SPATIAL VARIATION IN ROUGHSTALK BLUEGRASS AFFECTS TALL FESCUE SEED YIELD

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Introduction

Roughstalk bluegrass is an especially troublesome weed of grasses grown for seed. Severity of infestations increases over time through establishment of new seedlings and enlargement/spread of older plants. This weed reduces crop yield through competition in the field and increases losses during seed cleaning due to difficulty of removing the hairy weed seed from crops such as tall fescue and perennial ryegrass. Registered herbicide treatments usually control seedling roughstalk bluegrass, but incompatibilities between rainfall patterns, weed seed germination, timing of herbicide applications, and uniformity of stubble, chaff, and weed seed distribution often allow some new seedlings to successfully establish in portions of fields. Use of glufosinate herbicide as a “salvage/rescue treatment” does a good job of reducing seed production by roughstalk bluegrass plants but also reduces tall fescue seed yield. High-resolution mapping of roughstalk bluegrass distribution within tall fescue seed fields was conducted to quantify yield loss due to this weed and to identify patches that might be amenable to semi-automated “spot-spraying” through modern GPS-controlled field sprayers.

Materials and Methods

Tests were conducted in three established stands of tall fescue grown for seed in Linn County, OR. Roughstalk bluegrass severity was first evaluated in January 2018 at grid sample spacing of 180 feet, followed by additional counts at 60-foot resolution later in the winter in the portions of fields transitioning from low to high density of roughstalk bluegrass. The number of roughstalk bluegrass plants encountered in 32 stops along a 64-foot circular path walked around each target point was counted, with a maximum of 5 plants allowed in the 2-square-foot zones viewed at each stop. When totals of 10 or more roughstalk bluegrass plants were found in the circular walk, the count was terminated to speed up the process. Aerial photographs were taken in late spring as a possible alternative means for quantifying weed severity.

The three fields varied in age, ranging from a new stand with only one prior harvest to older stands in production for more than a decade. Fields studied in the first year of the project were from a single grower.

Data from the coarser-resolution weed counts were made available to the grower in time for consideration of spatially varying application of herbicides such as glufosinate. However, the unusually high prices being offered for grass seed in 2018 led to a decision to not apply treatments likely to substantially reduce tall fescue seed yield. Hence, the relationship between roughstalk bluegrass severity and combine yield data in 2018 was simply one of competition between crop and weed, rather than a combination of that factor plus injury where “salvage/rescue treatments” might have been applied.

Results and Discussion

At two of the sites, there were no clear relationships between roughstalk bluegrass severity and tall fescue seed yield. In the case of the second-year stand, roughstalk bluegrass plants had simply not yet had the opportunity to grow into sizes able to compete aggressively with the tall fescue, at least not on scales represented by combine yield monitor data points and grid sample measurements of weed severity. The problem at the second site was that moderately high roughstalk bluegrass densities, combined with conversion of the tall fescue stand from rows to varying-sized clumps no longer identifiable by row spacing or direction, resulted in greater variability in the uniformity of tall fescue stands than in the severity of roughstalk bluegrass infestation.

The third site was in its 13th year of seed production in 2018, with easily discernible variation in roughstalk bluegrass infestation severity ranging from nearly weed-free conditions in much of the center and northwest quarter of the field to severe patches on the south side of the field and around much of its periphery. Approximately 40% of the field was characterized as having moderate to heavy infestations of roughstalk bluegrass, defined as at least one roughstalk bluegrass plant present per every 5 square feet of area. Our technique for measuring roughstalk bluegrass severity maxed out at 2.5 plants/ft^2, a severity level actually encountered at several spots across the field.

When ordinary least squares (OLS) regression was used, tall fescue (yield monitor) seed yield was best defined by fourth-degree regressions on roughstalk bluegrass severity, with *R*-square values of 48.7% in 2018 and 27.1% in 2017. Predicted yield loss at average levels of roughstalk bluegrass infestation was 49.1% for 2018 and 20.3% for 2017. Yield loss measurements in 2017 were compounded by the fact that weed severity was measured only in 2018, not in 2017, and by the grower's application of glufosinate to the southwest corner of the field in 2017.

Best practices for spatial data analysis include replacement of OLS regression with geographically weighted regression (GWR) models able to account for the presence of spatial autocorrelation—the tendency of measurements near each other in space to possess similar values simply due to their geographic proximity. When GWR was run on tall fescue yield as a function of roughstalk bluegrass severity, only a cubic polynomial was needed, with *R*-square values of 53.5% in 2018 and 34.9% in 2017. The GWR model allows regression coefficients to vary across the field and therefore lacks the simpler interpretations of the OLS model.

Compared with many other factors commonly used in analysis of spatial data, the impact of roughstalk bluegrass on tall fescue seed yield stands out as an unusually strong factor with clear implications. Because some of the yield monitor signal was actually from roughstalk bluegrass seed harvested along with the tall fescue seed, the true impact of this weed on tall fescue clean seed yield would be even worse than that indicated in these regressions. Separate samples taken from swathed windrows indicated that the grower's combines were removing approximately three-quarters of all roughstalk bluegrass seed initially present in the windrows.

Our next step was to evaluate the potential for aerial photography to supplement or potentially replace the most labor-intensive step in our analysis, the 60-foot grid sampling of roughstalk bluegrass severity. Data taken on behalf of crop advisors working for Nutrien Ag Solutions included color, infrared, and NDVI in photographs taken from a piloted airplane on April 4, 2018. Data contracted by USDA-ARS consisted of color imagery from UAV drone flights on May 30, 2018. Tests of relationships between bands of these images and the 60- to 180-foot grid samples of roughstalk bluegrass severity found strongest links for the May 30 color mosaic band2 and the April 4 color image band3, infrared, and NDVI. Regressing grid sample roughstalk bluegrass severity on values of these four bands plus their squares produced an *R*-square value of 47.0%, a reasonable but far-from-perfect recreation of weed severity even with knowledge of weed density over areas approximately 20 feet wide. In the absence of prior knowledge of weed density, these images would almost certainly do an even poorer job of quantifying roughstalk bluegrass severity across a field.

To test the possibility that the weed severity estimates produced from the aerial photographs were actually better than our grid sample counts and not just randomly different, we regressed combine yield monitor data on the same four image bands plus their squares. The best OLS model for 2017 yield monitor data omitted the NDVI terms and possessed an *R*-square value of 28.9%. The best model for 2018 yield monitor data omitted the linear NDVI term and possessed an *R*-square value of 44.4%. Both of these *R*-square values were poorer than those for the GWR third-degree polynomials for roughstalk bluegrass severity, although the 2017 OLS image band model was slightly better than the OLS roughstalk bluegrass severity model.

The difficulty in making multiple image bands perform as well as actual grid samples in modeling yield monitor data suggests that there will be no easy shortcuts simply from aerial photography conducted at an approximately 1-foot pixel size when subsequently averaged over distances in the range of 60 feet. Some degree of intensive within-field sampling of weed severity currently appears to be unavoidable, although higher-resolution imagery capable of identifying individual roughstalk bluegrass plants and/or leaves might provide an alternative to the 60-foot grid sampling we employed in this study. Movement of leaves in the wind will cause difficulties in obtaining clear images of individual grass plants.

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