
The Effect of Nitrogen Rate and Weed Density on Spring Wheat Yield at Two Landscape Positions

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Abstract

Site-specific fertilizer applications may have implications for weed population dynamics that have been largely ignored. The purpose of this study was to determine the effect of landscape specific nitrogen application on wild oat (*Avena fatua* L.) and wild buckwheat (*Polygonum convolvulus* L.) competitiveness in spring wheat. This experiment was a split-split plot design wherein the main plot was landscape position, the subplot was nitrogen rate, and the sub-subplot was target weed density. The main plots were planted with either wild oats or wild buckwheat. The experiment was conducted at two sites near Birtle and Carman, Manitoba. Measurements of weed competitiveness included wheat grain yield per plot (as percentage of weed-free treatment), and plant dry biomass (g/m²). Other measurements included soil fertility, gravimetric moisture, soil profile characterization, and site topographical characterization to provide a detailed description of the landscape encountered at each site. Results from three site years indicate that under high nitrogen rates relative wild oat competitiveness may increase with increasing density. Results from three site years suggest that increasing wild buckwheat density caused no consistent decline in wheat yield. Landscape position has no apparent effect on either wild oat or wild buckwheat competitiveness, though analysis is ongoing. Birtle 1999 plots and biomass data from all site-years have yet to be analyzed. Independent soil characteristics will be tested for correlation to yield, biomass, density and landscape position.

Key words: spring wheat, *Avena fatua*, *Polygonum convolvulus*, site-specific nitrogen, site-specific farming

Introduction

With increasing availability and decreasing cost of GPS and GIS technology, there is intense interest in the development of site-specific farming. Site-specific farming caters management practices to unique areas within a field, encouraging the application of appropriate input rates. This technique may reduce of the total volume of chemical fertilizers and pesticides applied, benefiting both the environment and the farmer. Yields may be increased via optimization of the rate of fertilizer application, particularly where fertilizer was under-applied and crop yield was below maximum potential. Fertilizer losses resulting from excess application may also be reduced. Pest control efficiency may increase. The practice of site-specific farming shows promise, and calls for further study into its incorporation into farm management systems.

Two components of site-specific farming are of interest in this study. Site-specific weed management uses weed infestation maps created through ground reconnaissance or remote sensing to facilitate spot spraying. This allows the farmer to target each weed species

individually and on a spatially specific basis in one pass. This would provide more effective weed control on a whole field basis, leading to increased yields and more prudent use of herbicides. The efficacy of spot spraying and the benefits associated with it are reliant upon the accuracy of the weed infestation map, and its functional lifespan. We can only determine the useful lifespan of a weed map if we understand how, why, and what rate weed patches move. If weed patches move unexpectedly, the maps may be rendered useless. Site-specific fertilizer application uses the variability of crop response to landscape variability to map areas of differing yield potential. Farmers then typically boost fertility in high yield potential areas, often areas already high in fertility and moisture, which are more able to support a higher yielding crop. This technique frequently increases profits, but the effect on weeds is currently unknown.

Some information about the interaction of weeds and nitrogen comes from Sexsmith and Pittman (1963). In studies conducted in Alberta, they found that fertilization increased number of wild oats present in an oat field. Early spring applications of nitrogen broke dormancy of greater number of WO seeds, increasing wild oat germination. In a review paper by Di Tomaso (1995) various authors noted that increased N at high weed densities provided little improvement in yield, but tended to increase weed growth. Dependence on weed control measures was increased, and fewer nutrients were available for the crop. Carlson and Hill (1985) observed the same results while conducting three years of field experiments in California looking at wild oat in wheat (Figure 1). They noted an antagonistic effect whereby increased nitrogen rates at high wild oat densities increased the rate of relative wheat yield loss, actually quadrupling the relative wheat yield loss at high wild oat densities compared to plots with no nitrogen applied.

This research suggests that increased nitrogen rates, particularly on high densities of weeds, make the weeds more competitive. Weeds that are more competitive may produce more seed, and may also result in an unpredicted weed patch spread. This could prove costly for producers in terms of unexpected yield loss and will be of particular concern to producers who are dealing with herbicide resistant weed patches. In addition, it will hinder the development of site-specific weed management because it will lower the value of weed maps by decreasing the predictability of weed patch spread.

