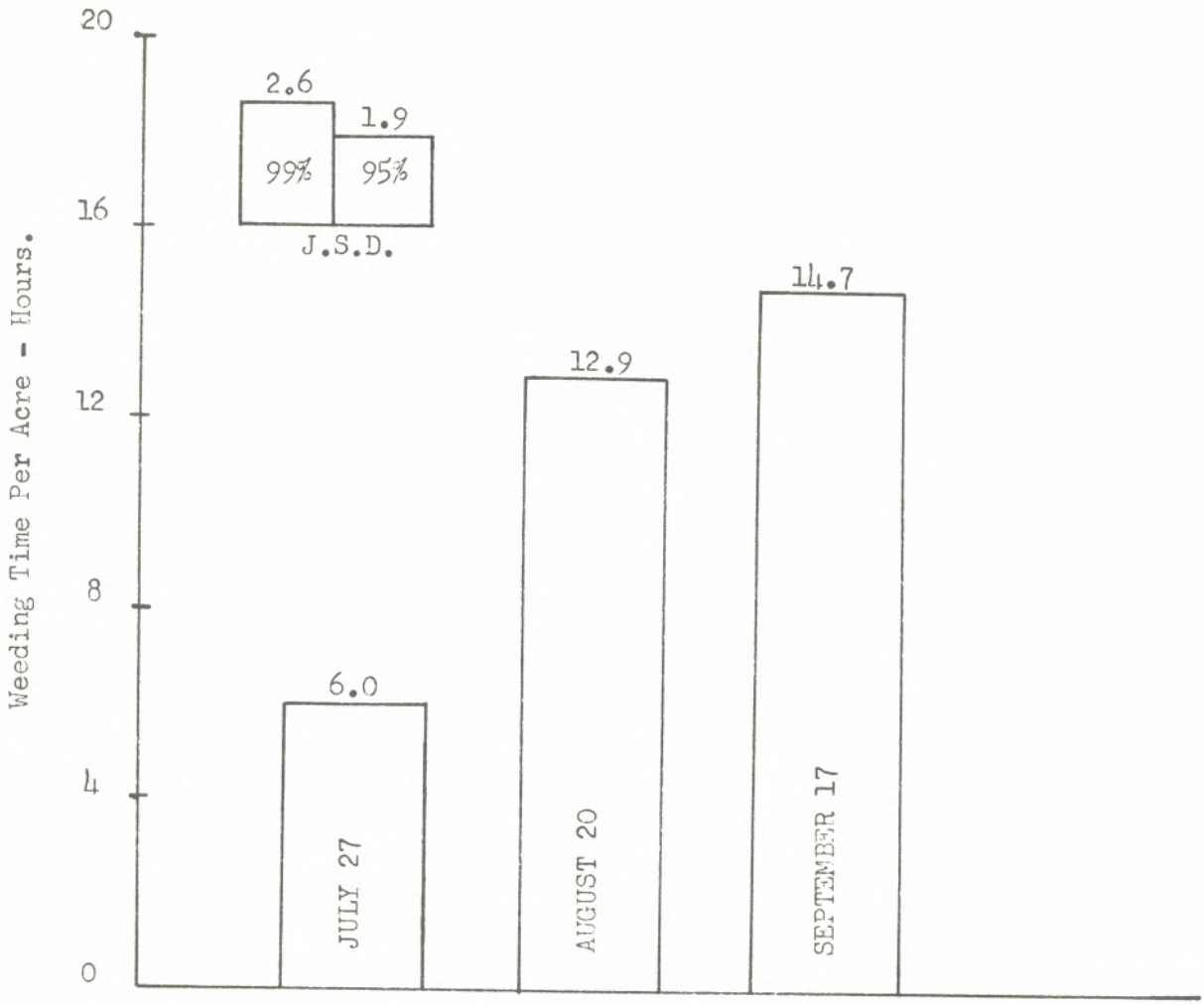


Figure 3. The effects of Weeding Date on weeding time per acre, averaging out the effects of Treatments and Blocks, for 2-1 Douglas-fir transplants grown at the Webster Forest Nursery.

