Factors Influencing Bitterweed Seed Germination

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Abstract

Bitterweed seed germination exceeded 90% at constant temperatures between 20° and 25° C and more than 65% between 15° and 30° C in a controlled environment chamber. Seeds germinated equally well in light and dark conditions. Germination percentages of seeds in aqueous media with a pH range of 5 to 9 were significantly different, but the range of germination (91 to 97%) probably is not sufficient to affect distribution. However, a decrease in water availability significantly decreased bitterweed seed germination. Viability of bitterweed seed did not change significantly after 39 months dry storage at room temperature, but was significantly reduced at 47 months.

Bitterweed (*Hymenoxys odorata* DC.) is the major poisonous plant problem on the western Edwards Plateau of Texas. Annual death losses of sheep average 1 to 6% (Sultemeier 1961), with rare losses in cattle and goats. Cases of poisoning usually occur between December and May in years with sufficient moisture for rapid vegetative development of bitterweed. Bitterweed is not normally palatable to sheep, but they will consume it when other forage is limited (Kingsbury 1964). Bitterweed poisoning may be acute, subacute, or chronic. Chronically poisoned sheep become very weak and probably die from starvation and dehydration resulting from insufficient strength to obtain food and water. Many subacute and chronically poisoned animals will recover if removed from bitterweed infested rangeland and fed in confinement. A single lethal dose of bitterweed commonly causes death in 14 to 36 hr (Rowe et al. 1973).

The genus *Hymenoxys* Cass. (Compositae) contains 27 species and is confined to limestone soil or derivatives of limestone or of basic igneous rocks. Bitterweed is a native weed of overgrazed rangelands, roadsides, and disturbed areas (Correll and Johnston 1970). The distribution of bitterweed is from Kansas and Colorado south through Texas, Oklahoma, New Mexico, Arizona, and into Mexico (Tamaulipas, Nuevo Leon, Cohuila, Chihuahua, and Sonora) with the greatest concentration in the western Edwards Plateau region of Texas (Correll and Johnston 1970). The plant is a bushy, much branched annual which varies from 7 to 60 cm in height depending on environmental conditions (Sperry et al. 1964). The leaves are pinnatisect into 3 to 15 filiform lobes, with each ascending branch terminating in a small solitary head (Correll and Johnston 1970). The head has 6 to 13 yellow rays around a yellow disk. Unlike most composites, the achenes (seeds) are not released at maturity but are sealed into compact heads by the involucral bracts. When in contact with sufficient moisture the bracts open widely and free the achenes (Cory 1951).

The invasion and spread of bitterweed is an important economic problem in the western Edwards Plateau. Bitterweed is a prolific seed producer with 50 to 75 seeds per head (Rowe et al. 1973) and reports of 100 (Sperry 1949) to 3000 (Cory 1951) heads per plant. Cory (1951) reported bitterweed densities from 8.6 million to 18.5 million plants per hectare in an Edwards County study. The objective of this study was to determine some basic germination requirements of bitterweed seeds, with special reference to temperature, moisture stress, pH, light, and duration of viability. This information on germination responses to simulated environmental parameters should help to explain the geographical distribution of bitterweed and aid in predicting severity of bitterweed infestations in different range sites and seasons.

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Materials and Methods

Bitterweed seeds were collected in Glasscock County, Texas, in May, 1978. The seeds were left enclosed in the heads and stored at room temperature until the germination trials began. Each germination experiment was conducted using six replications of 50 seeds each in 10-cm diameter petri dishes. Fully developed and undamaged seeds were selected for all germination trials. Two Whatman No. 3 filter papers saturated with 6 ml of test solution were used as the germination substrate. The petri dishes were randomly placed on moist paper toweling in sealed clear plastic boxes which were placed within an environmental chamber for testing. Cumulative germination was recorded at 24-hr intervals over the 14-day exposure period. Seeds were considered to have germinated when the radicle was at least 2-mm long. Each experiment was repeated 1 to 3 times and the data pooled for presentation.

The effect of constant temperature on germination was tested at 5° C ± 1° C increments between 5° and 45° C. An alternating temperature regime of 20° to 30° C (16 hr low, 8 hr high) was also studied. All other experiments were conducted at 25° C.

The effect of moisture stress on germination was conducted at 25° C using aqueous solutions of polyethelene glycol (PEG) 6000 (Carbowax 6000, Union Carbide Corporation). The solutions were mixed by the method described by Michel and Kaufmann (1973) to exert osmotic potentials of -2, -4, -8, -12 and -16 bars. Distilled water was used for the 0 bars treatment. The pH of these PEG solutions was 7.2. The effects of concentration and temperature on the osmotic potential of PEG-6000 solutions differ from those for most salts and sugars and are apparently related to structural changes in the polymer (Michel and Kaufmann 1973).

