

Transpiration Capacity of Dormant Buds of Forest Trees

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readily at the second trifoliate leaf. To attribute this difference to a difference in maturity may explain differences in the young leaves, but it does not explain the greater absorption in the second trifoliate leaf at all ages.

Discussion and summary

Absorption of P-32 by the leaves, including the cotyledons, of soybean is greatest by immature leaves. It has been shown by THORNE (1958) that this is also true in *Phaseolus vulgaris*. Leaflets of immature soybean second and third trifoliate leaves do not export absorbed phosphorus; this suggests that it is utilized by the growing leaves and is not available for translocation. As the leaves mature, however, there is a decrease in the amount of phosphorus absorbed, but a considerable portion of that absorbed is translocated out of the leaf.

Absorption of P-32 by the primary leaves was variable, although similar to that of the trifoliate

leaves. Total absorption by all young primary leaves was high and decreased as the leaves matured. There was also variation in total absorption by these leaves in treatments of older plants. For all treatments to the primary leaves the amount of phosphorus translocated was quite constant. Young primary leaves transported P-32, which was not true for any of the trifoliate leaves, but it is possible that the first treatment may not have been made early enough to determine the "non-transporting stage" of the primary leaves.

Absorption by the cotyledons decreased with age until senescence. Transport of P-32 also decreased with an increase in age but to a smaller extent, which indicates that there is an increasing amount of P-32 being transported and a decreasing amount retained by the treated leaves. The cotyledons translocated P-32 at all ages; this was to be expected since they provide the young embryo and seedling with stored materials for initial growth.

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TRANSPIRATION CAPACITY OF DORMANT BUDS OF FOREST TREES

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ABSTRACT

Experiments were conducted on transpiration capacity of excised dormant buds of trembling aspen (*Populus tremuloides* Michx.), white birch (*Betula papyrifera* Marsh.), red pine (*Pinus resinosa* Ait.), white pine (*P. strobus* L.), and jack pine (*P. banksiana* Lamb.). The bases of the buds were fixed in Petri dishes containing paraffin and paraffin oil. Bud transpiration was determined gravimetrically under a range of temperatures and relative humidities. Bud transpiration of all species was responsive to changes in vapor-pressure gradients from the bud surface to the surrounding atmosphere. Large species differences were found in bud transpiration. Water loss among the pines was in the following order: white pine > red pine > jack pine. Vegetative buds of *Populus tremuloides* transpired faster than flower buds. Bud transpiration did not correlate well with bud size or surface development.

Introduction

Transpirational water loss usually is classified as stomatal, cuticular, or lenticular, with most water loss occurring through the stomates. In addition some water is evaporated from twig and stem surfaces of

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woody plants (KOZLOWSKI, 1943, 1964; KOZLOWSKI and PETERSEN, 1960; KRAMER and KOZLOWSKI, 1960) and from dormant buds because bud scales do not wholly prevent water loss. Bud transpiration may be quite variable among species. BURSTRÖM (1948), for example, found higher bud transpiration in *Carpinus* than in *Fagus*, and KOZLOWSKI and PETERSEN

(1960) reported greater water loss from buds of *Ulmus americana* than from those of *Pinus strobus*. Bud transpiration of the latter two species varied greatly on different days and was influenced more by changes in weather conditions than by moisture contents of buds. Bud transpiration is also influenced by size of buds, bud moisture content, properties of the bud scales, and water deficits of the surrounding atmosphere (BURSTRÖM, 1948).

A review of the literature indicated that data on bud transpiration during the dormant season were available for only a few species of woody plants. The present experiments were performed to compare transpiration capacity of dormant buds of several species of gymnosperms and angiosperms under controlled environmental conditions. A comparison also was made of transpiration from vegetative and flowering buds in one species.

TABLE 1
RANGE OF HUMIDITIES AND SOLUTES EMPLOYED

HUMIDITY		WATER DEFICIT (mm Hg)	SATURATED SOLUTIONS OF SOLUTES INDICATED
mm Hg	Per cent		
0.0	0 ^a	17.5	KOH dry
6.1	35	11.4	Cr O ₃
10.1	58	7.4	NaBr·2H ₂ O
14.1	81	3.4	(NH ₄) ₂ SO ₄
16.1	93	1.4	Na ₂ SO ₄
17.5	100	0.0	Water

^a A relative humidity of 0% here and throughout paper actually refers to <<1%.

Methods

A study was conducted from November, 1960, to March, 1961, on water loss from excised dormant buds of trembling aspen (*Populus tremuloides* Michx.), paper birch (*Betula papyrifera* Marsh.), red pine (*Pinus resinosa* Ait.), eastern white pine (*P. strobus* L.), and jack pine (*P. banksiana* Lamb.). Using a razor blade, a supply of buds was cut off at the point of attachment from several trees growing near Madison, Wisconsin, and carried to the laboratory in plastic bags. The buds were kept in these plastic bags at 100% relative humidity and under refrigeration for 2-4 days until initiation of the following experiments.

