

Biology and Control of Perennial Pepperweed

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Background

Perennial pepperweed (*Lepidium latifolium* L.) is an invasive weed found throughout California. It is a herbaceous perennial that produces stems up to 1.5 meters in height in dense stands. These stems originate from large desiccant-resistant rhizomes or semi-woody crowns beneath the soil surface. Features such as these help perennial pepperweed infest a variety of environments or ecosystems throughout the west including rangelands, wetlands, meadows, pastures, marshes, riparian areas, flood plains, roadsides, irrigation channels, and even agricultural fields (alfalfa). In these areas perennial pepperweed can outcompete nearly all other species.

Perennial pepperweed is native to Africa, Europe and Asia (2). Initial infestations in California were suspected to have originated from a sugarbeet seed contamination in the 1930s (8). This noxious weed has been rapidly spreading since, and is now found in every county in California except Del Norte, Humboldt, and Imperial. It has also been documented in every state in the western United States except Arizona (10). Perennial pepperweed poses a serious threat to many native ecosystems and previously disturbed areas returning to their native conditions (3). In these environmentally sensitive habitats perennial pepperweed can displace threatened and endangered species, such as the salt marsh harvest mouse (9) or interfere with the regeneration of important plant species such as willows and cottonwoods (10). Due to its invasiveness the California Department of Food and Agriculture (CDFA) has rated perennial pepperweed a class B noxious weed and the California Exotic Plant Pest Council (CalEPPC) categorized this weed as A-1 (most invasive wildland pest plant).

Biology

Very little information is known about the biology of this pest. Germination rates are high when seeds are exposed to fluctuating cold/warm temperatures (3). However, seeds do not seem to be capable of surviving long periods in the soil (lack a hard seed coat), thus seed viability may be short. This suggests that reinfestation by seed may not be a problem once control is achieved (3).

Vegetative growth appears to be the primary mechanism for spread in California. Excavation of below ground organs revealed that 19% of all roots and rhizomes were present in the top 10 cm of the soil, with 85% in the top 60 cm (5). These below ground organs constitute 40% of the plants overall biomass (5). This large underground root and rhizome system is thought to enhance the below ground competitiveness of perennial pepperweed for water and nutrients while increasing the carbohydrate reserve important for rapid shoot development in the spring (1,4,5,6,7).

Control

Long-term management of perennial species is often difficult. Perennial pepperweed is no exception. When used alone, non-chemical control methods, including disking (11) and mowing (5,6,7,9), are not effective. Limited success has however, been documented with the use of herbicides. Young et al. (11) found that two years of control was obtained with the use of chlorsulfuron at 0.11 kg/ha. Unfortunately, this herbicide is only registered in non-crop situations in California. Herbicides approved for use in environmentally sensitive areas vulnerable to infestations (2,4-D, glyphosate, triclopyr) provide poor control of perennial pepperweed 1 year after treatments (see table) (7). Thus, many riparian and wetland areas which are highly susceptible to invasions lack an effective control strategy for perennial pepperweed.

Research

The goal of this study is to develop perennial pepperweed control strategies for sensitive wetland and riparian areas. Research is focusing on understanding important biological processes of this weed and using this information to develop integrated control strategies. Our current efforts are centered on determining the seasonal translocation patterns into rhizomes and crowns of perennial pepperweed and evaluating the affect mowing has on this process. With this information, we can determine the optimal timing of control strategies such as herbicide applications and/or mowing. From our initial results we have found that integrating mowing and herbicides can significantly enhance long-term control of perennial pepperweed (6,7). We are currently pursuing the mechanisms responsible for improved control and optimization of this integrated approach.

From earlier studies, we reported that minimum energy is stored in the rhizomes when the plants are at the bolting stage (6,7), indicating the optimal time to mow stems. Perennial pepperweed quickly recovers from mowing and produces leaves from previously dormant buds. These leaves quickly expand and reestablish a positive carbon budget for the plant. This was shown to require less than 14 days (unpublished data) and can explain why mowing alone is not an effective control strategy.