Light requirements were investigated at 25° C by comparing germination of bitterweed seeds in petri dishes covered with aluminum foil with that of seeds in transparent dishes. Aluminum foil was not removed from the petri dishes during the 14-day trial. All other experiments were conducted under constant light. Fluorescent and incandescent lights were used for all experiments using light.

The effect of pH on germination was investigated at 25° C by adjusting the hydrogen ion concentration of distilled water with HCl or KOH. This approach avoided the potential osmotic effects exerted by buffered solutions (Scifres and McCarty 1969). The changes in pH of these unbuffered solutions was minimal (from 0.1 to 0.2). A range of pH values from 5 to 9 in whole unit increments was tested.

The effects of age on seed viability was evaluated by testing germination of seeds collected in Sutton County, Texas, in May 1976 at bimonthly intervals from collection to 47 months after collection. This test was made on seeds collected in Sutton County in 1976.

Germination data were subject to arcsin $\sqrt{P}$ (P = proportion germinated) transformation prior to conducting analyses of variance. Differences among means were compared with Duncan's multiple range tests where appropriate.

Results and Discussion

Description of Achene

Bitterweed achenes are 2 to 3 mm long and densely hairy with acuminate scales. The hairs on the achenes tend to expand outward with the absorption of water thus orientating the achene with one end touching the substrate. This agrees with the observation of Mayer and Poljakoff-Mayber (1975) that the orientation of achenes toward the soil is frequently determined by morphological features of the achene, particularly in the Compositae. Sheldon (1974) stated that the position of an achene on a soil surface has a significant effect upon germination. He also stated that in the case of the achenes of Compositae, a high level of germination occurs if the scar of attachment region is buried. The dry achenes used in this study weighed 0.228 g per 1000.

Temperature

Temperature is one of the most important of the specific conditions that must be met during the period of seed germination (Toole et al. 1956). In the range of temperatures within which any seed germinates, there is usually an optimal temperature. Above and below this optimum temperature germination is delayed but not prevented. This optimum may be considered that temperature at which the highest number of seeds germinate or at which the highest percentage of germination is attained in the shortest time (Mayer and Poljakoff-Mayber 1975). A rise in temperature does not necessarily result in an increase in either the rate of germination or in ultimate germination percentage.

The constant temperature germination data are shown in Figure 1. Limits of germination were approximately 5° and 45° C with no germination occurring at either temperature. The optimum temperature appeared to be between 20° and 25° C with no significant ($P<0.05$) differences in germination between these temperatures on day 14. The highest germination percentage was achieved at 20° C but initial germination was more rapid at 25° C. Total germination exceeded 90% at these temperatures. Cumulative germination exceeded 65% at constant temperatures of 30° C or 35° C but less than 40% at 15° C and less than 20% at 10° C or 40° C (Fig. 1). Germination at 40° C was rapid but never exceeded 10%. The alternating temperatures regime of 20° to 30° C (16-hr and 8-hr, respectively) did not significantly ($P<0.05$) increase the germination percentage over that obtained at constant temperatures of 20° or 25° C (data not shown). These data support field observations that bitterweed seeds germinate at any time of the year but most often germinate and establish during late fall, winter, and spring.

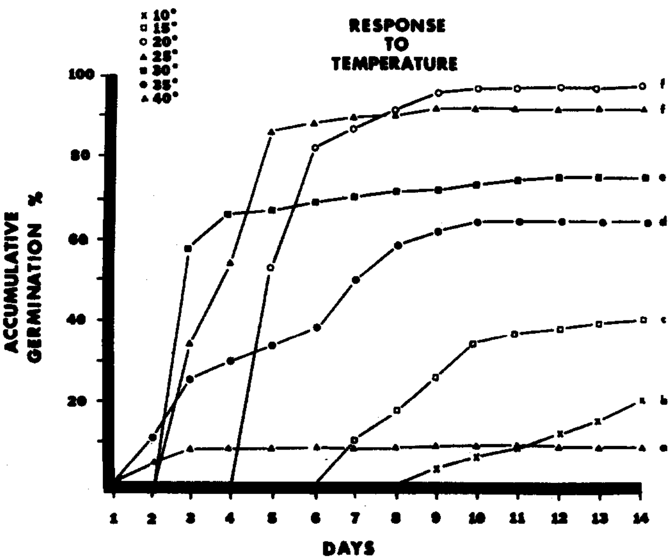

Fig. 1. *Bitterweed germination response to constant temperatures. Mean germination percentages for day 14 with similar lower case letters are not significantly different at P<0.05.*

Moisture Availability

The germination response of bitterweed to moisture stress is shown in Figure 2. Germination at day 14 was significantly ($P<0.05$) reduced by any increase in moisture stress. These data are in agreement with field observations which show that bitterweed is most abundant during cool weather when soil-water contents are adequate for vegetative growth. The ability of seeds to absorb water from the soil as compared to water uptake from the prepared solutions is determined not only by the osmotic potential of the soil solution, but also by the matrix potential of the soil. Contact of the seed surface with soil particles is very important in this respect (Mayer and Poljakoff-Mayber 1975). A lack of tolerance to moisture stress under these laboratory conditions might be even more critical under field conditions.

