Seedling Functional Traits to Inform Plant Material Selection

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Summary:

Native plant biotypes that germinate and emerge early in the season, and have fast cold-temperature growth rates, may have greater weed resistance and ability to establish in arid climates. This study examined seedling growth of local and cultivated accessions of Sandberg bluegrass (*Poa secunda*) and cheatgrass (*Bromus tectorum*) in response to different temperatures. We found that accessions differed in cold temperature germination timing and growth. Two commercial accessions had superior growth traits in cold temperatures compared to local biotypes. We identified relationships between accession origin and growth variables. Accessions sourced from areas with colder winter climates had earlier germination and greater seedling growth when incubated under cold conditions.

Seedling trait and ecology research can inform and improve restoration practices and outcomes (James et al. 2013). For example, James et al. (2011) identified seedling emergence and early establishment phases as the primary bottlenecks to restoration plant species survivability. Invasive species, climate variability, and edaphic factors such as soil crusting, all impede seedling emergence and early establishment (Call and Roundy 1991, Bakker et al. 2003, Madsen et al. 2012). Seedling growth traits influence seedling survivability but are understudied compared to adult plant traits (Jones et al. 2010).

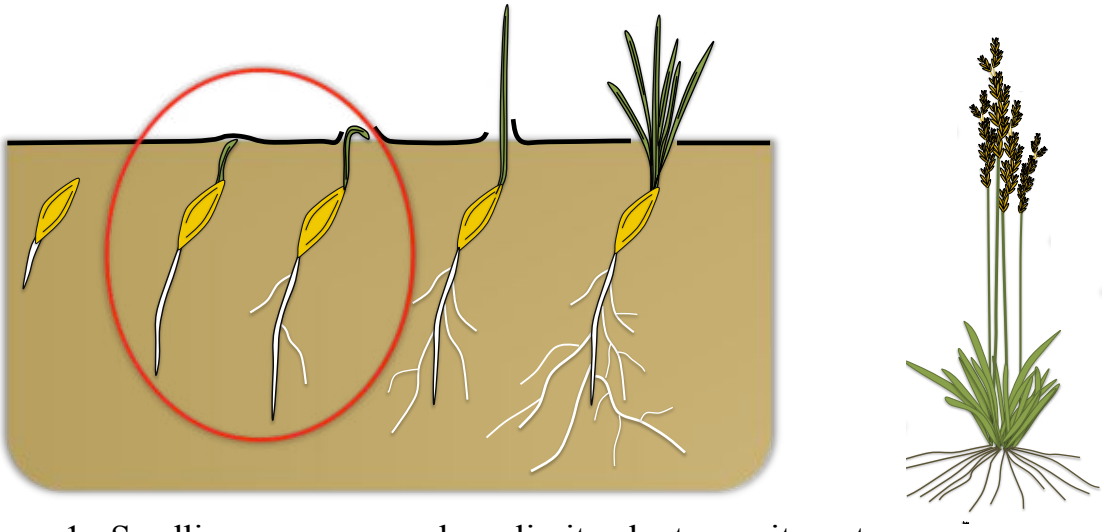


Figure 1. Seedling emergence phase limits plant recruitment.

Early emergence allows exploitation of available resources before competitors arrive. In arid climates, seedlings that emerge earlier and have fast root elongation, also have greater access to soil moisture (Harris and Wilson 1970, Moreno and Oechel 1992). Small differences in early growth rate can have long term effects on seedling survivability and adult plant fitness (Verdu and Travaset 2005, deLuis 2008).

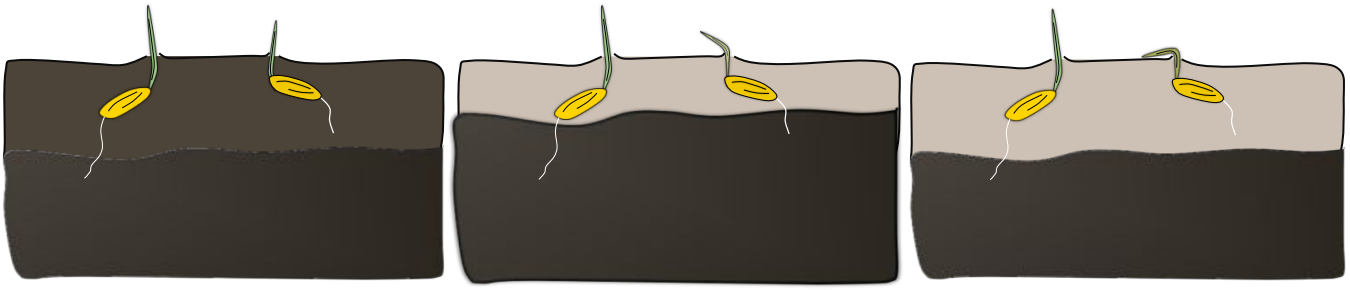


Figure 2. As the soil profile dries down, even small differences in root growth allow some plants to access soil moisture and survive drying fronts.

Functional traits of invasive annual grasses include early germination, fast growth rates and rapid emergence (Jones et al. 2010). Native species biotypes that have similar functional traits may improve plant community invasion resistance (Drenovsky and James 2010; Jones et al., 2010).

Study species

Sandberg bluegrass (*Poa secunda*) is a cool season, native, perennial bunchgrass that establishes early in the spring. The phenological similarity of Sandberg bluegrass to cheatgrass (*Bromus tectorum*) makes it a good competitor. Previous studies demonstrate that adult populations of Sandberg bluegrass differ in their ability to tolerate and compete with cheatgrass (Georgen et al. 2011, Mummey et al., unpublished data), but adult competitive ability does not indicate ability to establish and compete at the seedling stage.

