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Release of postsenescent dormancy in leafy spurge (*Euphorbia esula*) by chilling[1]

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Abstract:

The growth and development of leafy spurge (*Euphorbia esula* L. #[2] EPHES), collected during postsenescent dormancy and grown in the greenhouse was increasingly stimulated by chilling treatments longer than 14 days duration at 0 to 6º C. Production of stems with flower buds, primary flowers, and secondary flowers was greater in plants chilled for 42 days or more. The effects of chilling on total number of stems, number of strictly vegetative stems, or number of stems with vegetative branching were not significant. The height of the tallest stem per pot was influenced by chilling longer than 42 days. Growth rate also increased as a function of chilling duration. Based on our findings, we believe that there is little possibility that any significant growth can occur in the postsenescent period because of the prevailing climatic conditions found in areas of leafy spurge distribution in North America.

Introduction

Leafy spurge is a serious noxious weed of the northern Great Plains and Rocky Mountain regions of North America and persists despite the many chemical and cultural control efforts (1, 7, 13). While aboveground growth can be temporarily halted or destroyed by chemical and cultural methods, the long-term persistence of leafy spurge is primarily due to its extensive root system (1, 7, 13), which has both crown buds and numerous adventitious root buds capable of producing shoots (2, 10, 11, 12). Successful management of leafy spurge will be greatly enhanced by a better understanding of this complex root system, which is so difficult to control.

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[2] Letters following this # symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl. 2. Available from WSSA, 309 West Clark Street, Champaign, IL 61820.

Published work has demonstrated the effect of phytohormones, plant nutrients, and water status on root bud dormancy in leafy spurge (5, 6, 8, 9). Seasonal variation in the capacity of root buds to produce new shoot growth has previously been observed (8, 11), but experiments designed to test the effect of chilling on dormancy in leafy spurge were only done on excised buds from presenescent plants (8).

Root cuttings collected from the field and planted in the greenhouse during the first week of September (1984) for rearing of biological control agents failed to grow more than 1 to 2 cm even after 3 months of warm temperatures and adequate water and nutrients. Similarly, root cuttings collected during the last week of September (following 2 weeks of cold temperatures and some snow) initiated rapid growth within 1 week in the same greenhouse under identical growing conditions. After 3 months, the late September cuttings had grown 30 to 50 cm in height and had flowered on both primary and secondary inflorescences. In a different study, we have been investigating the phenology of new shoot development at the perimeter of established clones of leafy spurge, and preliminary evidence suggests that new stems appear after seed dispersal but before winter (unpublished data). Our observations that postsenescent dormancy was broken by a short cold weather period suggested that new stem initiation might be possible even in late fall during warm weather, following a cold spell.

The primary objective of our study was to determine the effects of different lengths of chilling on the growth and development of leafy spurge during the period of postsenescent dormancy. Implications of these findings were then related to the possible postsenescent production of new growth in leafy spurge.

Materials and methods

Two hundred root cuttings of leafy spurge were collected 2 mi. north of Bozeman, MT (45º 40' N Lat., 111º W Long.) in the first week of September 1984 and potted in 16-cm-wide by 18-cm-tall round pots in a mix of equal volumes of sand, silt loam, and peat. The plants were maintained in a greenhouse with alternating day/night temperatures of 25/18 C (± 3º C) and a 16-hour photoperiod maintained with wide spectrum fluorescent lighting.

On January 2, 1985, five groups of 10 pots were selected randomly and assigned to a treatment or control. Forty pots for the chilling treatments were placed in a greenhouse room maintained at 3 ± 3º C without supplemental lighting [prevailing day length: treatment day 1 (January 2) 8 hours 50 minutes; day 32 (February 2) 9 hours 48 minutes; day 60 (March 2) 11 hours 11 minutes.]. All pots were initially randomly positioned and thereafter systematically rotated twice weekly. The 10 control pots were placed in a heated (21 ± 3º C) greenhouse room without supplemental lighting. At 14-day intervals, 10 pots (one treatment group) were removed from the chilling room and placed in the heated room with the control group and all pots randomly repositioned. Thereafter, all pots were systematically rotated twice weekly.