Hydrogen Ion Concentration

The response of bitterweed seed germination to hydrogen ion concentration is shown in Figure 3. Within the range of pH tested (5 to 9), bitterweed germination demonstrated a significant ($P<0.05$) positive linear response to increasing pH. The highest germination percentage occurred at pH 9. Since the germination percentage ranged from 91% to 97%, the geographical distribution of bitterweed cannot realistically be attributed to a germination response to pH. This is surprising because bitterweed reaches its greatest concentrations on the highly calcareous limestone derived soils of the western Edwards Plateau. Thus, more research is needed concerning seedling establishment requirements to elucidate the mechanisms responsible for the affinity of bitterweed to calcareous soils.

Light

Light requirement is frequently associated with small seeds because they presumably have small quantities of food reserves and therefore must germinate under conditions where photsynthesis occurs soon after germination. However, seed size is not an adequate measure of the amount of food reserves present relative

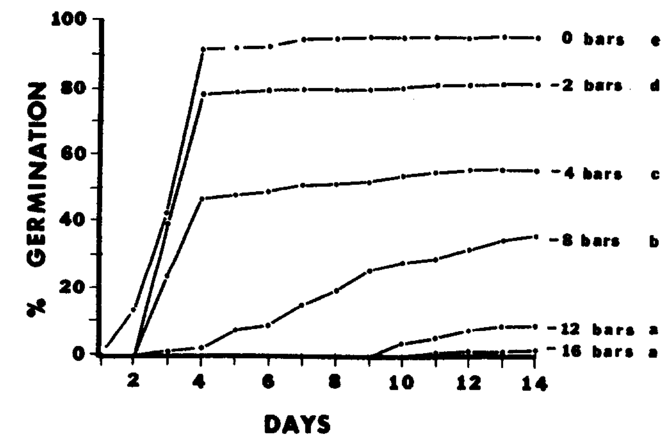

Fig. 2. *Bitterweed germination response to various moisture tensions at 25° C. Mean germination percentages for day 14 with similar lower case letters are not significantly different at P<0.05.*

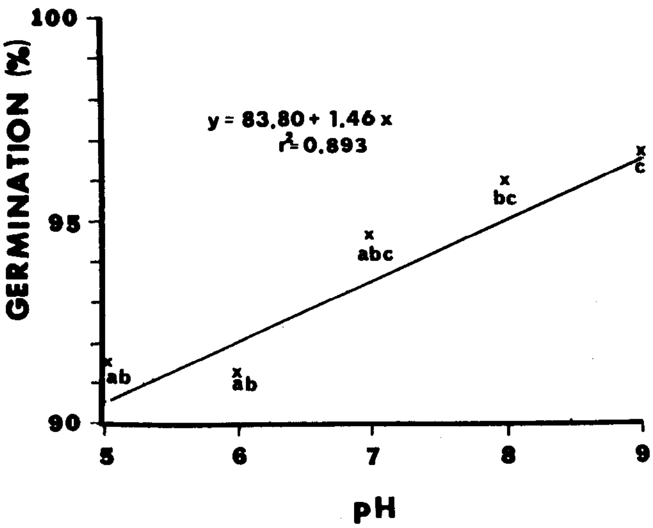

Fig. 3. *Bitterweed germination response to various hydrogen ion concentrations at 25° C.. Mean germination percentages with similar lower case letters are not significantly different at $P<0.05$.*

to the requirements of the seedling (Mayer and Poljakoff-Mayber 1975). Moreover, the light exposure required to stimulate germination is so brief that it is received under most normal circumstances (Mayer and Poljakoff-Mayber 1975). In this experiment the presence of light had no significant ($P<0.05$) influence on the germination of bitterweed seeds (data not shown).

Length of Viability

Germination of bitterweed seeds was not significantly reduced at 39 months after collection ($P<0.05$), compared to 1 month after collection (61% germination). However, germination decreased by almost half (to 33%) at 47 months after collection which was a significant ($P<0.05$) reduction.

Conclusions

Bitterweed has tremendous reproductive potential and the capacity to rapidly infest new areas. Bitterweed seed germination occurs over a wide range of temperatures and pH, but adequate soil water content is critical to germination. These studies demonstrate the wide range of environmental parameters tolerated by bitterweed seeds. If environmental conditions for seedling establishment parallel those for germination, bitterweed could potentially occupy a much larger distribution than its present range suggests. Since the geographical distribution apparently cannot be explained solely on the basis of germination requirements, at least those parameters tested in this study, they may be determined by factors affecting seedling establishment or other aspects of its life cycle. However, knowledge of germination requirements will aid range managers in predicting the severity of annual bitterweed infestations within its distribution.

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