How do seedlings perform?

We compared seedling growth characteristics of six Sandberg bluegrass accessions and cheatgrass to identify plant materials with functional growth traits thought to confer weed resistance and improve establishment in arid climates. We addressed the following questions:

1. Does germination timing and growth of different Sandberg bluegrass accessions differ in response to temperature?
2. Does seedling growth of cultivated varieties of Sandberg bluegrass differ in temperature response compared to local sources?
3. How does seedling growth of accessions compare to cheatgrass growth in different temperatures?

Methods: Seed source

We evaluated six different accessions of Sandberg bluegrass for seedling growth traits: MT-1, Opportunity, High Plains, Mountain Home, and two populations from MPG Ranch.

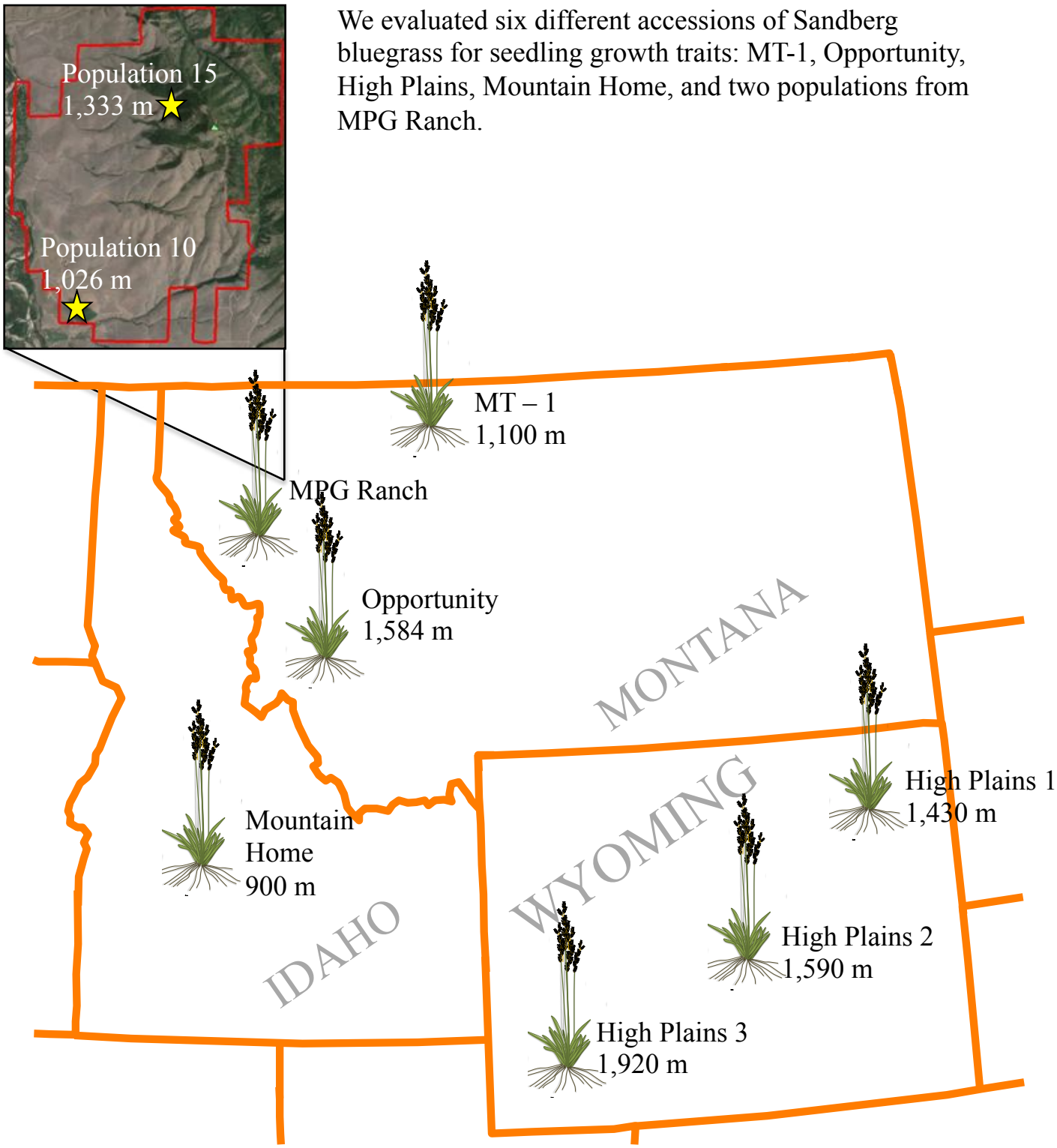


Figure 3. Seed source origin location and elevation of tested Sandberg bluegrass accessions.

Accession Name	Source location
High Plains	USDA; sourced from populations collected from three counties across Wyoming.
MT-1	Natural track accession; sourced from populations collected in Toole County, Montana.
Opportunity	USDA; sourced from populations collected near Anaconda, Montana.
Mountain Home	USDA; sourced from populations collected near Mountain Home, Idaho.
Population 15	Local population collected from higher elevation area on MPG Ranch.
Population 10	Local population collected from lower elevation area on MPG Ranch.

Study Design

We started the six Sandberg bluegrass accessions and cheatgrass from seed under warm (20°C day/ 15°C night) and cold (10°C day/ 5°C night) conditions.
We grew seeds in seed germination pouches (CYG; Mega International, St. Paul, MN., USA). Seedling roots grew in nutrient solution between blotting paper and clear plastic. We grew seeds of each accession and cheatgrass in separate pouches.

