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FEATURES

Controlling Summer Annual Weeds

You have to know your enemy in order to vanquish it. A basic understanding of dormancy and germination can help you plan your attack on weeds in the field nursery.

By James Altland

A large percentage of problematic weeds in nursery production are summer annuals. Summer annual weeds complete their life cycle in a single year. They germinate in spring or summer, then mature and release their own seed before the first fall frost. Summer annuals generally produce a horrific number of seed that persist in the soil for many years (broadleaf seeds persist for years; grass seeds are short-lived). For example, redroot pigweed (Amaranthus retroflexus) can produce up to 100,000 seeds on a single plant, and those will persist in soil for up to 30 years. Annual weeds are easily controlled with herbicides and cultivation practices, however, their sheer numbers mean that even if a small percentage survive, weed control efforts appear ineffective.

Understanding weed biology offers clues about how summer annuals can be controlled. In this discussion we focus on seed dormancy and germination, which provides hints about how to use herbicides and tillage more effectively against massive numbers of germinating weeds.

Shown left, smartweed can produce viable seed just four weeks after germination, and a single plant can produce up to 19,000 seed. Below, Common lambsquarter germinates en masse in early summer; herbicide timing should occur just before peak germination.
PHOTOS COURTESY OF JAMES ALTLAND.

Seed dormancy

Weed control would be easy if seeds all germinated at one time. A single, well-timed herbicide or cultivation event, or even a fortunate hard freeze, would solve the problem by killing small seedlings when they are vulnerable. Of course, life is never that simple. Weeds defy obliteration in a single attack from man or Mother Nature by germinating at the time of year that maximizes their chances for survival, and by germinating sporadically over an extended period of time. To accomplish this, seeds use a clever set of tricks formally known as dormancy.

Dormancy is a condition of arrested development in seeds, buds or spores, even when conditions are otherwise favorable for growth. Seeds of most plants are dormant upon being dispersed by the mother plant.

The mechanism of seed dormancy varies by species. Seed dormancy can be induced by thick seed coats that restrict emergence of the embryo. Thick seed coats have to be worn away by mechanical abrasion, microbial feeding or cracked by freeze/thaw events. Once the seed coat has been compromised, water can be imbibed and germination can proceed. Some seeds contain immature embryos that require a period of time and/or changes in temperature to complete the maturation process. Other seeds contain chemical inhibitors within the seed coat that must be flushed away by rain or irrigation. There are many other mechanisms of dormancy.

Above, redroot pigweed is one of the most prolific weeds in nursery fields, producing up to 100,000 seed per plant.

Dormancy ensures survival in two ways. First, it ensures that seed germinate when environmental and climactic conditions are favorable for seedling establishment. For example, seed of many summer annuals require cold stratification before germination. This ensures that seed released late summer do not germinate when early fall frosts could kill the entire population. Instead, germination can only occur after several weeks of exposure to cold winter temperatures, ensuring springtime germination.

Dormancy also causes staggered germination over time. This prevents the entire population from germinating all at the same time and dying as a result of a sudden catastrophic event (such as flood, frost, tillage and so on). Staggered germination is accomplished many ways, but perhaps the most common mechanism is variable thickness in seed coat.

Herbicides applied too early in this field resulted in a weakened chemical barrier in early summer when many weeds germinate.

Dormancy vs. quiescence

Quiescence is enforced dormancy, which is an inhibition of germination due to local environmental factors. Quiescent seeds that are exposed to the proper environment germinate immediately. For example, seeds that are buried several inches in the soil will not germinate, likely because there is insufficient light or oxygen to trigger germination. However, if plowing brings these seeds up to the soil surface, they will germinate immediately.