Transpirational losses of the excised buds were determined by a modification of a method used by BURSTRÖM (1948) and KOZŁOWSKI and PETERSEN (1960). After each collection, 100 randomly selected buds of a species were placed in a tared weighing bottle and their moisture content determined after oven drying at 70° C to constant weight. Additional buds from the same collection were placed in an up-

right position in an open 45-mm Petri dish containing approximately equal portions of warm and soft paraffin wax and paraffin oil. The bases of the buds were rapidly fixed in this mixture. In every experiment three Petri dishes each containing 50 buds were used for a species. Control dishes consisting of pure paraffin wax and no buds also were included. These showed no weight changes as a result of treatment. Water loss from buds was determined by rapid weighing of the Petri dishes at 24-hr intervals on a Mettler balance. Transpiration was expressed cumulatively as per cent water lost based on initial water content.

The Petri dishes containing the upright excised buds were subjected to various constant humidities and temperatures in glass desiccators. A range of humidities was maintained by placing different saturated salt solutions in each desiccator as shown in table 1. The desiccators were then placed in the dark in appropriate constant-temperature rooms.

Three separate experiments were conducted. The first tested transpiration capacity of jack pine, red pine, white birch, and both flower and vegetative buds of trembling aspen for 14 days at 20° C and relative humidities of 100, 93, 81, 58, 35, and 0% for 14 days. A second experiment tested bud transpiration of jack, red, and white pines at 20° C over a range of relative humidities for 10 days. The third experiment evaluated bud transpiration by maintaining a constant temperature and varying the relative humidity or by holding the relative humidity constant and varying the temperature. Daily water losses for 13 days from aspen flower buds were determined at 10° C and three relative humidities (93, 58, and 0%) and at 0% relative humidity and three temperatures (0°, 10°, and 27° C).

Results and discussion

There was little water loss over a 14-day period from dormant buds of various species at 20° C and relative humidities of 100 or 93% (fig. 1). At 93% relative humidity there apparently was a small initial loss of moisture, which was followed by absorption of moisture from the air after about 4 days by buds of jack and red pine. Decreasing relative humidity to 81% caused much greater transpirational water loss than occurred in a more saturated atmosphere. There was, however, considerable variation among species in bud transpiration, with jack-pine buds especially well adapted for retaining moisture. After 14 days at a relative humidity of 81% jack-pine buds had lost only about one-fifth of their total moisture. In contrast, vegetative buds of aspen had lost well over half of their water. Further reduction in relative humidity to 58% resulted in more rapid water loss in all species and indicated that red-pine buds also