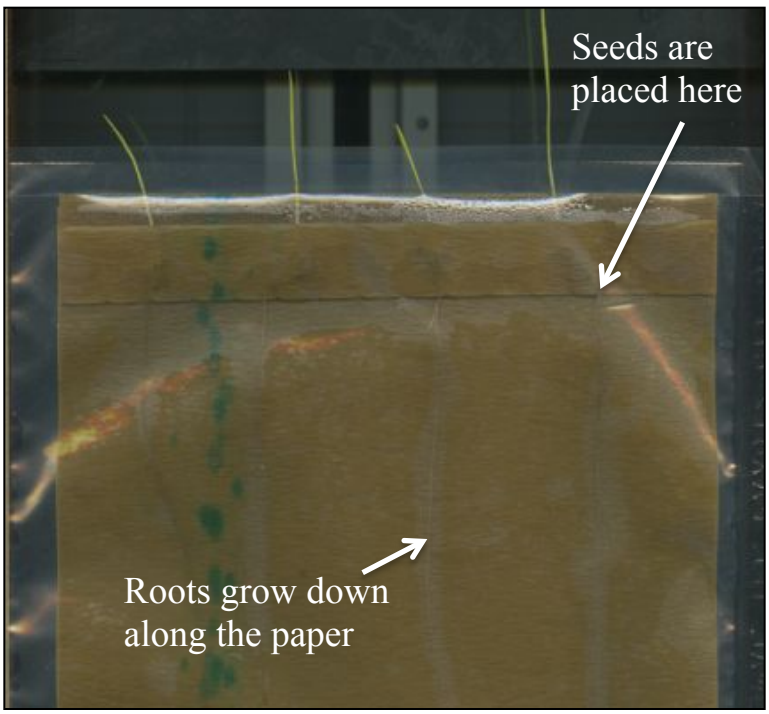


Figure 4. Seed germination pouch

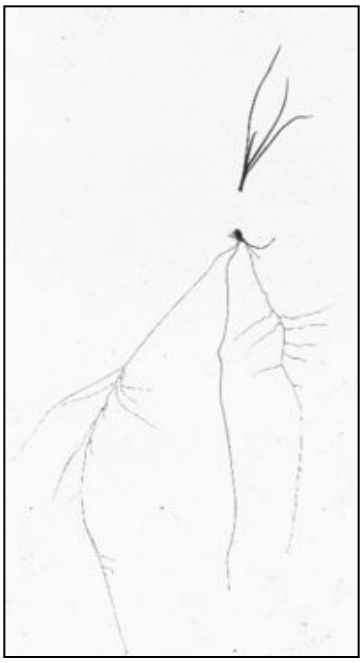


Figure 5. Image of a scanned seedling after harvest.

We monitored pouches every other day for root initiation. After root initiation, we scanned germination pouch images every other day for the duration of the study (21 days) and used winRHIZO software to measure root lengths of scanned images.