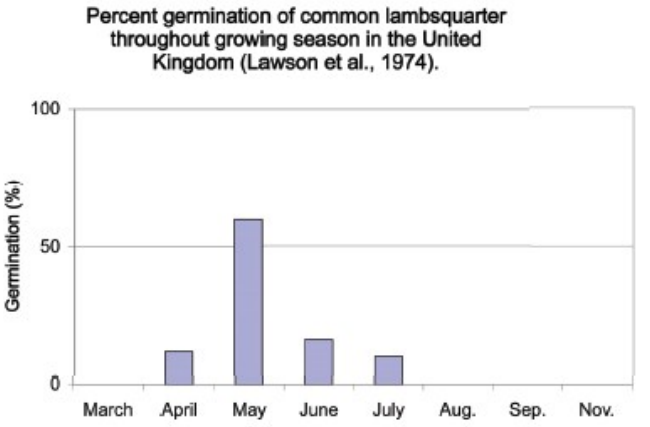

Figure 1. Although germination periods will differ by region, the chart demonstrates how some species germinate at peak times.

Quiescence is a powerful biological tool that increases the probability that seeds will survive after germination. Several factors are known to increase germination rates in seeds, and many of these factors are associated with soil disturbances. Recently germinated plants (weeds or otherwise) are poor competitors due to their small size. Larger plants are not likely to be present immediately after a soil disturbance (from tillage, for example), so seeds have evolved with mechanisms that promote germination soon after soil disturbances. Soon after soil is disturbed, seed that were buried several inches and brought closer to the soil surface would experience warmer soil temperature, increased fluctuations between day and night temperatures, increased oxygen levels, elevated soil nitrate concentration (from nitrification of decomposing organic matter) and, most importantly, increased light levels. One or more of these factors have been shown to increase germination in a broad spectrum of weed species.

Quiescent seeds will germinate when exposed to the above-mentioned changes in environment (species dependent). However, dormant seed will not germinate until dormancy conditions have been removed and local environmental cues indicate germination and survival will be successful.

Management guidelines

- Observe which annual weed species are most prevalent in your nursery.
- Observe the time of year in which they first germinate in high numbers.
- Apply preemergence herbicides just before peak germination. For summer annuals like common lambsquarter, redroot pigweed, smartweed (*Polygonum persicaria*) and nightshade, this might mean adding a supplemental herbicide application in late spring in addition to the early spring application.

The dormancy cycle

Seeds of most species dispersed from the mother plant have primary innate dormancy. This is the biologically programmed "built-in" dormancy seeds possess as they are released from the mother plant. After receiving the correct set of environmental cues (several weeks of cold weather, for example), dormancy is released and the seeds are ready to germinate. However, if the local environment is not right, seed remain quiescent. After a short period of quiescence, seed reenter a secondary state of dormancy called induced dormancy. Once they reenter dormancy, they cannot

germinate until the same set of environmental cues reoccur (again, several weeks of cold weather, for example). After receiving these cues, seed are once again "ready" to germinate.

Seeds cycle in and out of dormancy until the correct set of environmental and seasonal conditions are present that suggest the seeds will germinate and survive. Seeds cycle into the period when germination can occur at specific times of the year. The result is a period of peak germination.

Germination peaks

It has been observed with many weed species that germination occurs at a "peak" time during the year. For example, redroot pigweed germinates in large numbers in early summer. Throughout the rest of summer and early fall, conditions are right for germination, and there are certainly available seed for germination; however, germination rates are much lower. Chemical and mechanical weed control efforts should be concentrated at peak germination events in order to eliminate as many weeds as possible.

Figure 1 shows peak germination of common lambsquarter (Chenopodium album) in a study conducted in the United Kingdom. Germination periods will differ by region; nonetheless, it demonstrates how some species germinate at peak times.

Timing herbicide applications

Preemergence herbicides form a chemical barrier over the soil surface (see Figure 2). As seeds germinate and grow through this barrier, they are either stunted or killed. As soon as herbicides are applied, UV light, microorganisms and soil chemical factors cause herbicides to degrade. As herbicides degrade, gaps in the chemical barrier allow for weed germination.