We have also found that perennial pepperweed begins allocating large amounts of photosynthate to the rhizomes and crowns during the flower bud stage. Translocation to below ground structures is maximal from throughout the flowering to seed filling stages (7, unpublished data). Assuming that herbicide movement parallels carbohydrate movement, herbicide applications during the flowering to seed filling stages would be expected to maximize herbicide accumulation in the rhizomes and thus provide more effective long-term control. Previous reports however, have determined the optimal timing for herbicide applications to be the flower bud stage (1,9,11). Why is control maximized when using herbicides at the flower bud stage? We hypothesize that coverage and absorption of herbicides is much greater during the flower bud stage than the flowering to seed fill stages. During the flowering to seed filling stages plants developed many flowers, stems and fruits not present during the flower bud stage. We hypothesize that these organs reduce the interception of herbicide by leaf tissue. We also hypothesize that these organs cannot absorb herbicides to the same degree as leaves. Leaf

abscission during flowering also reduces leaf area. Although translocation rates are not maximized in the flower bud stage, increased coverage and absorption may allow greater accumulation of translocated herbicide into rhizomes and crowns. We plan on quantifying this hypothesis next year.

By integrating mowing and herbicides, dramatic increases in the control of perennial pepperweed have been demonstrated (6,7). This control strategy involves mowing stems when minimum energy is stored below ground, followed by a herbicide application to recovering stems when translocation patterns favor accumulation in rhizomes and crowns. One year control data showed all different mowing regimes evaluated (control, mowed once, mowed twice and chemically mowed) increased the effectiveness of herbicides in controlling perennial pepperweed stems compared to unmowed plots with and without herbicide treatments (see table) (6,7). Glyphosate provided an 89% increase in control 1 year after treatments, compared to 20% in unmowed areas (see table). We are currently determining the mechanisms responsible for this increased control.

We did not find any differences between seasonal translocation patterns into rhizomes and crowns in unmowed and mowed plants. This indicates that mowing did not alter seasonal translocation patterns or rates and is not responsible for increased control. Herbicides were applied to mowed areas later in the season during periods of maximal translocation. This could have increased herbicide accumulation into rhizomes and crowns thereby enhancing control. Stem and leaf morphology and architecture also differ dramatically between mowed and unmowed stems at the time of application. Leaves of unmowed plants were small and often perpendicular to the ground while leaves from mowed plants are much larger and parallel to the ground. Mowing can reduce stem density (64 stems/m² in mowed plots compared to 142 stems/m² in unmowed plots) and stem height (49.21 cm in mowed plots compared to 96.42 cm in unmowed areas) at the time of application (5,6,7). These factors may increase coverage and absorption of the herbicide, resulting in increased accumulation in rhizomes and crowns.

Conclusions

Even though perennial pepperweed has low carbohydrate levels stored in rhizomes and crowns during the bolting stage, it can quickly reestablish a positive carbon budget. This limits the use of mowing as a sole control strategy. Herbicides registered for use in wetland and riparian areas also show limited control, but mowing appears to dramatically increase their control (see table). This increase is not due to a shift in the seasonal translocation pattern or an increase in translocation rates to the rhizomes and crowns. Mowing may change the stem and leaf morphology and architecture of recovering perennial pepperweed, enabling greater coverage and absorption of herbicides. Later applications also appear to coincide with maximal basipetal translocation rates, potentially increasing herbicide accumulation in rhizomes and crowns. Future research efforts will examine the physiological mechanisms involved in optimize this integrated approach.

Table. Percent Visual Control of Perennial Pepperweed - 1 Year after Treatment

Herbicide	Rate (kg ai/ha)	Unmowed	Mowed Once	Mowed Twice	Chemically mowed*
Chlorsulfuron (Telar [®])	0.052	57.50 (CDE)	87.25 (AB)	99.50 (A)	88.75 (A)
Glyphosate (Roundup [®])	3.33	20.00 (DEFG)	88.75 (A)	81.67 (AB)	86.67 (A)
Imazapyr (Arsenal [®])	0.14	35.00 (CDEFG)	76.25 (AB)	87.50 (A)	80 (AB)
2,4-D (Weedar 64 [®])	2.11	13.75 (EFG)	2.5 (G)	45.00 (CD)	58.33 (BC)
Untreated	-	0 (G)	0 (G)	10.00 (FG)	12.50 (FG)

*Plots were chemically mowed by applying 2,4-D (2.11 kg/ha) at the flower bud stage. Herbicide treatments were applied to stems after they recovered to the flower bud stage.

Table: Data taken from a roadside area in Woodland California 1 year after treatments were applied. Mowed treatments were cut when plants or recovering plants reached the flower bud stage. Herbicides were applied to unmowed plots: 4/29/97, mowed once plots: 5/28/97 and mowed twice & chemically mowed plots: 8/8/97. Different letters indicate a significant difference between all treatments (tukey's $p < 0.05$).

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