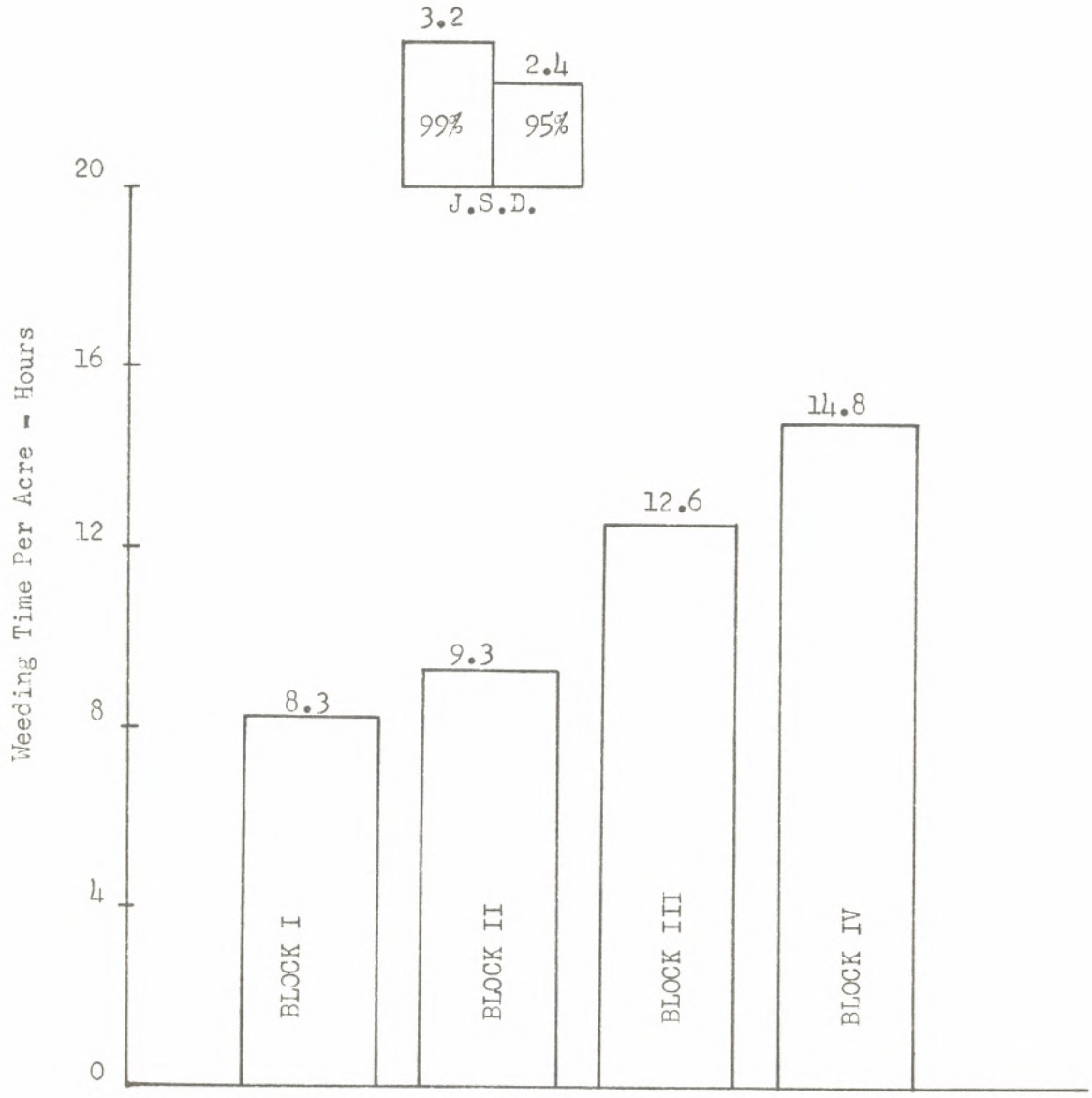


Figure 4. The effects of Blocks on the weeding time per acre, averaging out the effects of Weeding Date and Treatments for 2-1 Douglas-fir transplants grown at the Webster Forest Nursery

TABLE III A Comparison of total weeding cost per acre and cost per thousand for four herbicides and a control applied to 2-1 Douglas fir Transplants grown at the Webster Forest Nursery

Cost Per Acre	TREATMENT AND RATE				
	Simazine 5 lbs/acre	Propazine 5 lbs/acre	Dowpon 12 lbs/acre	Kloben 8 lbs/acre	Control
WEEDING LABOR[1]	$20.09	$29.22	$52.38	$34.29	$74.56
MATERIALS[2]	12.50	12.50	16.68	44.40	-
APPLICATION LABOR[3]	6.59	6.59	6.59	6.59	-
TOTAL COST	$39.18	$48.31	$75.65	$85.28	$74.56
PRODUCTION/ACRE	180,000	180,000	180,000	180,000	180,000
WEEDING COST/M	$0.22	$0.27	$0.42	$0.47	$0.41

1 $1.25/hour

2 Dowpon @ $1.39/lb., Simazine @ $2.50/lb., Propazine @ $2.50/lb., Kloben @ $5.55/lb.

3 Tractor - 1 hour @ $2.00/hour, 2 men - 1 hour each @ $2.15/hour and $2.44/hour.

The fact that all the herbicides significantly reduced weeding time as compared to the control was not a good measure of their economic success. In comparing the total weeding cost for the summer for each herbicide and the control, the application cost and material cost need to be added to the hand weeding cost. This is shown in Table III and changes the picture. Both Dowpon and Kloben show total costs above the cost of hand weeding alone. This is due to the high rate of Dowpon (almost 12 lbs.) coupled with only fair weed control, and the high cost of Kloben ($5.55/1b.) and the fact that it contains only 50% active material. Simazine and Propazine, with low application rates, 80% active material, low cost per pound, and excellent weed control, show a decisive savings in total cost when compared to the control. Propazine shows a savings of better than $26 per acre per year over hand weeding alone, while Simazine shows a savings of better than $35 per acre per year. This is in close agreement with Aldhous (1) who found a net savings of approximately $30 per acre per year following an application of 4 lbs. active Simazine per acre.

Since the production of 2-1 Transplants at the Webster Forest Nursery is approximately 180M per acre (12 beds-15M per bed) the savings in cost per M can be shown (Table III). This amounts to $0.19/M for Simazine and $0.14/M for Propazine.

CONCLUSIONS

Simazine was by far the best herbicide utilized in this trial. Not only did it significantly reduce weeding time per acre, but what is more important, also reduced weeding cost by almost 1/2 the cost of hand weeding alone. Next best was Propazine. Dowpon and Kloben, although significantly reducing weeding time, did not reduce the cost per acre compared to the control because of high application rates and high cost of material.

Simazine, Propazine, and Kloben were able to maintain significant weed control throughout the summer with only one application. Dowpon, on the other hand, showed a reduction in effectiveness as the summer progressed, indicating the need for repeated applications to insure good weed control.

Use of the triazines or Kloben in a nursery soil could lead to residual problems because of their relatively slow breakdown. Periodic checks would be required with these materials, either by the use of a sensitive cover crop between transplant crops, or by the use of a greenhouse bio-assay to assure that toxic levels are not reached.

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