Seed germination in native, naturalized, and invasive populations of the grass *Andropogon virginicus* (broomsedge) grown in a common environment

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Abstract

Andropogon virginicus is a C_4 perennial grass that colonizes old fields in its native range in eastern North America. It is naturalized on moist soils in California and has become invasive in the Hawai'ian islands. In a common greenhouse environment we compared germination of seeds collected from each of these regions; germination speed and quantity are important components of weedy and invasive plant success during colonization. Our study system includes *Sporisorium ellisii*, a smut fungus, which appears to be restricted to certain native broomsedge populations. Early germination and growth may be especially advantageous when smut fungus is present, since the youngest germlings may be most vulnerable to infection. We planted 50 seeds (a seed family) from each of 20 seed mothers from each sampled population, and measured two-week germination rates and maximum germination rates for each family. For both variables there was highly significant variation among regions and among populations. Contrary to our expectation, Hawai'ian populations showed the lowest average germination speed and quantity, and Californian populations were highest. Mean maximum germination ranged from 14.4% to 49.3% in eastern, 12.3% to 63.0% in Californian, and 0.0% to 52.9% in Hawai'ian seed families. Mean two-week germination ranged from 2.0% to 46.9% in eastern, 8.1% to 60.8% in Californian, and 0.0% to 47.0% in Hawai'ian seed families. Germination did not differ among families from smut-infected versus healthy eastern populations. Local and regional conditions appear to be driving divergence among populations for the key life-history component of seed germination.

Introduction

Early and abundant seed germination are important components of ecological success for colonizing and invasive plants like the perennial grass *Andropogon virginicus* (broomsedge). During early succession competition for space among plants can be intense, so a strategy of germinating a large number of seeds as quickly as possible may provide a significant competitive advantage. *Andropogon virginicus* can be parasitized by the pathogen *Sporisorium ellisii*, a smut fungus, in which case rapid and abundant germination may be even more important since natal stages are potentially more susceptible to infection.

Andropogon virginicus is a native species in eastern North America, where it is common in old fields. It is introduced and naturalizing on moist soils in California, and it is widespread and considered invasive in the Hawai'ian islands. Only certain native populations appear to harbor the smut fungus disease. In a common greenhouse experiment we examined variation in germination rates among these three regions and among populations within each region. Our goal was to determine whether germination rates were associated with the plants' native, naturalizing, invasive, or disease status.

Methods

- Populations sampled from 3 regions: East Coast (n = 16), California (n = 7), Hawai'i (n = 8).
- Planted 50 seeds each from 20 seed mothers from each population.
- Seeds planted in 2 x 3'' pots, 5 rows of 10 seeds, between 6/29/2006 and 7/17/2006.
- Census of emerged germlings recorded weekly, for six weeks post-planting.
- The greenhouse environment was maintained at approximately 36° C, and seeds were sub-irrigated throughout the experiment.
- Nested analysis of variance on two variables: maximum germination percentage and two-week germination rate.

Results

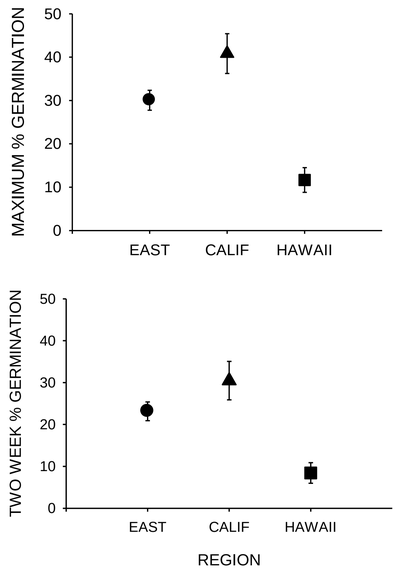


Figure 1. Seed families from all three regions exhibited significantly different germination characteristics. Plants in the invasive range (Hawai'i) had the lowest germination rates (nested ANOVAs: max germ $F_{region} = 7.20$, $P = 0.003$; 2wk germ $F_{region} = 4.36$, $P = 0.022$; df = 2, 28).

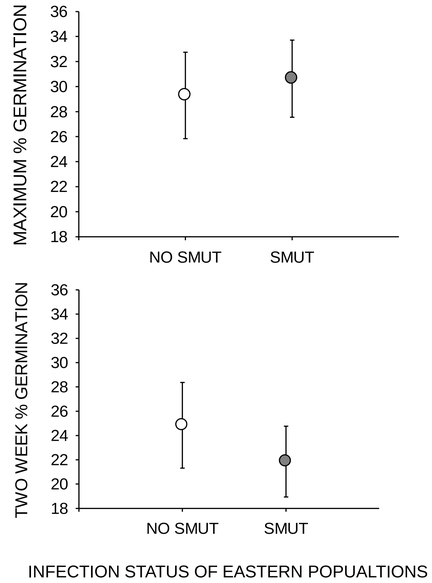


Figure 3. Seed families from the eastern region that came from populations with smut present versus those with smut absent showed no significant variation in germination characteristics (ANOVAs: max germ $F_{smut} = 0.33$, ns; 2wk germ, $F_{smut} = 1,69$, ns, df = 1, 318).