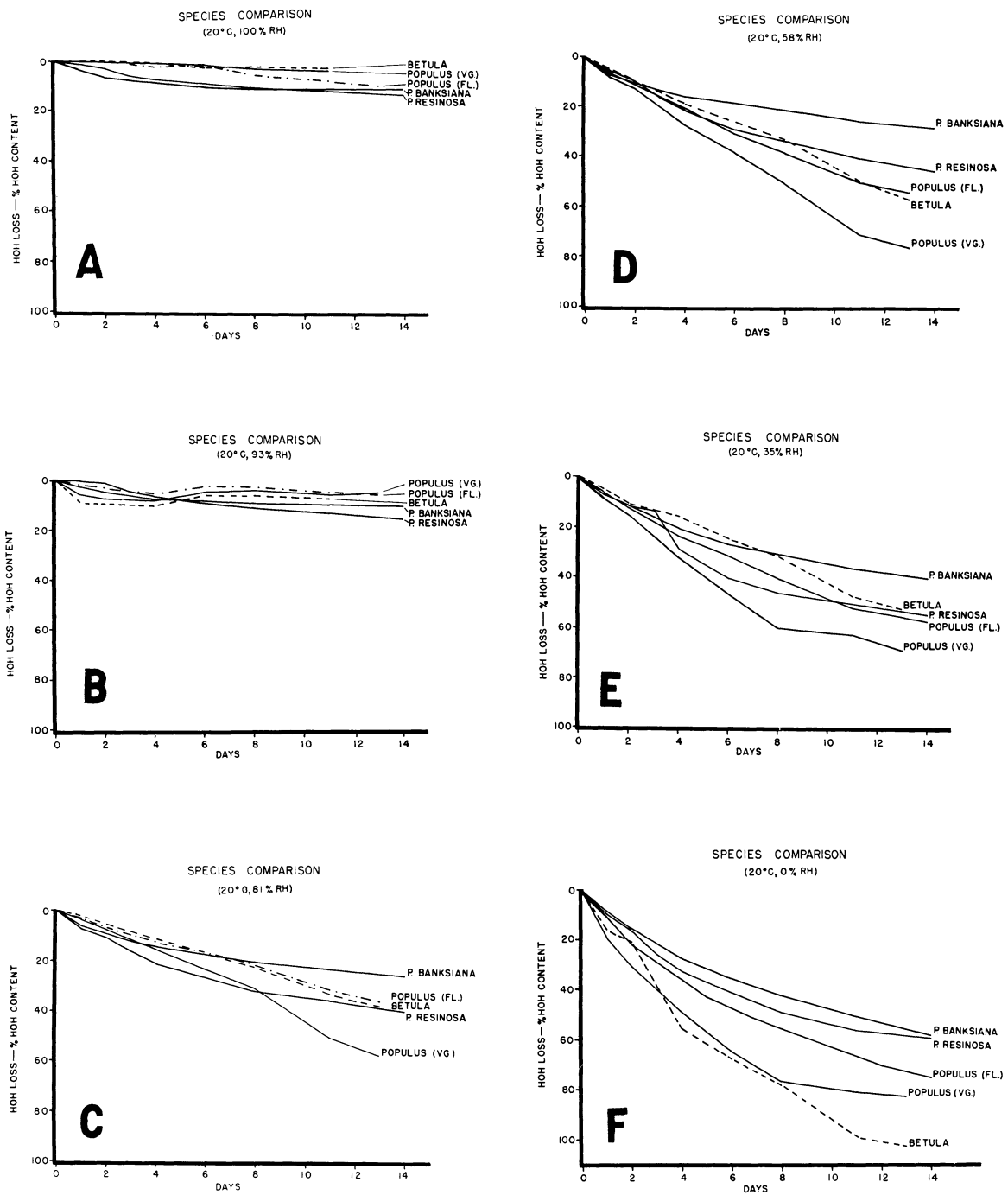


FIG. 1.—Variations in bud transpiration of various tree species for 14 days at 20° C and at various relative humidities

lost water slowly. Still further reduction of relative humidity to 35 and 0% caused progressively more rapid water loss and further identified jack and red pines as well adapted to prevention of water loss by bud transpiration. Even at 0% relative humidity jack- and red-pine buds had lost only slightly more than half their moisture after 14 days while, in contrast, the vegetative buds of aspen had lost approximately four-fifths and white-birch buds practically all their moisture. Vegetative buds of aspen consistently transpired faster than flower buds.

Marked differences in bud transpiration among the three pine species are shown in table 2. With a constant temperature (20° C) a progressive decrease in relative humidity caused greater bud transpiration. Water loss was in the following order: white pine > red pine > jack pine. The unusual ability of jack-pine buds to prevent water loss was demonstrated by retention of over 40% of their total moisture even after continuous exposure for 10 days to 0° relative humidity at 20° C. Red-pine buds showed only

slightly greater moisture loss than those of jack pine at 0% relative humidity. At higher relative humidities, however, moisture loss by red-pine buds was more than twice as great as that of jack-pine buds. In contrast, white-pine buds lost well over half their moisture in 10 days at a relative humidity as high as 81%. The white-pine data were somewhat erratic but in general showed rapid dehydration of buds at low relative humidities.

Figure 2 shows that water loss from aspen flower buds could be increased either by increasing the temperature while maintaining a low relative humidity or by keeping the temperature constant and decreasing the relative humidity. After 13 days at 0% relative humidity and a temperature of 0° C transpiration had reduced bud moisture content by slightly over three-tenths of the total. Increasing the temperature to 27° C while maintaining a relative humidity of 0% almost completely dehydrated the buds in 13 days.

TABLE 2
VARIATION IN BUD TRANSPIRATION AMONG THREE SPECIES OF *Pinus* AT 20° C
AND AT DIFFERENT RELATIVE HUMIDITIES^a

RELATIVE HUMIDITIES	DAYS														
	<i>P. banksiana</i>					<i>P. resinosa</i>					<i>P. strobus</i>				
	2	4	6	8	10	2	4	6	8	10	2	4	6	8	10
100.....	2.6	3.2	3.9	4.4	4.8	3.1	6.2	7.9	9.1	10.9	2.5	3.0	5.5	6.7	8.4
93.....	3.2	3.7	4.4	5.2	5.6	1.7	5.8	7.2	9.4	11.8	2.9	10.0	16.0	24.2	26.4
81.....	4.6	6.1	7.3	8.8	10.1	10.3	16.2	21.6	26.8	32.0	23.5	37.0	50.1	72.1	79.3
58.....	5.3	6.7	7.7	9.3	10.8	10.4	17.0	22.6	29.4	34.6	18.7	36.2	56.9	77.6	98.9
35.....	5.7	8.4	10.3	13.3	15.4	11.9	23.5	29.9	40.6	46.5	18.8	31.2	40.2	57.4	65.8
0.....	15.0	21.1	27.4	35.2	42.3	16.1	24.6	32.7	41.6	48.6	32.0	44.7	64.6	79.1	95.0

^a Cumulative water loss as per cent of original water content.