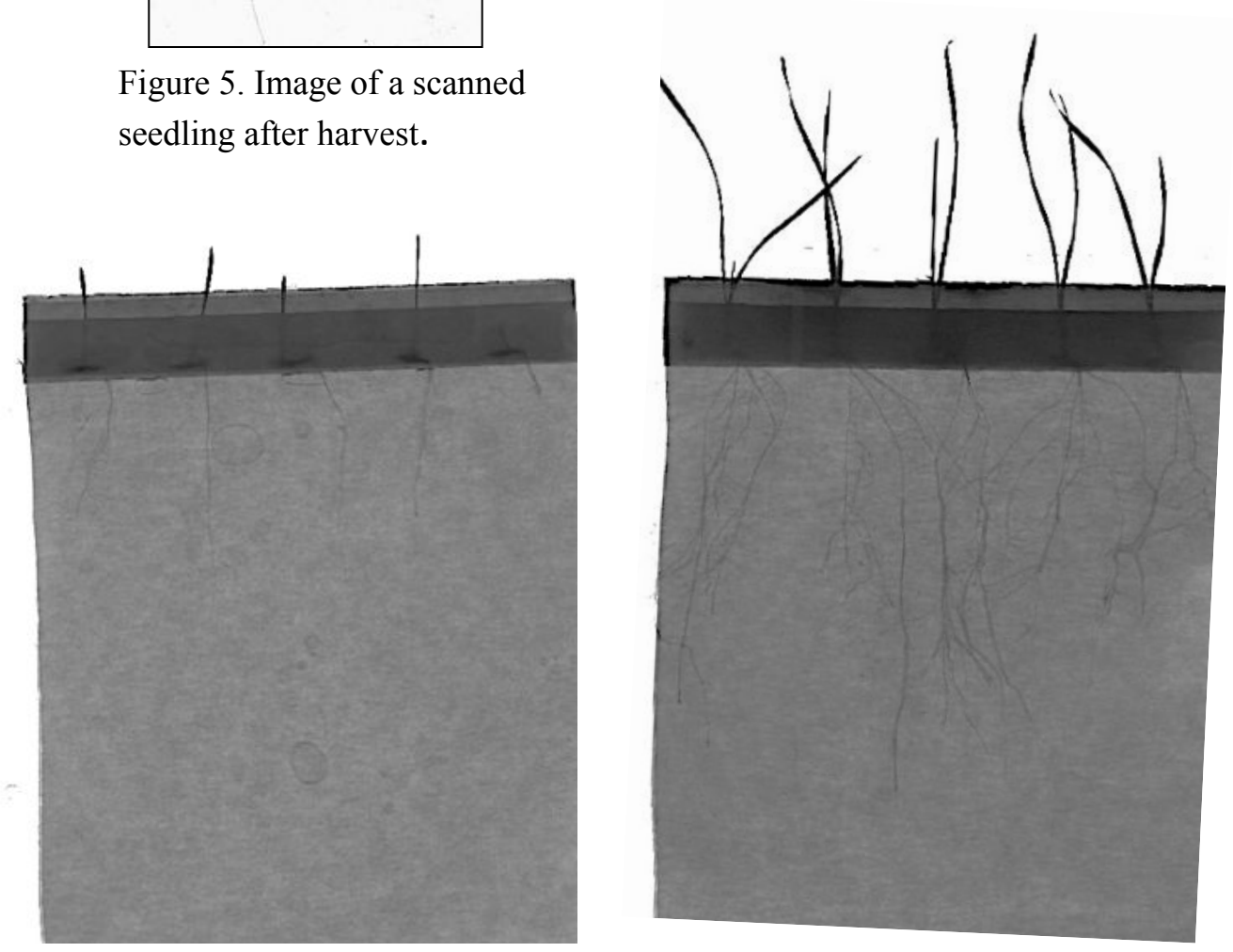


Figure 6. Examples of scanned images showing five cheatgrass seedlings growing at the beginning of the experiment (left) and fifteen days later (right).

Results

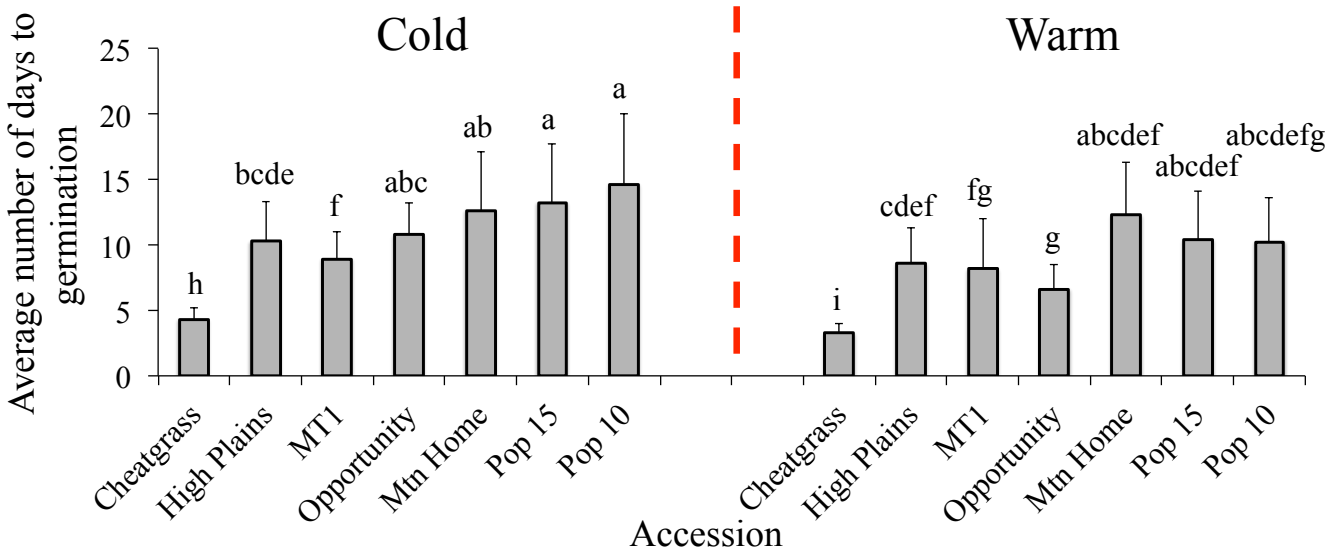


Figure 6. Days to germination of each accession and cheatgrass in both temperature treatments.

Cheatgrass germinated earlier than all the Sandberg bluegrass accessions in both the cold and warm treatments. MT-1 germinated significantly earlier than the other Sandberg bluegrass accessions in the cold treatment. The High Plains accession germinated earlier than MPG populations in the cold treatment. Error bars are +1 S.D. Pairwise comparisons for all variables were performed using the Bonferroni adjustment of the significance level, here $p<0.0005$ (.05/91).