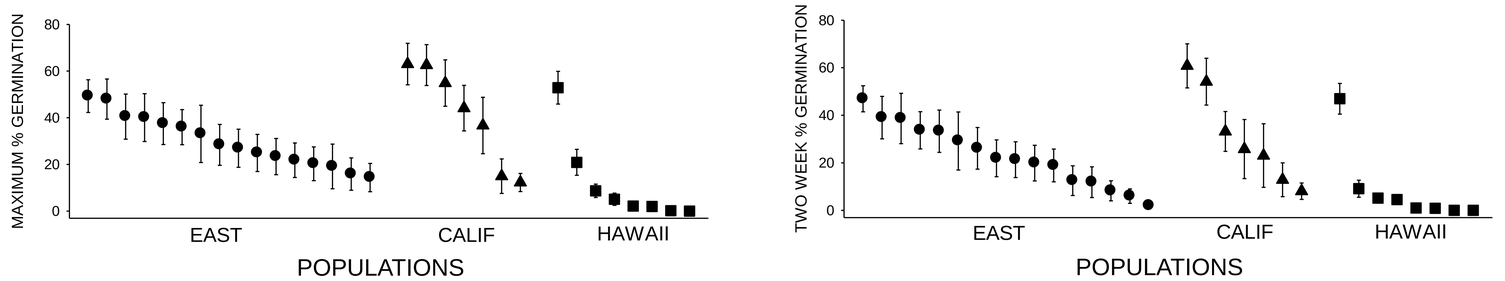
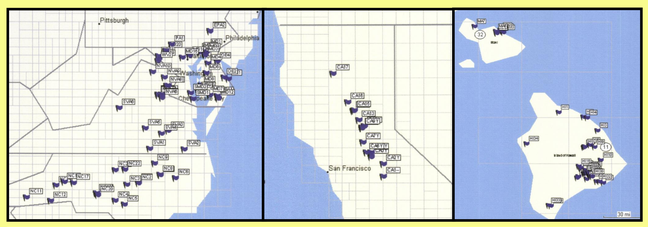


Figure 2. Seed families from the different populations within regions varied significantly in germination characteristics. Most Hawaiian populations grew on new, xeric, volcanic substrate. The Hawai'ian population with the high germination rate grew in an atypically moist microsite (nested ANOVAs: max germ, $F_{population(region)} = 18.09$, $P < 0.0001$; 2wk germ, $F_{population(region)} = 19.85$, $P < 0.0001$; df = 28, 590).



POPULATION SURVEYS Multiple broomsedge populations have been located and mapped with a GPS in the eastern states (NJ through NC), in California (central valley), and in Hawai'i (especially in Volcano National Park).

East Coast plant

A. virginicus seedlings

Hawaiian plant

Discussion

Contrary to our expectations, *Andropogon virginicus* seed families from Hawai'ian populations showed the lowest maximum and two-week germination rates, on average. We had hypothesized that the Hawai'ian plants, which are identified as invasive, would exhibit enhanced characteristics that could promote invasiveness, such as greater and more rapid germination, relative to native eastern plants and naturalized (but not invasive) Californian plants. The evolution of increased ability (EICA) hypothesis contends that invasive plants evolve in their new range to become more competitive, because they need fewer defenses against natural enemies. However, we found that even though the Hawai'ian plants are not subject to the smut fungus infection found in the native range, they do not exhibit enhanced growth, at least in the earliest life history stage. We also saw no difference in germination between eastern populations with and without smut presence. Rather, germination appears tied to other differences in regional and local (population level) environmental factors, most likely the moisture regime. The highest and fastest germination rates were in the Californian populations, which were located along water courses or shore lines, probably due to the prolonged dry season; the environmental conditions experienced by seed mothers were likely to be favorable for high quality seed production (a maternal effect). The poorest germination was seen in Hawai'i, and these seed mothers grew mostly on very xeric, gravel-like volcanic substrates. The two populations with the highest germination rates in Hawai'i were located on older, weathered lava with more organic matter (less xeric). The eastern populations grew on a range of soil types, from the sandy soils of pine forest to rich pasture soils. Because of the great variation among populations within regions it is clear that regional differences are only part of the germination story, and we do not yet know if the differences are due to maternal effects or ecotypic differentiation.

Acknowledgements This work was supported by grant USDA-NRI # NJR-2004-01992 to J.A. Morrison, an American Society of Plant Biologists Summer Undergraduate Research Fellowship to A.M. Romanchuk, the Support of Scholarly Activity (SOSA) Committee of The College of New Jersey (TCNJ) for sabbatical leave and reassigned time to J.A. Morrison, and TCNJ's Biology Summer Research Program (BSRP). Thanks to Ermal Bojdani for assistance in the lab and greenhouse and Laura Melman and Scott Morrison Melman for assistance in the field. Many thanks to the numerous organizations and individuals who granted collecting and research permits. * *Authorship is shared equally.*