Research Objectives

The objective of this project was to determine if the practice of site-specific fertilization influenced the competitive ability of weeds in the field. In order to meet this objective, the most economically important grassy weed (wild oat, *Avena fatua* L.) and the most common broadleaf weed (wild buckwheat, *Polygonum convulvulus* L.) in Manitoba crops (Thomas et al., 1998) were studied in a common crop (spring wheat).

Methodology

The experiment was conducted at two sites near Birtle and Carman, Manitoba. The Birtle site is classified as a gently undulating glacial till soil of the Newdale association. The main plots were planted on either the knoll or the footslope, wherein the relief differed by roughly 4m, and the gradient did not exceed 4%. The Carman site is classified as a localized depression of the La Salle soil type, ranging from sandy clay loam to clay loam in texture. Relief between main plots on the knoll and the toe differed by approximately 1m, and the gradient did not exceed 5%.

Treatment factors included landscape position (knoll and foot), weed species, target weed density, and nitrogen rate. Wild oat and wild buckwheat were planted at target densities of 0, 25, 50 and 100 plants/m². Nitrogen rates of 0, 40, and 80 kg N/ha were replicated twice in all site years, with the exception of three replicates in Carman 1998.

Wheat grain yield loss was plotted as a function of weed density by weed species, and was fit to either a rectangular hyperbolic (Cousens 1985) or linear equation. The parameters of initial slope (i) and asymptote (a) in the hyperbolic equation are biologically realistic representations of weed competitiveness and maximum potential yield loss, respectively. The linear equation depicts weed competitiveness with the slope parameter (m), but assumes infinite potential yield loss. Wheat yield loss was also plotted as a function of relative biomass for wild oat plots at both sites in 1998.

Preliminary Results and Conclusions

Wild Buckwheat

Results from the three site years that were analyzed indicated that wild buckwheat caused no consistent reduction in wheat yield as density increased (Figure 2). The factors of year, site and nitrogen rate were not significantly different, thus they were combined for analysis. The data distribution for wheat yield loss by wild buckwheat density was relatively evenly distributed on either side of 0% yield loss, ranging from approximately 65% yield loss to 75% yield gain. The even distribution of yield loss in wild buckwheat treatments may indicate a lack of competition from wild buckwheat, even when it appears at relatively high densities (>150 plants/m²). The extreme variability in the yield loss was attributed to the inherent variability of yield within the field, and the yield variability among the control plots to which treatment plots were compared.

Preliminary analysis of wheat yield loss as a function of wild buckwheat relative biomass (Birtle 1998 only, data not shown) indicated that wild buckwheat relative biomass had no consistent effect on wheat yield loss. This data will be more thoroughly analyzed, as will data for the other site years. Birtle 1999 yield data is also being analyzed.

Wild Oats

Trends in yield loss were noted for wild oat treatments for the three site years analyzed. Year was not significant according to ANOVA, thus the years were combined for analysis. Distributions of wheat yield loss by wild oat density were fitted to a rectangular hyperbola equation in order to compare the biologically meaningful parameters of initial slope (i) and the asymptote (a) (Table 1). Distributions from Birtle 1998 fit the rectangular hyperbola model relatively well ($r^2=0.52$ and 0.60 for low and high nitrogen treatments, respectively). The Carman distribution, combined over years, did not fit this equation. Thus the data was fit to a linear equation ($r^2=0.52$ and 0.58 for low and high nitrogen treatments, respectively), and slopes of the equation were compared. The i values for Birtle 1998 low nitrogen ($i=0.28\pm 0.04$) and high nitrogen ($i=0.97\pm 0.07$) treatments were significantly different ($p<0.01$), with wild oats becoming more competitive under high nitrogen treatments. The a values for Birtle 1998 were not statistically different (77.5 ± 10.4 for both the low and high nitrogen treatments) (Figures 3a and 3b). The linear slope parameter 'm' differed significantly, with a value of 0.12 for low nitrogen

treatments, and 0.19 for the high nitrogen treatments (graphs not shown).