Plants were measured twice weekly for the duration of the experiment. Variables measured for each pot were: 1) the number of elongating stems, 2) the height of the tallest stem, 3) the number of stems with flower buds present without open flowers, 4) the

number of stems with open flowers on the primary inflorescence (the terminal umbel), 5) the number of stems with flowers on primary and secondary inflorescences (lateral umbels), 6) the number of stems that had lateral vegetative branches, and 7) the number of stems that remained strictly vegetative.

Data were analyzed by one-way analysis of variance and, where appropriate, multiple comparisons of means based on Newman-Keul's sequential studentized range test were applied. Regressions of the growth rates of the last 45 days of growth were compared by t-test.

Results and discussion

Growth of leafy spurge stems was dramatically affected by the length of the chilling treatment (Figure 1). Within 10 days of being placed in the chilling room, all leaves turned red and began to abscise. In all cases, no new stems were initiated during the chilling and no stems present before chilling had any growth during or following chilling. All post-treatment growth was from elongation of existing crown and/or root buds.

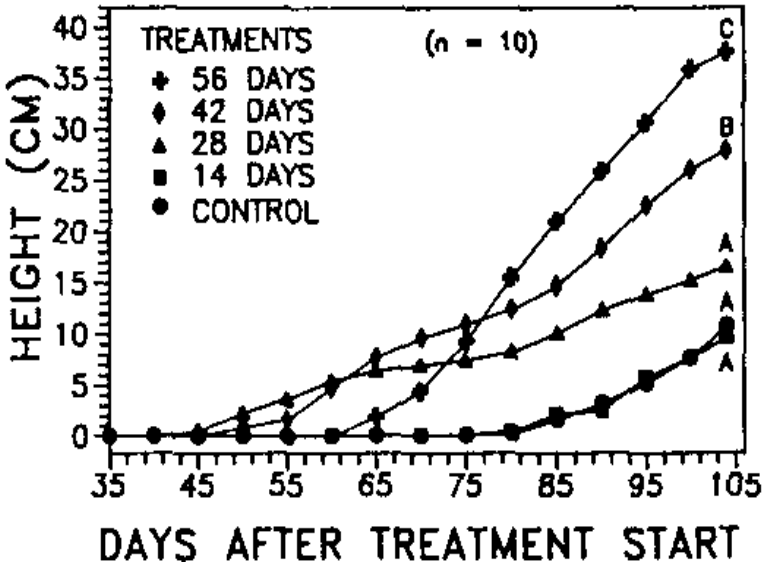

Figure 1. Growth of field-collected postsenescent leafy spurge grown in the greenhouse following four different durations of chilling treatment at 3 ± 3° C. (Curves without letters in common are significantly different: P<0.01, Student's t-test of regression line slopes and analysis of variance of final height).

The height of treated plants at the end of the experiment was significantly greater than those in the control group after 42 days of chilling (P<0.01). Fourteen days chilling had no effect on shoot growth. Growth rate also increased with successively longer chilling periods. Plants from the 28-day treatment began growth 17 days after removal from the chilling temperature, whereas those from the 14-day treatment did not begin to grow until

56 days post-treatment. Plants from the 42-day treatment took only 19 days to surpass the growth of those from the 28-day treatment and maintained the higher growth rate throughout the remainder of the experiment. Plants from the 56-day treatment had the highest growth rate and in only 21 days surpassed the height of those from the 42-day treatment. As previously mentioned, each succeeding treatment had 14 fewer days of growing time in the warm room.

There were no apparent effects of chilling on the total number of stems per pot or on the number of strictly vegetative stems per pot. The effects of chilling on the number of stems with vegetative branching were also nonsignificant, although all treatments had at least one stem with vegetative branching while the control group had none.

Chilling significantly affected phenological development of the plants (Figure 2). Exposure to chilling temperatures for more than 42 days or longer increased the number of stems that, at a minimum, developed flower buds ($P<0.05$). Both primary and secondary inflorescences were more numerous with each successive increase in chilling time but significantly greater only after 56 days of chilling treatment ($P< 0.01$).