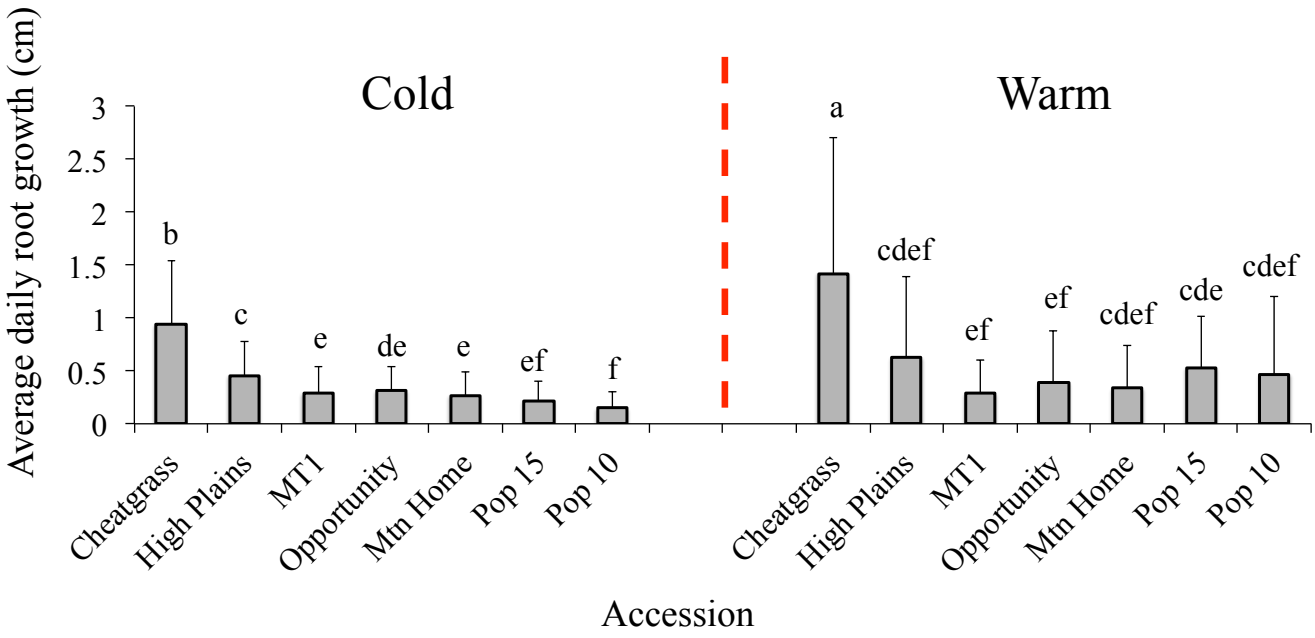


Figure 7. Daily root growth for each accession and cheatgrass in both temperature treatments.

Cheatgrass had greater daily root growth than all Sandberg bluegrass accessions in both warm and cold treatments. High Plains had greater root growth in the cold temperature treatment than all other accessions. Pop. 10 had the least cold temperature root growth. In the warm treatment, we detected no significant differences in daily root growth between the accessions.

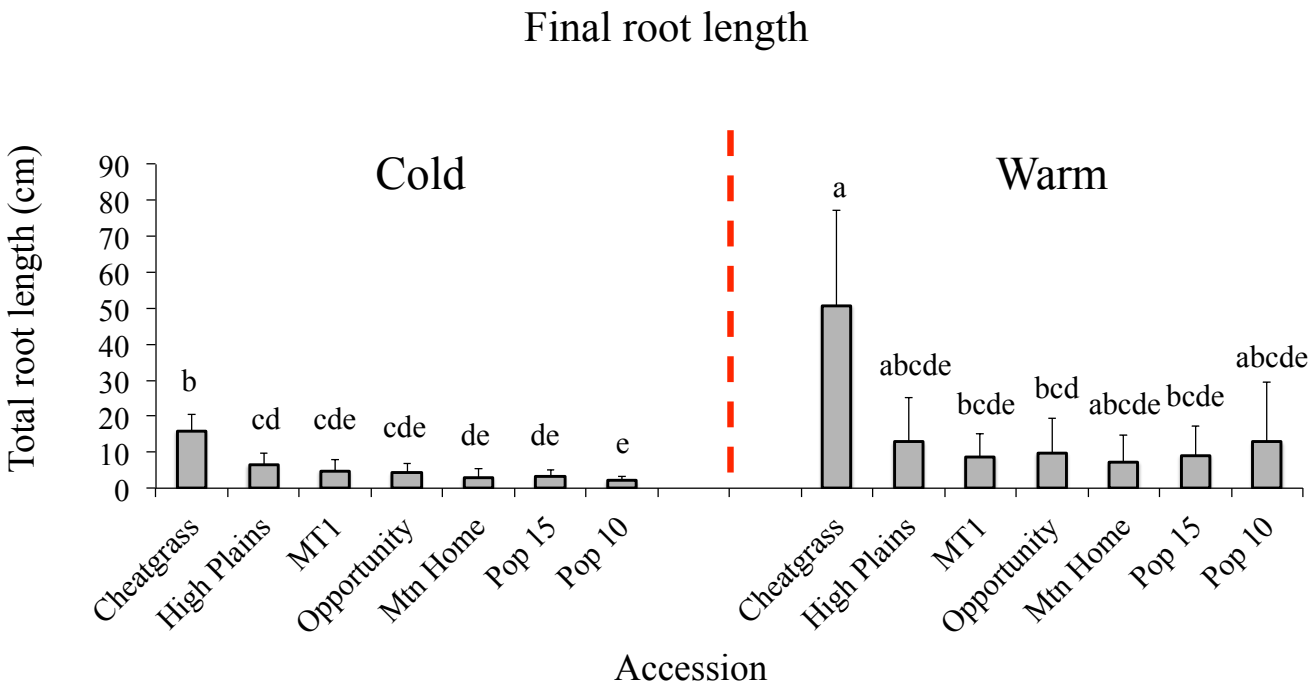


Figure 8. Total root length of each accession and cheatgrass in both temperature treatments.

Cheatgrass had longer final root length than all the Sandberg bluegrass accessions in both the cold and warm temperature treatments. High Plains trended toward having the longest roots in the cold treatment.

Discussion: Seedling performance

Accessions of Sandberg bluegrass respond differently to temperature in both germination timing and growth. High Plains and MT-1 germinated earlier in cold temperatures than other accessions and had greater root growth rates and longer final root lengths in cold temperatures than other biotypes. MPG populations had poor performance compared to other accessions in cold temperatures. Overall, cultivated varieties of Sandberg bluegrass tended to perform better than locally sourced accessions. High Plains and MT-1 seedlings had the greatest performance of seedlings tested in cold temperatures, but performance of both accessions was much lower than cheatgrass, which grew significantly better than all accessions at both temperatures.

Comparison with field results

These results support the results of our recent field study (Herget et al., in review). We planted High Plains, Mountain Home, Reliable and MPG populations 10 and 15 in the field, with and without cheatgrass competition. This experiment was conducted on a drought year that challenged biotypes even without competition from weeds. At the end of the season, High Plains had a significantly higher proportion of survivors compared to the other accessions with and without cheatgrass competition. Our results suggest that early seedling growth characteristics may be responsible for survivorship patterns observed in the field.

