EMERGENCE AND GROWTH OF TALL BUTTERCUP (*RANUNCULUS ACRIS* L.) SEEDLINGS ALONG A SOIL MOISTURE GRADIENT

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Impact Statement

Moisture appears to play a large role in tall buttercup recruitment and growth. Because soil moisture availability can be manipulated through irrigation practices, hay producers may have a non-chemical option for reducing current and future infestations of this invasive, toxic forb.

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SUMMARY

We conducted a greenhouse study to investigate the influence of soil moisture on emergence and growth of tall buttercup (*Ranuculus acris*, L.), a non-native invasive perennial forb that invades moist pastures, grasslands, and irrigated meadows. Tall buttercup seeds were planted into pots where soil moisture was maintained at 25%, 50% or 100% field capacity and allowed to grow for about two months. At the end of two months, tall buttercup seedling emergence, height, number of leaves, and biomass were measured. Tall buttercup emergence and growth was optimal in field capacities of 50% to 100%. Results suggest altering irrigation amount or timing should be considered as a management tool to reduce or eliminate tall buttercup infestations.

INTRODUCTION

Tall buttercup (*Ranunculus acris* L.) is a perennial, invasive forb that occurs in moist habitats including pastures, grasslands, and flood or sub-irrigated meadows (Lamoureaux and Bourdôt 2007). It is native to central and northern Europe (Coles 1971) and has spread to parts of northern North America (Bourdôt et al. 2013). Tall buttercup can displace pasture grasses and clovers (Conner 1977) and is cause for concern due to its toxicity to livestock, especially cattle. In Montana it has invaded over 8300 hectares and was listed as a priority 2A noxious weed in 2003 (Montana Noxious Weed Summit Advisory Council 2008).

Tall buttercup has been predominantly troublesome in western Montana in flood and sub-irrigated hayfield meadows. Irrigation may create conditions conducive to tall buttercup growth and survival (Bourdôt et al. 2013), but the amount of moisture required for optimal seedling emergence and growth has not been explored. Understanding the importance of soil moisture on seedling recruitment will aid in the development of effective management strategies.

PROCEDURES

We conducted a greenhouse study to assess seedling emergence and growth along a gradient of soil moisture. We collected seed from tall buttercup growing in flood and sub-irrigated hayfields near Twin Bridges, MT, planted them in soil in 2 liter pots, and subjected them to three soil moisture treatments including 25, 50, and 100 percent field capacity. Each soil moisture treatment was replicated 12 times, and soil moisture treatments were maintained throughout the study. After 65 days, tall buttercup seedlings in each pot were counted and measured (height, number of leaves, biomass).

RESULTS AND DISCUSSION

Tall buttercup seedling emergence, height, number of leaves, and biomass were all affected by soil moisture (Table 1). Seedling emergence was lowest in the 25% field capacity treatment where 18% of the seeds emerged. The 50% and 100% field capacity treatments resulted in similar seedling density with 40% and 36% of the seeds emerging as seedlings. All three soil moisture treatments resulted in different seedling heights. The 50% field capacity treatment had the tallest seedlings followed by the 100% field capacity treatment and 25% field capacity treatment. Treatments also affected the number of leaves on tall buttercup seedlings. The lowest number of seedling leaves was from the 25% field capacity; the 50% and 100% field capacity treatments resulted in similar tall buttercup seedling leaf numbers. Finally, biomass was affected by soil moisture treatments. The 50% field capacity treatment had the highest seedling biomass followed by the 100% field capacity treatment followed by the 25% field capacity treatment.

Seedling emergence and growth are critical stages of plant development that result in recruitment of new individuals in plant communities (Fay and Schultz 2009). Both are sensitive to environmental variability and require certain soil moisture conditions (Fay and Schultz 2009). While it has been observed that suitable habitat for tall buttercup encompasses areas of high soil moisture content (Lamoureaux and Bourdôt 2007), prior to this study there was no data on the influence of soil moisture on tall buttercup seedling recruitment. In our study, soil moisture affected all tall buttercup seedling response variables including seedling emergence, height, leaf number and biomass. Our results indicate that tall buttercup emergence and growth was optimal in field capacities of 50% to 100%, and minimal in drier conditions. Bourdôt et al. (2013) reported that without irrigation, habitat for the species declines in areas that do not receive sufficient rainfall. Flood and sub-irrigation management practices in western Montana with problematic tall buttercup infestations could be playing a role in the species' ability to persist.