Preemergence herbicides do not kill seeds. Instead, they kill small seedlings as they grow through the chemical barrier. As long as seeds remain dormant, chemical herbicides will have no effect on their survivability. Seeds cannot sense the presence of chemical herbicides in soil. They germinate at the point when external environmental cues break dormancy and/or quiescence. The trick is to apply herbicides so they are at high concentration in the soil at the time when most of the seeds germinate.

So how do I use this information?

It's been my observation that most nurseries struggle with one or a couple weed species. Sure, there are other weeds present, but it's just a few that seem to defy control practices and grow in large numbers. By focusing on these few weeds, you can tailor your herbicide applications to control peak germination events. This should dramatically improve your overall weed control program.

Consider, for example, redroot pigweed, which is one of the most difficult-to-control summer annuals in my part of the country. Observations from last year indicate this plant germinates during the first week of June. Many nurseries apply their first herbicide application in February or March. By June, after months of field activity to prepare plants for the growing season (staking, pruning, tying, and so on) and typical herbicide degradation, the chemical barrier is so depleted that there are numerous gaps for pigweed seeds to germinate. If peak pigweed germination does, in fact, occur in early June as suggested, a supplemental herbicide application applied prior to germination (in this case, mid-May) would reinforce the weakened chemical barrier and dramatically improve weed control.

Currently registered preemergence herbicides provide excellent control of redroot pigweed and other weeds. The trick is to make applications at the right time so that the chemical barrier is strongest when seed germination is highest. It is currently typical to apply two applications of preemergence herbicide each year - one in early spring and a second in early fall. An additional application made prior to the germination of the most problematic weed specie(s) should substantially improve control. Reduced hoeing costs should more than compensate for the additional cost of this extra application.

Seed dormancy is incredibly complex. Usually many factors interact to trigger dormancy and to release it. Investigation into seed dormancy is worth the time of serious weed managers. The ideas presented in this article are easier to write about than to implement. Nonetheless, by mapping critical events in weed germination, and preempting those events with herbicide applications, weed control should be much improved.

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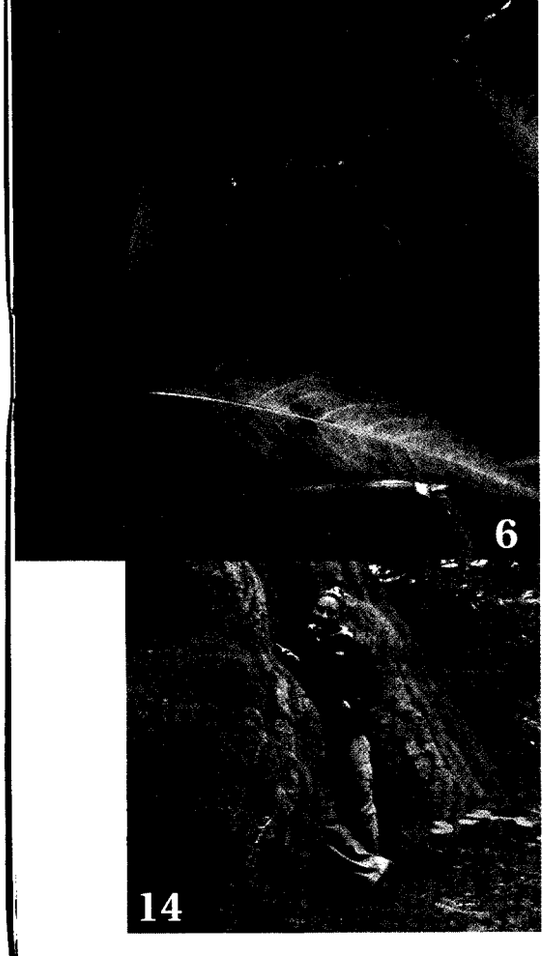

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On the cover:

One of the most common enemies found in field production, annual lambsquarters germinates prolifically in early summer.

PHOTO COURTESY OF JAMES ALTLAND.

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