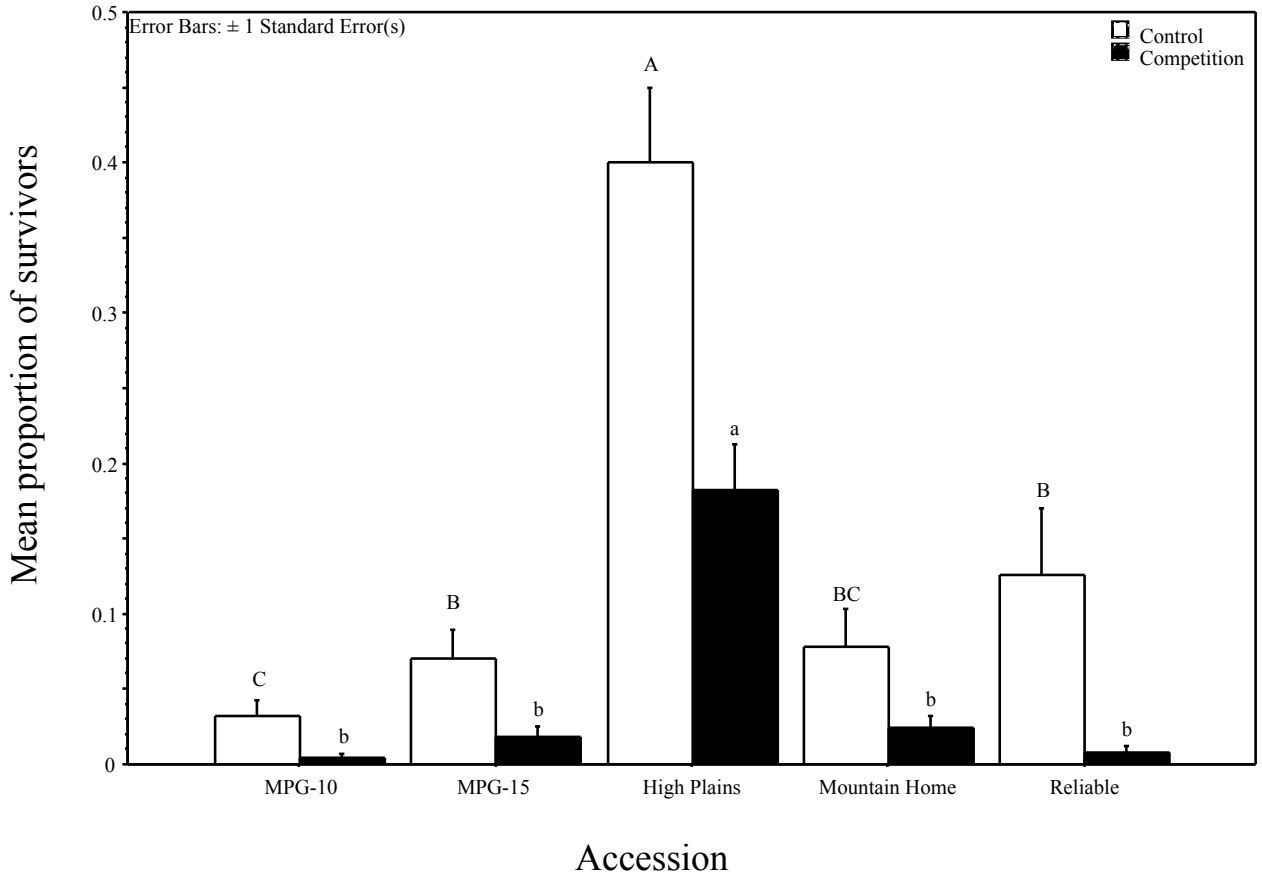


Figure 9. Proportions of survivors for each accession included in the field study

Early Spring Climate and Seed Source

Some Sandberg bluegrass accessions performed better than others, but all are recommended for planting in our region. Each seed source evolved in a unique environment and their source climate may make some better adapted to harsh climates than others. We researched the historical climate (PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu) of each seed source to examine these differences.

