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Developing an optimal release strategy for the rust fungus *Puccinia jaceae* var. *solstitialis* for biological control of *Centaurea solstitialis* (yellow starthistle)

Alison J. Fisher [a,*], Dale M. Woods [b], Lincoln Smith [a], William L. Bruckart III [c]

[a] *USDA, ARS, Exotic and Invasive Weeds Research Unit, Albany, CA 94710, USA*
[b] *California Department of Food and Agriculture, Sacramento, CA 95832, USA*
[c] *USDA,ARS, Foreign Disease-Weed Science Research Unit, Fort Detrick, MD 21702, USA*

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Abstract

The rust fungus *Puccinia jaceae* var. *solstitialis* (*P. j. solstitialis*) was first approved for release in California in 2003 as a classical biological control agent for *Centaurea solstitialis* (yellow starthistle, Asteraceae). It is difficult to produce large quantities of this obligate pathogen so it was necessary to develop an optimal release strategy for the efficient use of urediniospores. In 2005–2006 field experiments were conducted in two distinct habitats types, the coastal hills and Central Valley, CA, to determine the optimal month for introductions, and to determine if enclosing plots in tents at the time of inoculation was necessary to achieve high levels of infection. All releases resulted in infected plants at both sites for both years. At the Central Valley site near Woodland CA, disease incidence was higher than at the coastal hills, tent enclosures had no effect on infection, and the pathogen persisted throughout the growing season. One year after the 2005 release, *P. j. solstitialis* had reappeared in most Central Valley plots, although early season releases in 2005 resulted in greater severity in 2006 than the late season releases. In the coastal hills near Napa, CA, tent enclosures improved disease incidence and severity after January and May releases, perhaps by retaining moisture, but the pathogen did not persist in all plots until plant senescence, and there was no reinfection (the following spring) at this site. The rust fungus did not have a negative affect on plant mortality, biomass, or flower production at either location. Our results show that infection can be achieved from January to June, and tent enclosures sometimes appeared to increase infection; however, reinfection is probably limited by local environmental conditions.
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Keywords: *Puccinia jaceae* var. *solstitialis*; *Centaurea solstitialis*; Biological control; Rust fungus; Plant pathogen; California; Weed control

1. Introduction

Yellow starthistle (YST, *Centaurea solstitialis* L., Asteraceae) is a noxious invasive weed infesting over 7 million ha of California (CA) rangelands and natural areas (Pitcairn et al., 2006) and over 8 million ha of the western United States (US) and Canada (Skinner et al., 2000; Duncan, 2001). Yellow starthistle displaces desirable plants, lowers the value of recreational lands, and the spiny flowers deter feeding by grazing animals (Sheley et al., 1999).

Yellow starthistle is a winter annual adapted to the mild wet winters and dry summers of the Mediterranean (Maddox, 1981). Seeds usually germinate soon after the beginning of fall rains, rosettes develop slowly during the winter, plants bolt in late spring and flower continuously until the plant senesces from lack of moisture. Six exotic insect species have been introduced for biological control of YST, all of which attack flower heads and destroy developing seeds (Turner et al., 1995). However, these have not generally reduced populations to acceptable levels (Balciunas and Villegas, 1999; Pitcairn et al., 2002).

The rust fungus, *Puccinia jaceae* Otth var. *solstitialis* (*P. j. solstitialis*) was first released for biological control of

* Corresponding author. Fax: +1 510 559 5737.
E-mail address: afisher@pw.usda.gov (A.J. Fisher).

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