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WATER STRESS PROMOTES EARLY FLOWERING IN JACK PINE

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ABSTRACT: Young jack pine exposed to water stress produced several times more female strobili than trees watered regularly. The timing and duration of the treatments was important.

KEY WORDS: Flowering, gibberellin, drought stress, environmental stress, soil moisture.

The application of a giberellin A 4/7 (GA 4/7) mixture has been shown to increase the production of female strobili on young jack pine (*Pinus banksiana* Lamb.) trees (Cecich 1981). It has also been shown in other species that the effect of GA 4/7 application can be enhanced by the simultaneous application of environmental stress. Two stress factors that have been effective are temperature in western hemlock (Pollard and Portlock 1981), and soil moisture in western hemlock (Brix and Portlock 1982) and loblolly pine (Greenwood *et al.* 1979).

This paper reports the effects of water stress on flowering in young jack pine. The study was part of a larger effort to test the effects of various water stress regimes on the growth and morphology of 2-year-old potted jack pine trees.

MATERIALS AND METHODS

Seeds from 15 open-pollinated families of jack pine from a cooperative breeding program (Riemenschneider 1981) were used to grow seedlings for this study. Seed was germinated on wet filter paper in petri dishes and transplanted to book planters on January 16, 1981. The potting medium was a mixture of peat, pearlite, and sand (2:2:1). A slow-release fertilizer was added to the medium. Seedlings were grown in a greenhouse at Rhinelander, Wisconsin, under full sunlight supplemented by incadescent lighting to maintain an 18-hour photoperiod. Temperature was approximately 22° C days and 15° C nights. After 70 days, the seedlings were placed under 50 percent shade and reduced temperature for 17 days to slow growth. They were stored in the dark at 3 to 4°C until June 1 when they were transplanted to 17.8 cm diameter pots using the same potting medium. Potted seedlings were arranged in a double-walled polyethylene plastic greenhouse in a split-plot experimental design with eight replications. Whole plots were three water stress treatments plus control. The subplot was two trees from each of the 15 families. Each whole plot treatment had 30 trees per replication; the total size of the experiment was 960 trees.

Water stress treatments were imposed by withholding water for various periods of time. Control trees were watered every other day during the experiment. Trees in treatment 1 were dried to approximately −60 kilopascals (kPa) soil moisture tension, as measured by tensiometer, and then rewatered. The drying cycle was repeated three times from June 16 to August 25 (fig. 1). Trees in treatment 2 were stressed for one cycle only from June 16 to July 16 (soil water potential of −52 kPa) and were treated the same as the control trees for the rest of the experiment. Trees in treatment 3 received no water from June 16 to August 11. For this treatment, soil water potential was beyond the range of tensiometers from July 30 to August 11. However, leaf water potential measured with a pressure bomb (Waring and Cleary 1967) using excised needle fascicles was −1020 kPa on August 11; trees from treatment 1 at a soil water potential at −60 kPa had a leaf water potential of −450 kPa. Trees from treatment 3 were water every other day from August 11 to the end of the experiment.

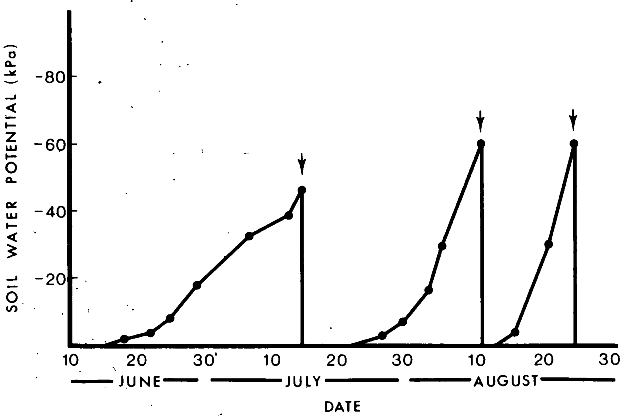

Figure 1.--*Soil water potential (lkPa = 0.01 bar) determined by tensiometer for treatment 1, three cycles of stress not exceeding 60 kPa. Arrows indicate rewatering of treatment. Treatment 2 was stressed during the first cycle only and watered as was the control for the rest of the experiment. Treatment 3 received no water until August 11 and reached soil water potentials beyond the range of tensiometers.*

Trees were moved to a sheltered cold frame on September 1 and were transferred without transplanting to the nursery at Rhinelander in May 1982. In early June 1982, female strobili were counted on trees in six of eight replications. Data were analyzed on a whole plot basis disregarding subplot family variation. Because numbers of female strobili were small and not normally distributed, null hypotheses of no differences between treatment combinations were tested using the non-parametric Mann-Whitney test.

RESULTS

Flowering was generally sparse on the 18-month-old trees. Six trees out of 180 control trees produced female strobili (3.3 percent) and only 2 trees in treatments 2 and 3 produced flowers (1.1 percent). The difference between the control and treatments 2 and 3 were not significant. Trees from treatment 1, however, flowered more frequently and produced more total flowers than trees from the control or from the other two treatments (table 1). Twenty-six trees flowered (14.4 percent) in treatment 1 and produced a total of 35 female strobili, which differed significantly from the control and the other two treatments (table 1).

DISCUSSION

Brix and Portlock (1982) found a significant interaction between water stress and GA 4/7 application in the stimulation of flowering in western hemlock but no effect of water stress alone. They noted that, in combination with GA 4/7, stress of long duration (to July 27) resulted in a 3.3-fold increase in flowering over stress of short duration (to July 4) in 1-year-old plants. We observed a similar pattern in this study for the effect of water stress alone. Trees receiving periodic stress from June 16 to August 25 (treatment 1) produced 17.5 times more female strobili than trees stressed for a shorter duration and 4.4 times more strobili than the control trees watered every other day (table 1).

For water stress to be effective in stimulating female strobili production, the stress probably must be correctly synchronized with ovulate cone primordia differentiation. The time at which this occurs in jack pine can only be estimated. Bud initiation begins in the axils of cataphylls of the terminal bud between June 28 and July 12 in jack pine in Wisconsin (Curtis and Popham 1972), and is preceded by the cessation of active shoot elongation. Because ovulate strobili are near-terminal or midway on the shoot, August to early September is a reasonable period during which such primordia may be initiated and begin differentiation. In this study 95 percent of the elongation in treated trees had been completed by July 13, 3 days before treatment 2 was rewatered. Treatment 1 continued stress well into the period of active bud initiation and was effective in increasing female flowering. Treatment 3, which continued to August 11, did not show increased flowering but the stress imposed on this group of trees may have been so great that any effect related to duration was overcome by severity.

The results presented here are limited in scope because of the small number of stress treatments in regard to duration and timing. The results do indicate that late July and August, after active elongation is completed, may be a critical time when stress treatment may promote female strobili production in jack pine.

ACKNOWLEDGEMENT

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Table 1.--*Total number of female strobili for the control and each water stress treatment (on diagonal) and results of Mann-Whitney comparisons among treatments*

	CONTROL	T1	T2	T3
CONTROL	8			
T1	★[1]	35		
T2	ns[1]	★★[1]	2	
T3	ns	★★	ns	2

[1]★ = significant at p 0.05
★★ = significant at p 0.01
ns = not significant

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