Dry biomass data from 1998 (Table 1) suggests that wheat yield loss, as a function of relative wild oat biomass was not significantly changed by nitrogen rate at either site. The rate of yield loss per unit increase in wild oat density may have been higher at Carman, but significance has not been analyzed. The asymptote for both Carman and Birtle was similar, with the exception of the 80N treatment at Birtle 1998. The a value at Birtle 1998 of 382.63% loss \pm 711.2% is not biologically realistic, and warrants further analysis.

Birtle 1999 grain samples, all biomass samples, and all soil and landscape characteristics have yet to be analyzed in detail.

Conclusions

These results indicate that under high nitrogen rates relative wild oat competitiveness may increase. Results from the three site years analyzed suggest that wild buckwheat caused no consistent decrease in wheat yield. The effect of landscape position was not apparent.

Implications

Efficacy of weed control measures is critical in high nitrogen systems, as wild oat competitiveness appears to increase in these conditions. Landscape position appears to have no effect on weed competition, but the interactions of position and crop yield are complex and difficult to measure accurately under field conditions. More detailed analysis is required. Examination of biomass data and independent soil characteristics may demonstrate the effect of landscape position more clearly.

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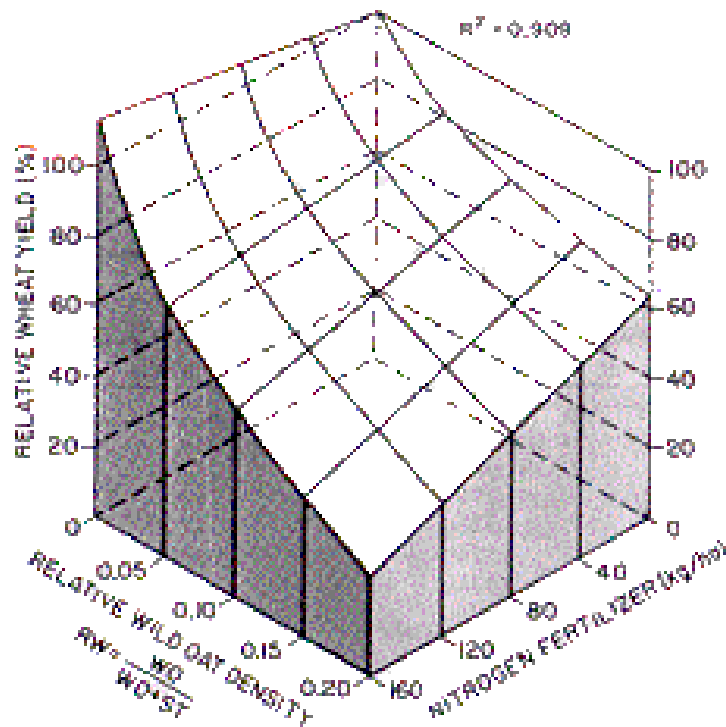


Figure 1. Relative wheat yield response to relative wild oat density and nitrogen fertilizer rate. (from paper by Carlson and Hill 1985).

Table 1. Hyperbolic and Linear Model Parameter Values for Wheat Grain Yield Loss as a Function of the Independent Variable (Density or Relative Biomass) Under Wild Oat Treatments.

Independent Variable	N Rate	Hyperbolic Model		Linear Model
		i	a	m
Birtle 1998				
Density	0N	0.28	77.5	
	80N	0.97	77.5	
Relative Biomass	0N	1.1	44.95	
	80N	1.1	382.63	
Carman 1998/99				
Density	0N			0.12
	80N			0.19
Relative Biomass (1998 only)	0N	2.65	45.04	
	80N	2.65	45.04	

NB Parameters with different values under the same independent variables are statistically significant at p=0.05