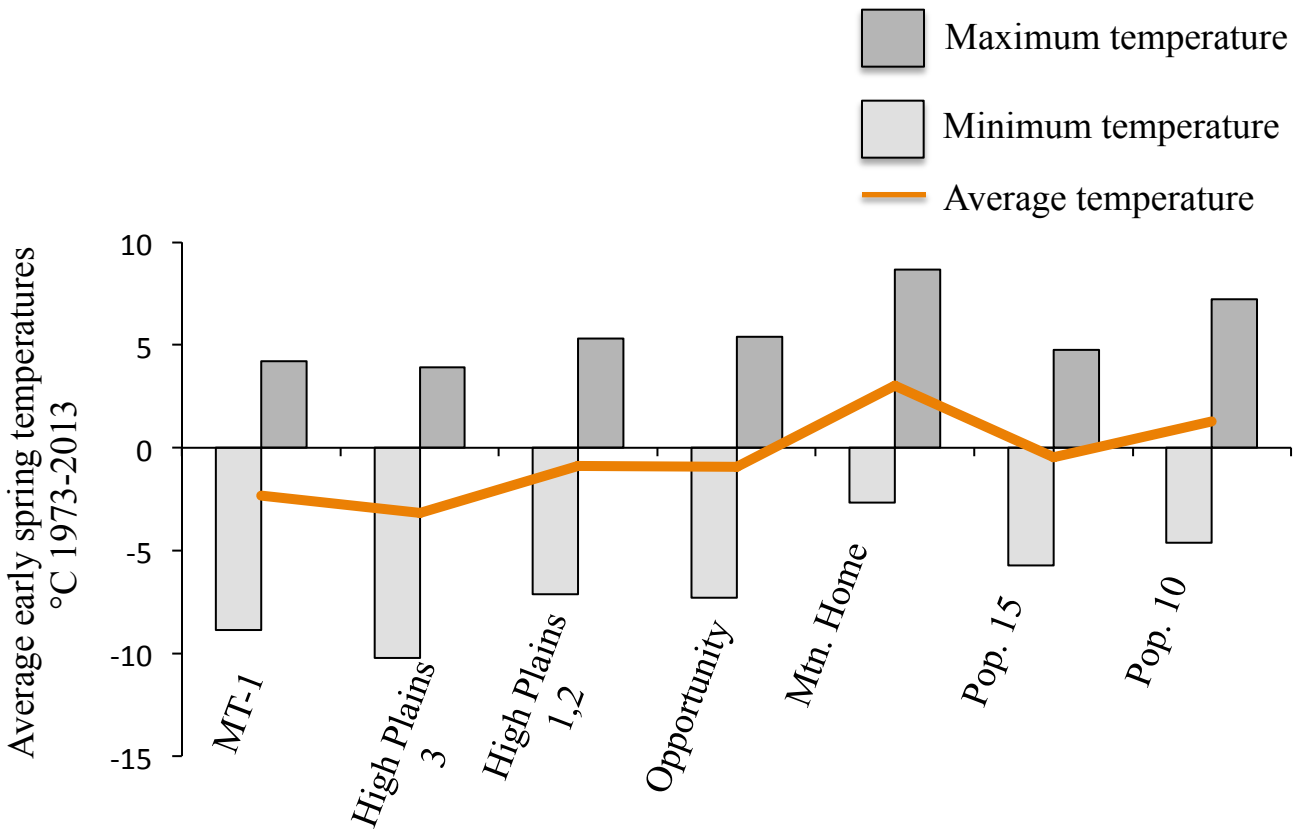
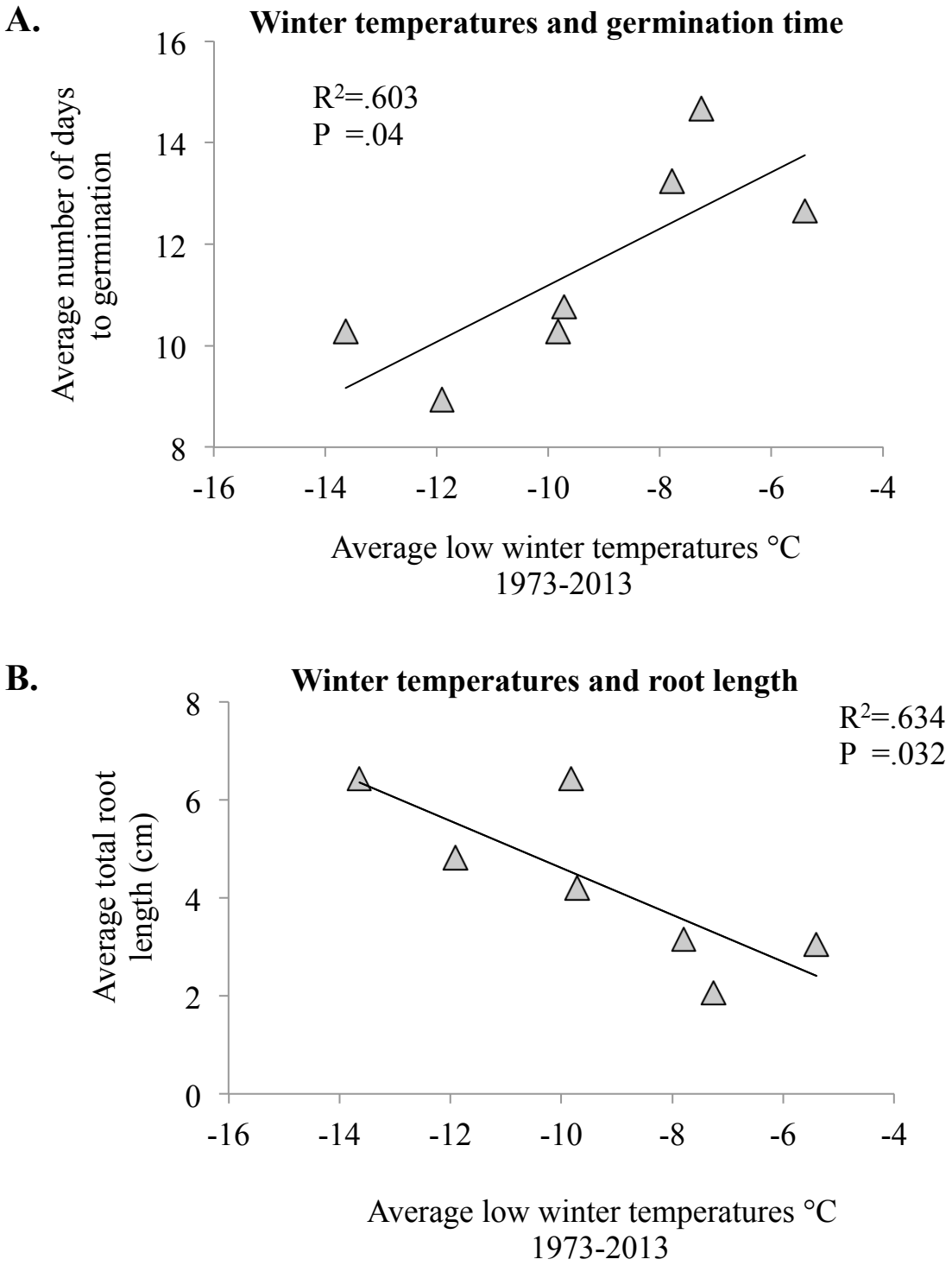


Figure 10. The maximum, minimum and average thirty-year early spring temperatures of each accession source area.

