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The physiology of leafy spurge root bud dormancy

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Anyone who has been around leafy spurge very much knows the vegetative root buds are key to the persistence of this weed. The tremendous root system of leafy spurge stores enough carbohydrate for several years, and anytime the top growth is disturbed. The adventitious shoot buds can produce new photosynthetic growth. Our research has focused on factors which control the growth of these root buds.

We have worked with plants that have extensive root systems, so that we could study the root buds along the entire length of the root system. Uniform plant material was produced by taking root cuttings of a single plant. Plants were grown in containers for several months and then these plants were transferred to large PCV pipe 4" diameter and 39" long. Plants range in age from 1 to 2 years, so we feel this is fairly representative of a field-type perennial plant; Leafy spurge does extremely well in this system.

Using plants grown in the system I have just described, a wide variety of experiments have been performed, all aimed at developing an understanding of root bud dormancy. Initial work examined the relationship between growth and 1) bud size, 2) distance of the bud from the crown, and 3) diameter of the root on which the bud is located. We also were interested in the effects of chilling temperatures on the growth response of leafy spurge root buds since chilling temperatures have been shown to affect the growth of buds in many types of plants.

Controlling bud growth with exogenous auxin applications and ethylene inhibitors has also been examined.

On the whole plant basis, we have determined the effects of TIBA, which restricts the polar movement of IAA in the plant. The flow of auxin from the top part of the plant to the lower part can be restricted using this compound. We have also worked with materials called cytokinins, which stimulate cell division and are currently engaged in measuring endogenous IAA levels in root buds.

By looking at the growth response of the bud in relationship to the initial size, the distance from the crown, and the root diameter. We hoped to determine how these parameters related to the potential for new shoot production. The potential of each bud on the root system to produce new shoots appears to be about equal. This means that any bud remaining alive has the potential to produce some new growth.

Now, let's examine the effects of chilling temperatures on root bud activity. The only time we found a positive response from chilling temperatures was after flowering, during that period we call summer dormancy. Leafy spurge will often lose its leaves after seed set and be in a dormant state until fall rains come. Regrowth from axillary buds marks the end of summer dormancy.

We found that root buds from plants which were setting seed grew very little. By placing intact plants in a cold room at 4°C for 8 days, a dramatic increase in root bud activity was produced. This indicated that the buds of leafy spurge respond to chilling temperatures and that fall or summer dormancy may be alleviated by over-wintering. This may partially explain the geographic distribution of spurge.

For our work with exogenous plant hormones, we devised a simple system where the hormone is placed in buffered solution in a small plastic vial, the open end covered with parafilm, and the end of a 2-cm root piece containing one root bud is pushed a short distance through the parafilm to contact the solution. A series of experiments were conducted in which we looked at the effect of varying levels of exogenous IAA and NAA, a synthetic auxin, on root bud growth. We were not able to stimulate growth, but we were able to inhibit the growth of buds by high IAA levels. We repeated the same experiment with NAA (napthalene acetic acid) and found it to be 100 times more effective in reducing root bud growth.

Working with exogenous plant growth regulators provides valuable information about the plants' physiology but it can lead to erroneous conclusion. That is why measuring endogenous IAA levels in the root buds is very important. IAA behaves as a weak acid, a property which is often used to separate it from other compounds in the plant. At pH 9.0, IAA is water soluble while at pH 2.7, it is soluble in organic solvents. We use this property of the molecule to do our separations and HPLC work.

Reverse phase high performance liquid chromatography (RPLC) was used in combination with fluorescence detection to measure endogenous IAA levels. The limit of sensitivity is approximately 1 ng per injection.

Approximately 100 milligrams of bud tissue is required to determine free IAA levels. A dormant bud from a plant which is growing vegetatively, has a free IAA level of 650-nanograms/gram fresh weight. In buds from flowering plants, a somewhat higher level was measured. In comparison, the roots themselves have about 20-nanograms/gm fresh weight. There is about 50 times more IAA concentrated in the root buds.

In the process of measuring IAA levels in spurge root buds, we also found an unusual auxin compound present indole proponic acid (IPA). It was first reported in 1983 and has been reported in only three plant species to date. IPA is not a strong promoter of cell elongation but is more potent than IAA at producing lateral root formation.

I would like to summarize by listing some of the basic conclusions from the research we have conducted at Montana State University on the physiology of root bud dormancy. (1) All the buds have a tremendous potential for growth. (2) Chilling temperatures appear to be critical during certain life stages of the plant. (3) Growth of the root buds can be inhibited with high exogenous auxin levels. (4) No response from ethylene inhibitors indicated that ethylene was not involved in root bud inhibition. (5) A small stimulation of growth was produced using TIBA but not cytokinins. (6) Dormant root buds were found to have high levels of free IAA. (7) A unique auxin compound called Indol-3-Proponic acid was identified in the root buds of leafy spurge.