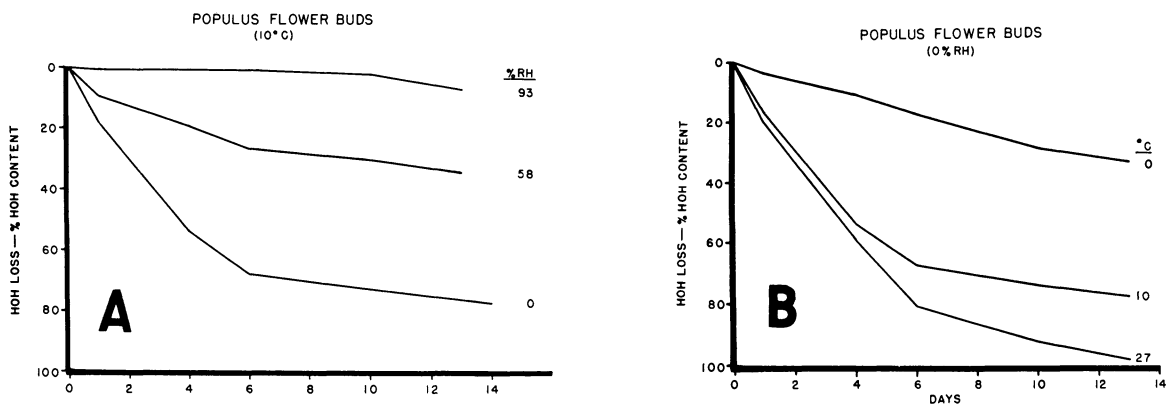


FIG. 2.—Effect of varying temperature (humidity constant) or varying humidity (temperature constant) on transpiration of flower buds of aspen.

These experiments emphasized the fact that water loss from detached dormant buds of forest trees is very responsive to changes in vapor-pressure gradients from the buds to the surrounding atmosphere. There were, however, marked differences among species in water retention by their buds even under severe drying conditions. Bud transpiration among the three species of pine was not well correlated with actual bud size or surface development of buds. Red pine, for example, had the largest buds of the three pines but retained its moisture almost as well as jack pine and much better than white pine, which had the

smallest buds. The surface development of buds computed as cm^2/g for the three species of pine was: white pine—10.7, red pine—5.7, and jack pine—9.6. Hence, no positive correlation existed between bud transpiration and surface development. This is not in accord with BURSTRÖM (1948) who found that *Carpinus* buds with a surface development of 14.6 (calculated as cm^2/g) had higher transpiration capacity than *Fagus* buds with a surface development of 11.5. Possibly bud transpiration in pine is controlled largely by the properties of the scales and especially the amount of resinous coating.

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PHENOTYPIC STABILITY IN CORN AS RELATED TO TIMING OF MOISTURE STRESS DURING EARLY DEVELOPMENT¹

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ABSTRACT

During 2 years three dent corn inbreds and their hybrids were subjected to specific periods of moisture stress early in development in the greenhouse. Timing and length of seven stress treatments were based on emerged leaf number. The severity of stress was judged by observation of the plants rather than by actual determination of soil moisture. Measurements made during the post-silking period of kernel-row number, plant height, and dry root weight for treated plants were compared with similar data for plants not subjected to deficient moisture. Kernel-row number of the top bud was reduced significantly only by treatments imposed during the six- to nine-leaf stage. In contrast to the short period of sensitivity found for kernel-row number, plant height and root weight were reduced by all treatments and increasingly so by successive stress periods. The conservative nature of kernel-row number is attributed to a short period of sensitivity to environmental influence during ontogeny.

Introduction

Investigations of the inheritance of phenotypic stability have provided theories on the genetic mechanism of homeostasis in corn and other plants (LERNER, 1954; LEWIS, 1954; ADAMS and SHANK, 1959). While different genotypes and levels of heterozygosity influence constancy of performance, individual characters have different levels of stability. In corn kernel-row number is established during early ontogeny (MARTIN and HERSHEY, 1934; KIESSELBACH,

1949; BONNETT, 1953) and usually does not deviate consistently or extensively regardless of the environment in which development occurs (EMERSON and SMITH, 1950). For a given corn inbred or hybrid, however, row number is not always constant, and even for the same plant differences between top and second ears occur. Number of kernel rows has been reduced by severe early defoliation (ALEXANDER, 1952) and increased by early application of nitrogen fertilizer (SCHREIBER, STANBERRY, and TUCKER, 1962). In contrast, plant height and root development may be modified more readily by environmental factors (MARTIN and HERSHEY, 1934).

The experiments reported here concern the greenhouse phase of investigations into environmentally

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