Challenges and opportunities for revegetation in areas dominated by invasive annual grasses

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Abstract. Invasive annual grasses (IAG) are a primary ecological threat to sustainability and ecological integrity of rangelands in the western U.S. While availability of effective tools to control IAG is increasing, ensuring compatibility of control practices with other management practices, such as seeding desirable species, is a critical information need. We summarize a series of studies investigating influences of timing, seeding depth, species selection, and planting timing with various herbicides in sites dominated by invasive annual grasses.

Introduction

Invasive annual grasses, such as cheatgrass (*Bromus tectorum* L.), ventenata (*Ventenata dubia* (Leers) Coss.), medusahead wildrye (*Taeniatherum caput-medusae* (L.) Nevski), and others, are a primary cause of sagebrush grassland degradation in the western United States, often associated with reduced species diversity, decreased forage quantity and quality, and altered fire regimes. In extreme cases, invasive annual grasses may create near monocultures that require augmentation of species diversity to meet management objectives. Re-establishing desirable native plants on such highly-degraded sites has long proven difficult due to interactions among weed competition, poor recruitment of desirable species, and compatibility of management tools. Indaziflam is quickly becoming a standard for treating invasive annual grasses in rangelands. However, since it effectively kills most germinating seeds shallow in the soil profile, it makes seeding desirable species into degraded sites difficult. Our objectives were to evaluate if indaziflam tolerance varies among desirable species and whether seeding depth and time between herbicide application and seeding affected seeded species establishment.

Methods and Study Site

We used a combination of greenhouse and field studies to assess potential interactions among species identity, depth of seeding, and duration of time between indaziflam application and seeding. Under greenhouse conditions, we planted seeds of four perennial plant species western wheatgrass [*Pascopyrum smithii* (Rydb.) A Love], blue grama [*Bouteloua gracilis* (Willd. Ex Kunth) Lag ex Griffiths], Green needlegrass [*Nassella viridula* (Trin.) Barkworth), and maximilan sunflower (*Helianthus maximiliani* Schrad.) at four different depths with and without indaziflam (73 g ai ha^{-1} for all studies described here) applied at the time of seeding. We watered all trays one week following seeding. We evaluated emergence and plant growth characteristics 48 days after planting.

In two companion studies, we seeded the same four species at four depths in two years under field conditions. In the first study, we applied indaziflam immediately prior to seeding (pre-plant) while we applied it immediately following seeding in the second study (pre-emergence). We counted seedling densities in each plot multiple times in the year of seeding. To screen for differential species tolerance, we applied indaziflam to half of four paired ‘split plots’ and seeded 45 plant species (grasses, forbs, shrubs) into treated and non-treated portions of the plots roughly 9 months after indaziflam application. All plots were hand-weeded to minimize confounding effects of weed competition. We evaluated first year

emergence and second year survival of each species with and without indaziflam. Finally, we seeded six perennial species into soils treated with indaziflam at four different intervals of time since herbicide application (1, 2, and 3 years after treatment and a non-treated control). We documented seedling density during the year of seeding.

All field research took place at the Sheridan Research and Extension Center's Wyarno Experiment Farm in Sheridan County, Wyoming, USA. The soil is a Wyarno clay loam (fine, smectitic, mesic Ustic Haplargid), and the site receives approximately 430 mm of precipitation annually. Mean annual high temperature is 16° C and mean annual low temperature is 1° C.

Results and Discussion

In controlled greenhouse studies, seeds placed deeper in the soil surface showed better emergence with indaziflam than when seeded more shallowly in the soil, particularly when species were capable of emerging from deeper (i.e. western wheatgrass, green needlegrass). Under field conditions, indaziflam reduced seeded species establishment at all depths, with differences being less pronounced when indaziflam was applied following seeding. It is important to note that we applied herbicide at the time of seeding and did not allow for a full replant interval to be met.

