Effects of burning and nutrient additions on *Puccinia dioicae* infecting *Erigeron strigosus* in tallgrass prairie

S.P. Dendy (1), K.A. Garrett (1), H.U Ahmed (1)
(1) Dept of Plant Pathology, Kansas State University, Manhattan, KS

Abstract

We studied the effects of burning and the addition of nitrogen and phosphate on a leaf rust caused by *Puccinia dioicae* in a common tallgrass prairie forb, *Erigeron strigosus*. We measured leaf rust severity, inflorescence size and plant height. Disease severity was three to five times higher in unburned plots than in burned plots in all three years of our study. Mean leaf rust severity was an order of magnitude higher in 2000 than in 2001, probably because of the unusually hot and dry summer after sampling in 2000. Inflorescence size and plant height were also significantly higher in unburned than in burned plots. In one year, inflorescence size was significantly greater in plots with added P. Inflorescence size was greater in +N than in -N plots in one year. There was evidence for correlation between the abundance of the primary host, *Carex gravida*, and rust severity on alternate host *E. strigosus* in two years. Differences in weather from year to year appeared to be the most important factor in determining the abundance of this pathogen in the short term, with burning and host abundance also playing an important role.

Introduction

Fire is used to manage some plant diseases and is a tool for maintenance of prairie grasslands, but little is known about how fire affects plant disease in prairies. We studied the effect of burning on a leaf rust of a common annual forb, *Erigeron strigosus* (daisy fleabane), caused by *Puccinia dioicae*. Our study was conducted at Konza Prairie Biological Station (KPBS), a 3487 ha tallgrass prairie remnant near Manhattan, Kansas. KPBS was established for studies of the effects of fire, grazing, and climate on the tallgrass prairie. In our experiment, we estimated the effect of burning as well as N and P additions on severity of this disease and on the size and fecundity of *E. strigosus*. We analyzed the correlation between disease severity and the abundance of the *Carex* species reported to be the primary hosts of *P. dioicae*. Determination of the role of these factors will allow us to better predict the abundance of this pathogen under different burning regimes and environmental conditions.

Materials and Methods

To consider the relationship between these factors, we measured plant disease in an existing experiment at KPBS. In our experiment, the plots we used (a subset of the complete “Belowground Study”) were arranged in a split plot design with burning applied at the whole plot level and nutrient additions applied at the subplot level with four blocks for a total of 64 subplots. Whole plots were burned annually in April or left unburned. Subplots received no nutrient addition (control), 10 g ammonium nitrate m^{-2} annually (+N treatment), 1 g m^{-2} superphosphate annually (+P treatment) , or both nitrogen and phosphate (+N + P treatment) annually since 1986. The abundance of the three *Carex* species in the 12.5 X 12.5 m subplots has been measured every five years by estimating the percent canopy cover of each plant species in $5m^2$ quadrats per subplot.

Measurements on individual plants included the height of the plant to the base of the inflorescence, the number of leaves and the number of leaves with leaf rust. We calculated severity as per cent diseased leaves. To obtain an estimate of reproductive effort, we treated the inflorescence as a oval, measured the semiaxes, and calculated the area of the oval. The size of the inflorescence was a strong predictor for the number of flowers produced by a plant (data not shown). We measured the 20 plants closest to a transect through the subplot, or all plants in the subplot if there were 20 or fewer. We counted the number of flowers of five randomly chosen plants in each subplot. We sampled in mid-June. In 2000 we sampled control and +P subplots, and in 2001 and 2002 all subplots. Statistical analyses were based on the subplot means for the 20 plants. Because no *Erigeron* was found in some +N and +N+P subplots in 2001 and 2002, appropriate blocks were excluded from some analyses.

Photo courtesy of Emmet J. Judziewicz and Wisconsin State Herbarium

Photo courtesy of KPBS

Results

Difference between years. Mean leaf rust severity was higher in 2000 than in 2001, probably because of the unusually hot and dry summer after sampling in 2000. Severity increased in 2002 but not to 2000 levels (Fig.1).

Effect of burning. Disease severity, inflorescence size, and height were all significantly greater ($p < 0.05$ in all but one case) in the unburned plots than in burned plots in all three years (Fig. 1-3).

Effect of nutrient addition.
On disease severity: There was some evidence ($p = 0.11$) for an effect of N addition to increase disease severity in one of the two years we could study this effect (Fig. 4). There was essentially no evidence for an effect of P addition on disease severity over three years ($p < 0.25$ each year).

On plant size: Mean plant size was greater in +N plots compared to plots with no added nitrogen in 2001 ($p = 0.11$) and 2002 ($p = 0.12$). The effect of P addition was not consistent from year to year.

On inflorescence size: Mean inflorescence size was greater in +N plots compared to plots with no added nitrogen (Fig. 5) in 2001 ($p < 0.001$) and 2002 ($p = 0.09$). Mean inflorescence size was greater in +P plots (mean = 72.4 cm^{-2}) compared to control plots (mean = 55.8 cm^{-2}) in 2000 ($p = 0.07$) but there was no evidence for an effect in 2001 or 2002.

Correlation with abundance of *Carex*. Severity of leaf rust was positively correlated with the abundance of *Carex gravida* in subplots in 2000 ($p = 0.05$) and 2001 ($p = 0.002$). In 2002, the severity of leaf rust was positively correlated with the abundance of *Carex meadii* ($p = 0.08$). There was no correlation between the severity of leaf rust and abundance of *Carex brevior*.

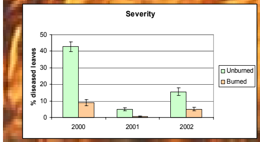

Figure 1. Mean disease severity in unburned and burned plots.

