



Use of axillary buds and other demographic parameters to evaluate control strategies for perennial invasive grasses.

Hendrickson, JR¹; Toledo, D¹; Carrlson, AJ¹; Kobilansky, C¹; DeKeyser, ES²

¹ USDA-ARS Northern Great Plains Research Laboratory, Mandan, North Dakota, USA; ²North Dakota State University, School of Natural Resource Science, Fargo, North Dakota, USA

Key words: Smooth brome grass; Kentucky bluegrass; defoliation, drought, burning.

Abstract

Cool-season perennial invasive grasses are a primary management concern on northern Great Plains rangelands in the USA. Management strategies to reduce these grasses often do not consider underlying mechanisms that can explain responses. One potential way around this constraint is evaluating axillary buds, which are meristematic tissue that provide the basis for future productivity. Our research projects evaluated responses of axillary buds of two perennial invasive grasses to different management strategies. In the first experiment, axillary bud numbers per m² were collected in the spring and fall of 2020 and 2021 from plots with ambient rainfall plus 2 different simulated drought intensities (30 and 60% of the ambient rainfall intercepted). Half of the plot under each rainfall intensity was burned, and the other half was left unburned. Both burning and moderate drought reduced the number of Kentucky bluegrass (*Poa pratensis* L.) axillary buds m² to 60% of the controls; however, the impact of burning changed with season and drought intensity. Regardless of burning or drought treatment, there were still over 400 active axillary buds m² suggesting a large pool of potential meristematic tissue was available for future growth. In the second experiment, smooth brome (*Bromus inermis* L.) tillers were clipped at vegetative, tiller elongation, and reproductive stages, and the number of axillary buds, tillers, and rhizomes (total outgrowth) was estimated in the fall over a 3-year period. Both total outgrowth and proportion of axillary buds that became outgrowth were greater when smooth brome was defoliated in the reproductive phase than when it was defoliated twice in the vegetative phase, suggesting the timing of defoliation may aid in smooth brome control. Both experiments suggest that evaluating the response of axillary buds and other demographic parameters provides mechanistic insights into the potential effectiveness of different management strategies for controlling invasive perennial grasses.

Introduction

Invasion by C₃, non-native, perennial grasses has been identified as one of the major challenges facing rangelands in the northern Great Plains of the US (Hendrickson et al., 2019). In particular, two grasses, smooth brome grass (*Bromus inermis* Leyss.) and Kentucky bluegrass (*Poa pratensis* L.) have rapidly increased (Hendrickson et al., 2021) with negative impacts on species diversity and resilience (Hendrickson

et al., 2021; Toledo et al., 2014). Burning and defoliation (Hendrickson and Lund, 2010) have both been evaluated as potential control methods for these two species.

Below-ground bud banks, made up of axillary buds located at the base of perennial grasses, are a major source of population resilience in the Great Plains (Ott et al., 2019). Because of the importance of these bud banks to vegetative renewal, evaluating how axillary buds and tiller respond to different control treatments can provide insight into their effectiveness. We used vegetative outgrowth and axillary bud numbers to evaluate the responses of smooth brome grass to defoliation and Kentucky bluegrass to burning and drought.

Methods

Both studies reported in this paper took place at the Northern Great Plains Research Laboratory (46.767085° N; -100°908629° W) on loamy ecological sites (Sedivec et al., 2021). Fifty smooth brome grass tillers were randomly assigned to 5 different defoliation treatments in three different ungrazed exclosures in 2018, 2019 and 2020 (n=30 tillers treatment⁻¹). Tillers were defoliated 1) once in the vegetative stage; 2) twice in the vegetative stage; 3) in the elongation stage; 4) in the reproductive stage; or 5) left undefoliated. Tillers were collected at the end of the field season and brought back to the laboratory where total tillers and rhizomes were counted (Total Outgrowth).

Drought and defoliation treatments were initiated on nearby sites in 2017 and continued through 2021. Each site had nine 2x2 m plots that were 1) exposed to ambient precipitation; 2) had 30% of ambient precipitation intercepted using plexiglass gutters or 3) had 60% of ambient precipitation intercepted. In addition, half of each plot was burned in the fall of 2017, 2019 and 2020. In May and November of 2020 and 2021, a cm⁻² sample was collected using a soil probe and brought to the laboratory where it was cleaned and stained using a 0.1% 2,3,5-triphenyl tetrazolium chloride (TTC) solution (Hendrickson & Briske, 1997). Stained buds were considered active and counted.

Results

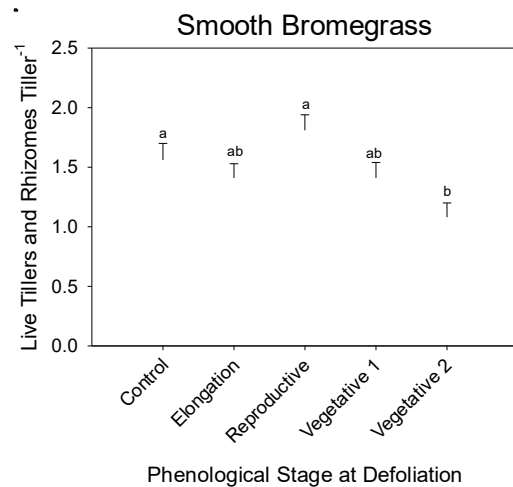


Figure 1. Number of live tillers and rhizomes for smooth brome grass tillers defoliated at different phenological stages. Different letters over the bars indicate significant differences at $P \leq 0.10$.