We observed differences among species in their tolerance to indaziflam under field conditions when seeded effectively 9 months after herbicide application. Species showing potential tolerance included basin wildrye [*Leymus cinereus* (Scribn. & Merr.) A Love], green needlegrass, prairie sandreed (*Calmovilfa longifolia* (Hook.) Scribn.), western wheatgrass, dotted gayfeather (*Liatris punctata* Hook.), and desert biscuitroot (*Lomatium foeniculaceum* (Nutt.) J.M. Coult. & Rose). Species where establishment was noticeably reduced by indaziflam included blue grama, bluebunch wheatgrass (*Pseudoroegneria spicata* (Pursh) A. Love), indian ricegrass (*Achnatherum hymenoides* (Roem. & Schult.) Barkworth), Sandberg bluegrass (*Poa secunda* J Presl), sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), purple prairie clover (*Dalea purpurea* Vent.), and prairie sunflower (*Helianthus petiolaris* Nutt.).

We seeded six species into sites with different times since indaziflam application (1, 2, and 3 years since treatment, and nontreated. Plant densities 60 days after planting were highest in non-treated plots across all species except crested wheatgrass, where plant density 3 years after indaziflam application was similar to the nontreated plots. For all other species except sideoats grama, plant density was higher 3 years after indaziflam application than 1 or 2 years after treatment, suggesting a 3-year replant interval may be best on sites with similar ecological conditions as the study area.

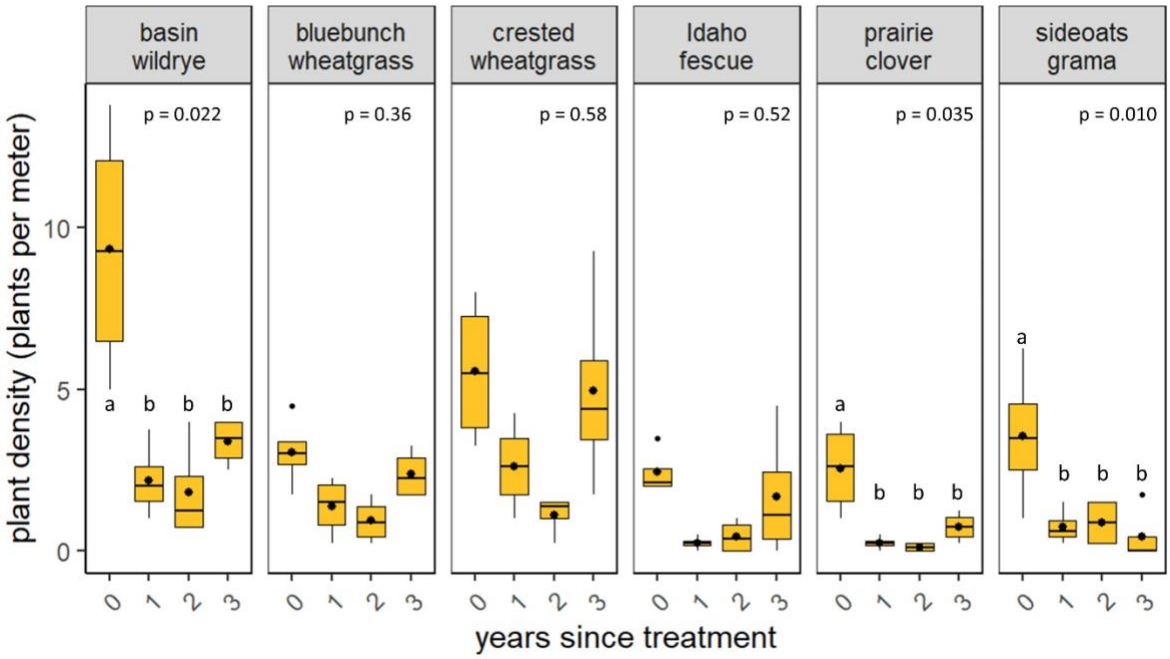

Figure 1. Seedling density of six species planted at 1, 2, or 3 years since treatment with indaziflam or into nontreated soils (0 years since treatment) on a field site in northeast Wyoming, USA. Different lower case letters denote differences among plant densities in years since herbicide treatment via Fisher's protected LSD.

Conclusions

Revegetating sites dominated by invasive annual grasses continues to be a challenge for land managers. Selecting plant materials, weed control practices, and appropriately-timed management actions is crucial for successful restoration. On sites where immediate establishment is crucial, shorter-residual invasive grass control methods should likely be considered during the establishment window. Once desirable species have become established, longer-residual invasive annual grass control options can be implemented and may improve growth and survival over the longer term.