Tall buttercup seedling emergence was generally low. Even with soil moisture at 50 and 100% field capacity, emergence was 40% and 36%, respectively. It is possible that the viability of seeds used in this study was relatively low. Thompson and Grime (1983) stated that tall buttercup seeds need exposure to warm, moist conditions in order to germinate. In the same study they found that a similar species, *Ranunculus repens*, requires fluctuating temperatures for optimal germination in the light. For this study, seeds were collected in late July and were stored at room temperature (23.5 °C) until planted in October. Seed storage and greenhouse conditions throughout the study may not have been optimal to achieve a higher seedling density than what was observed. However, because all seeds were stored in similar conditions, any reduction in seedling emergence due to seed viability was equal across treatments.

He and others (1999) found that in river floodplains tall buttercup thrives in the zone with approximately 30 days of flooding per year. Further, they observed that it is more resistant to flooding than other *Ranunculus* species. However, while tall buttercup is tolerant of flooding, perhaps mature tall buttercup plants can withstand long periods of flooding more so than seedlings. While seedling emergence from the 100% field capacity treatment was similar to the 50% field capacity treatment, seedling height and biomass were lower. Seedlings from the 100% field capacity treatment also showed signs of stress from overwatering including chlorosis. In comparison, seedlings from the 50% field capacity treatment had leaves that were a dark green color and were overall visibly healthier. Lower seedling biomass in the 100% field capacity treatment compared to the 50% field capacity treatment is indicative of plants having different requirements for emergence compared to growth following emergence (Lloret et al. 2004). It was not surprising that seedling biomass was lowest at 25% field capacity as previous research has shown tall buttercup to be poorly tolerant of drought (Sarukhan 1974).

Understanding how both tall buttercup seedling emergence and established seedlings respond to varying soil moisture conditions helps to understand how soil moisture may affect recruitment into a plant communities by this species (Fay and Schultz 2009). Further research could test tall buttercup seedling emergence and establishment at varying moisture conditions ranging from 30% and 100% field capacity both in the field and under controlled conditions in the greenhouse. Moisture conditions could be altered after the seedlings are established to understand how tall buttercup seedling growth may be positively or negatively influenced by the amount of moisture in the soil. Studies could also explore the differences in tall buttercup emergence and growth in simulated flood or sub-irrigation conditions versus overhead irrigation.

Integrated management with herbicides and other tools like mowing and fertilizer have resulted in site-specific outcomes (Strevey 2014). These results suggest altering irrigation amount or timing should be considered as a management tool to reduce or eliminate tall buttercup infestations. Removing flood or sub-irrigation practices for one to two years may be enough to eliminate tall buttercup infestations since studies have shown that tall buttercup does not typically accumulate a long-lasting seed bank (Champness and Morris 1948, Harper 1957, Sarukhan 1974). If altering irrigation practices eliminates current infestations of tall buttercup, it is possible that after a few years the tall buttercup seed bank would be depleted and irrigation practices could be reinstated with minimal growth of remaining viable seeds in the seedbank.

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Table 1. Tall buttercup average emergence and seedling height, number of leaves, and biomass as affected by soil moisture treatments

Soil Moisture Treatment	**Emergence (%)**	**Height (cm)**	**Number of Leaves**	**Biomass (g)**
25% field capacity	18^a	0.8 ± 0.2^a	1.2 ± 0.3^a	0.009 ± 0.001^a
50% field capacity	40^b	6 ± 0.3^c	5.7 ± 0.4^b	0.2 ± 0.03^c
100% field capacity	36^b	4 ± 0.5^b	4.0 ± 0.6^b	0.1 ± 0.02^b

[a-c] Means with similar letters within a measured parameter (i.e. emergence, height, number of leaves, biomass) are statistically similar to each other ($\alpha = 0.05$).