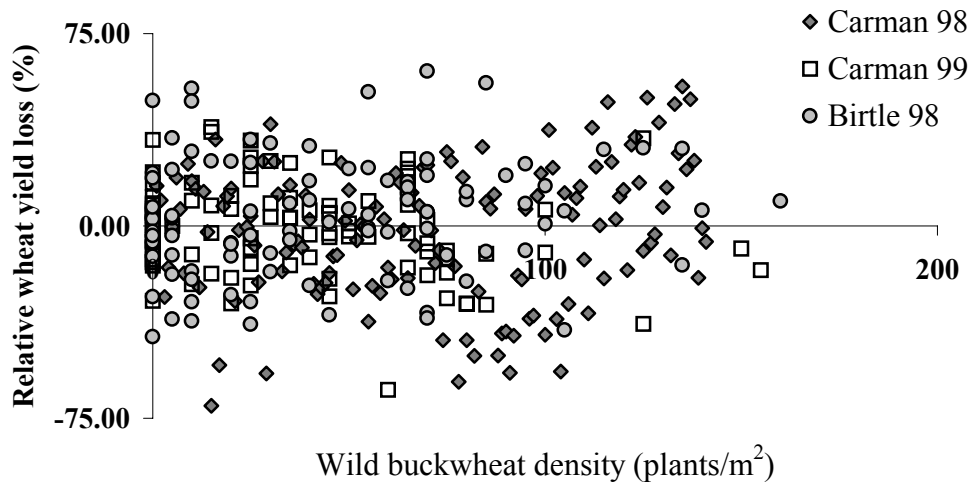


Figure 2. Response of wheat (relative yield loss) to wild buckwheat density under combined high and low nitrogen treatments at three site-years.

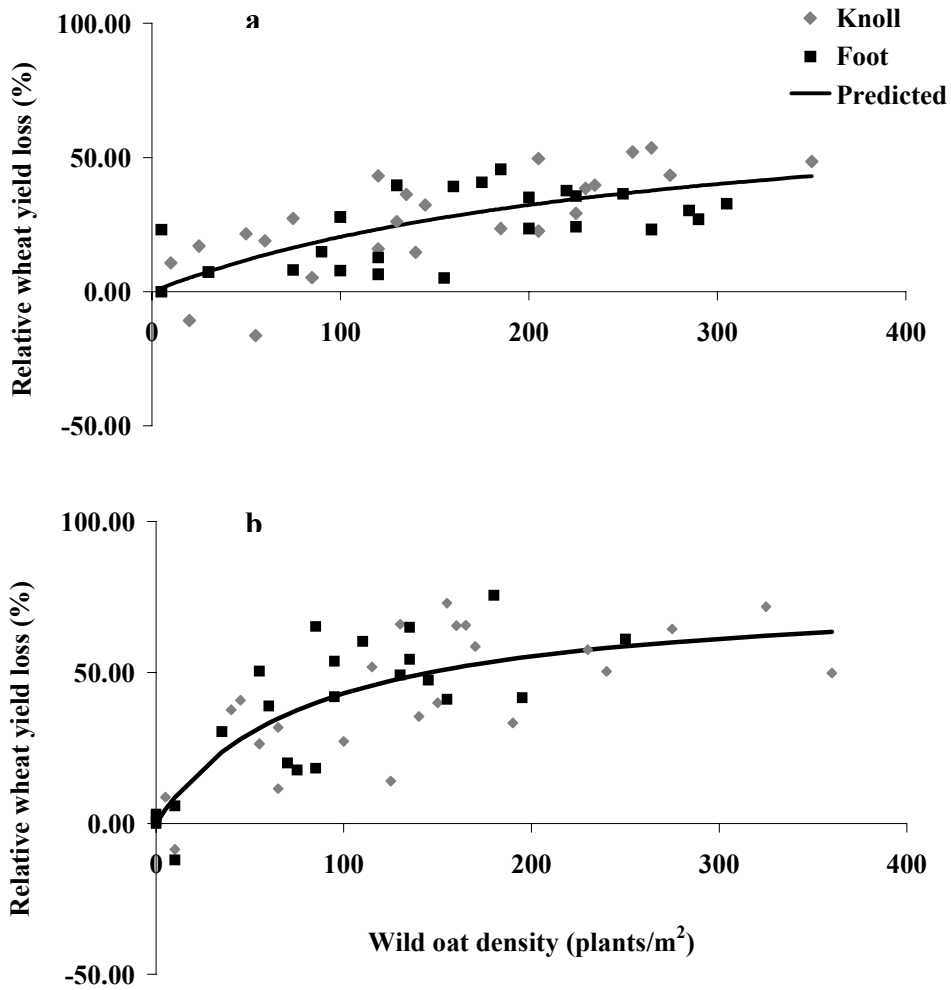


Figure 3a and 3b. Response of wheat yield loss to wild oat density under low nitrogen (a) and high nitrogen (b) treatments at Birtle 1998.