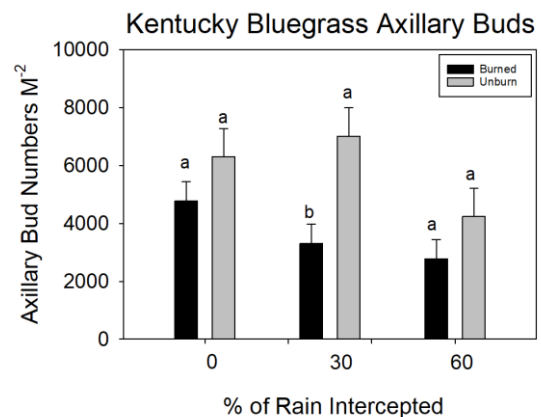


Figure 2. Number of Kentucky bluegrass active axillary buds per m⁻². Different letters over the bars indicate significant differences between burned and unburned plots at $P \leq 0.10$.

Smooth Bromegrass Defoliation

Defoliating smooth bromegrass twice in the vegetative stage reduced outgrowth (live tillers and rhizomes) compared to undefoliated controls and defoliating in the reproductive stage (Figure 1). However, outgrowth on a tiller⁻¹ basis still exceeded 1 indicating that outgrowth still exceeded the number required for population persistence.

Kentucky Bluegrass Response to Drought and Burning

Kentucky bluegrass had a burn by drought interaction. Axillary buds were significantly reduced by burning when 30% of the ambient rainfall was intercepted (Figure 2). Axillary bud number m⁻² on the unburned treatments was lower when 60% of the ambient rainfall was intercepted compared to 30% (P = 0.0575).

Discussion [Conclusions/Implications]

Outgrowth, such as tiller and rhizome numbers, and axillary bud numbers should not be used to predict future meristematic outgrowth for these two invasive perennial grasses. For both examples, the invasive grass has adequate amounts of outgrowth or axillary buds to maintain their populations into the future. Environmental variables also impact demographic processes as demonstrated by the reduction in axillary bud numbers on the unburned portions of the rain intercept plots when 60% of ambient precipitation was intercepted compared to 30%. However, the data suggest that demographic attributes can be used to identify potential treatments or to explain why certain control measures are more successful. For example, smooth bromegrass outgrowth suggests that grazing when the grass is reproductive may increase its tiller numbers. Similarly, burning appears to reduce the number of axillary buds in Kentucky bluegrass suggesting a potential mechanism for the success of burning as a control for Kentucky bluegrass (Erath et al., 2017; Hendrickson and Lund, 2010).

Acknowledgements

The authors would like to acknowledge the help of Levi Binstock, Vanessa Yeoman-Goodrich, Aaron Field, Kathleen Yeater, Amanda Hintz, Jeremiah Morrissette, and Alyssa Schiwal for help with data collection and analysis.

References

- Erath, C. B., Hendrickson, J. R., Kirby, D., Dekeyser, E. S., Sedivec, K. K., West, M. S. (2017). Controlling Kentucky Bluegrass with Herbicide and Burning Is Influenced by Invasion Level. *Invasive Plant Science and Management*, 10, 80–89. <https://doi.org/10.1017/inp.2017.2>
- Hendrickson, J. R., Briske, D. D. (1997). Axillary bud banks of two semiarid perennial grasses: Occurrence, longevity, and contribution to population persistence. *Oecologia*, 110(4), 584–591. <https://doi.org/10.1007/s004420050199>
- Hendrickson, J. R., Liebig, M. A., Printz, J., Toledo, D., Halvorson, J. J., Christensen, R. G., Kronberg, S. L. (2021). Kentucky Bluegrass Impacts Diversity and Carbon and Nitrogen Dynamics in a Northern Great Plains Rangeland. *Rangeland Ecology and Management*, 79, 36–42. <https://doi.org/10.1016/j.rama.2021.07.005>
- Hendrickson, J. R., Lund, C. (2010). Plant community and target species affect responses to restoration strategies. *Rangeland Ecology and Management*, 63(4), 435–442. <https://doi.org/10.2111/08-239.1>
- Hendrickson, J. R., Sedivec, K. K., Toledo, D., Printz, J. (2019). Challenges Facing Grasslands in the Northern Great Plains and North Central Region. *Rangelands*, 41(1), 23–29. <https://doi.org/10.1016/j.rala.2018.11.002>
- Ott, J. P., Klimešová, J., Hartnett, D. C. (2019). The ecology and significance of below-ground bud banks in plants. *Annals of Botany*, 123(7), 1099–1118. <https://doi.org/10.1093/aob/mcz051>
- Sedivec, K. K., Hayek, M., Printz, J. L., Sieler, S. (2021). *Ecological Sites of North Dakota* North Dakota State University Extension Service, Report No. 1556, Fargo, North Dakota, USA.
- Toledo, D., Sanderson, M., Spaeth, K., Hendrickson, J., Printz, J. (2014). Extent of Kentucky Bluegrass and Its Effect on Native Plant Species Diversity and Ecosystem Services in the Northern Great Plains of the United States. *Invasive Plant Science and Management*, 7(4), 543–552. <https://doi.org/10.1614/IPSM-D-14-00029.1>