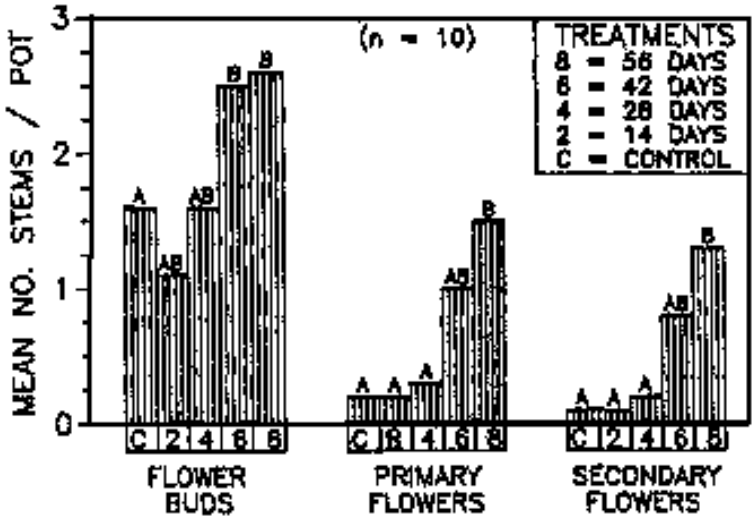

Figure 2. Phenological development of field-collected postsenescent leafy spurge grown in the greenhouse following four different durations of chilling treatment at 3 ± 3º C. (Bars without letters in common are significantly different: Flower Buds $P<0.05$, Primary and Secondary Flowers $P<0.01$).

These results indicate that the minimum length of the chilling period required to release the plants from the postsenescent dormancy is about 42. This is a longer chilling period than Nissen and Foley (8) report for release of innate dormancy of plants in full flower (8 days at 4º C). However, Nissen and Foley worked with plants from presenescent phenological stages (compared with our postsenescent plants) and experimented on excised root buds rather than fully potted plants. The discrepancy between results is not likely due to different ecotypes, since chemotaxonomic studies of leafy spurge have not demonstrated any biotype differentiation (4). The soil surrounding the buds in our ex-

periment may well have acted as a heat sink; the room temperature was maintained between 0 and 6º C but the soil temperatures may not have been as cool because of solar heating during sunny weather.

We did not determine whether the postsenescent dormancy observed was innate or caused by correlative inhibition, but the absence of any active growth centers makes the latter seem unlikely. Correlative inhibition of root buds occurs during most of the growing season in leafy spurge, although during full flowering the buds appear to be internally controlled by innate dormancy (8, 9).

Any significant production of new clone perimeter growth in the postsenescent period is unlikely in the field. Raju et al. (11) reported that in Canadian leafy spurge sites, the number of root buds and shoots present on 5-cm-long root fragments excavated in the field decreases in early summer to a seasonal low during the period of full flowering. During the postflowering stage, the number increases to a seasonal high during August and then decreases during senescence to the spring level by the first of October. Our results indicate that about four weeks of chilling would be required to release postsenescent dormancy and even then growth may not occur for another 17 to 19 days with the growth rate remaining quite low. Because the distribution of leafy spurge in North America is predominately north of 40º north latitude (13) where the average date for the first killing frost in the fall occurs during September (3), the likelihood for sustained warm temperatures following a 2-week chilling period is very low. Therefore, it is unlikely that much growth can occur during the postsenescent growth period throughout the current distribution of leafy spurge in North America.

Additional studies of postsenescent dormancy should include other temperatures and investigations of the interaction of photoperiod and chilling, since the timing of treatment during the senescence period and/or the treatment temperature could affect the degree or speed of response to a cold treatment.

Prevention or release of postsenescent dormancy by application of plant growth regulators have not been attempted in leafy spurge. If dormancy could be prevented or released, any fall shoot growth would be subject to winterkill. This may reduce the number of root crown and/or root buds present, and/or reduce root nutrient reserves. However, living plant tissues during this period are below ground and getting plant growth regulators into the plant would not only be difficult but likely expensive as well.

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