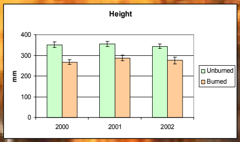

Figure 2. Mean plant height in unburned and burned plots.

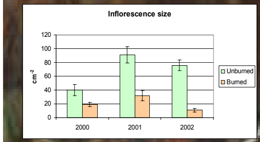

Figure 3. Mean inflorescence size in unburned and burned plots.

Photo courtesy of John M. Blair, Division of Biology, Kansas State University, Manhattan, Kansas

References

Hardison, J.R. 1963. Control of *Gloeotinia temulenta* in seed fields of *Lolium perenne* by cultural methods. Phytopathology 53:460-4.

Hardison, J. R. 1976. Fire and flame for plant disease control. Ann.Rev. Phytopathology 14:355-79.

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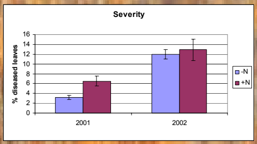

Figure 4. Mean severity in subplots with added nitrogen or no added nitrogen.

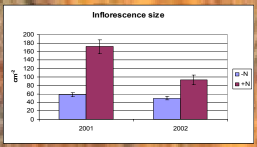

Figure 5. Mean inflorescence size in subplots with added nitrogen or no added nitrogen

Discussion

Fire may act on disease abundance through at least two mechanisms.
(1) Since *E. strigosus* is an annual, it must become established in the prairie each year. Spring burning destroys the *E. strigosus* plants germinating in the early spring. Plants germinating later, after the fire, may not be exposed to the same level of inoculum as plants that were established earlier in the year. Most of the precipitation at KPBS falls in the spring and fall, so later-established plants may have a shorter period of high moisture before the beginning of the dry period of summer.
(2) Burning probably also destroys some inoculum. This is a common mechanism by which fire has been used to manage diseases.

Added nitrogen leads to abundant vigorous grasses, which may make it more difficult for forb seedlings to become established. P is generally not limiting in the prairie because of mycorrhizal associations, so it is not surprising that additional P had little effect.

The difference in disease severity between years, probably due to very different weather conditions, was greater than the difference between treatments within a year in most cases. Weather from year to year at KPBS may vary dramatically. To understand how disease severity is affected by weather and other variables in this plant-disease system will require long-term study.

Research at KPBS has shown that different burning regimes strongly affect plant species composition. Burning may affect the pathogen both through its effects on survival of spores and through its effects on the abundance of the primary and secondary hosts.

Acknowledgments: We are grateful to John W. McCain for help in identifying the pathogen. Thanks to Mark Mayfield at the K.S.U. Herbarium for confirmation of the identification of *E. strigosus*. Field help was provided by Kate Galliher, Cathy Bylinowski, Tri Setiyono, Sabrina Jedlicka and Aaron Parks. This research was funded in part by the National Science Foundation under Grant No. DEB-0130692 and by NSF Grant No. EPS-9874732 with matching support from the State of Kansas.

Flowers are about 1 cm in width.

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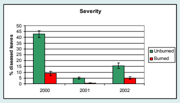
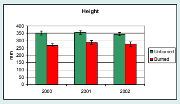
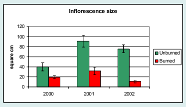
Materials and Methods

Results burning







Results nutrients

Conclusion

References

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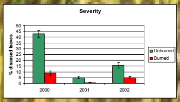

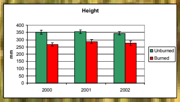

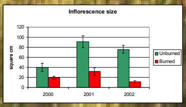

Results nutrients

Conclusion

References

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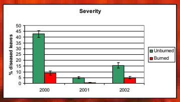

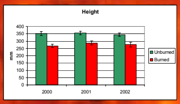

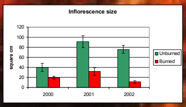

Results nutrients

Conclusion

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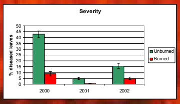

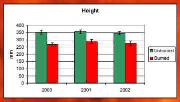

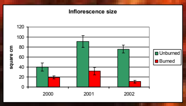

Results nutrients

Conclusion

References

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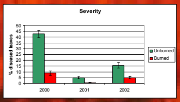

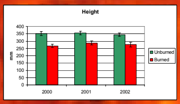

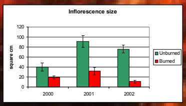

Results nutrients

Conclusion

References

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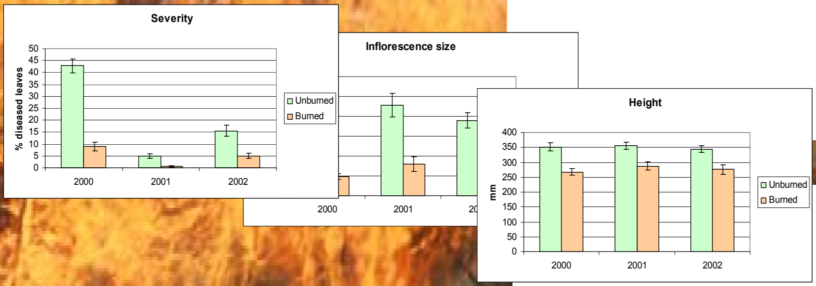

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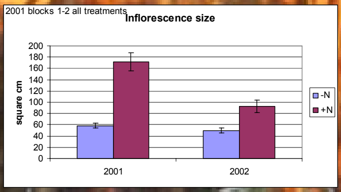

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Conclusion

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