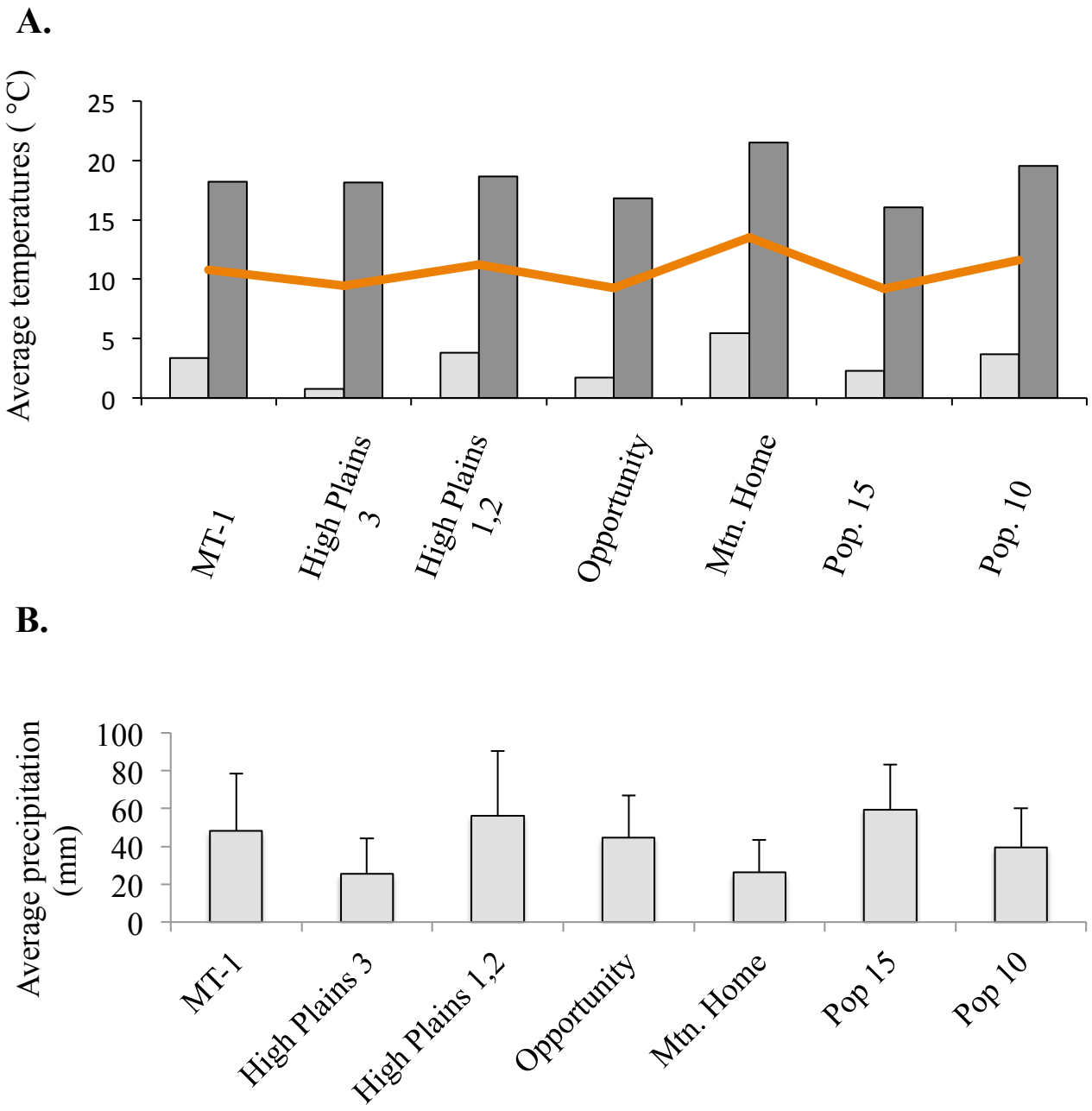
High Plains is sourced from three areas across Wyoming. High Plains 1 and 2 source areas and High Plains 3 have distinctly different climate and elevation and are separated here. MT-1 and High Plains have the coldest early spring temperatures. Mountain Home, population 15 and population 10 have warmer early spring temperatures.

Figure 11. Regression analyses of winter temperatures and different growth characteristics.



Regression analyses revealed relationships between seed origin minimum winter temperatures and seedling growth variables. Accessions sourced from areas with historically lower winter temperatures germinate earlier (Figure 11-A) and have longer root lengths when grown in colder temperatures (Figure 11-B).

Figure 12. Late Spring/Early Summer Climate and Seed Source, 1973-2013



Sandberg bluegrass begins to senesce and set seed in late spring and early summer as temperatures begin to rise. To survive the arid climate of our study region, accessions must be adapted to hot, dry conditions. The historical late spring and early summer temperatures of each source area are similar.

No origin historically receives more precipitation than any one of our local population sources. These results suggest that High Plains and MT-1 will tolerate hot and arid conditions as well as MPG populations.

Implications

Our results suggest that High Plains and MT-1 have seedling growth traits beneficial for establishment, persistence, and invasion resistance on MPG Ranch. Our analyses suggest that seed source climate data can predict seedling growth characteristics adapted to resisting invasive species and climate change. Examination of seedling traits combined with seed provenance characteristics can be used to inform the selection of plant materials most suited to current and future environmental conditions.

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