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SHORT COMMUNICATION

# Cereal rye cover crop suppresses winter annual weeds

Rodrigo Werle, Charles Burr, and Humberto Blanco-Canqui

**Abstract:** Cover crop (CC) adoption has increased in North America corn and soybean production areas. The objective was to evaluate the impact of cereal rye CC on winter annual weeds. Cereal rye reduced winter annual weed density and biomass by >90% at time of spring termination, showing potential as a component of an integrated weed management program.

*Key words:* cereal rye cover crop, weed suppression, integrated weed management, interspecific competition.

**Résumé :** On recourt de plus en plus aux cultures-abris dans les régions d'Amérique du Nord où l'on cultive le maïs et le soja. La présente étude devait évaluer l'impact d'une culture-abri de seigle sur les mauvaises herbes d'hiver annuelles. Le seigle avait réduit la densité et la biomasse des adventices annuelles d'hiver de plus de 90 % à la fin de la culture, au printemps, signe qu'on pourrait s'en servir dans le cadre d'un programme de lutte intégrée contre les mauvaises herbes. [Traduit par la Rédaction]

*Mots-clés :* culture-abri de seigle, suppression des mauvaises herbes, lutte intégrée contre les mauvaises herbes, concurrence entre espèces.



## Introduction

Cover crops (CCs) are increasing in popularity in corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.] production areas in North America (SARE/CTIC 2016). Cover crops are grown during periods of the year when cash crops are absent, potentially protecting the soil from water and wind erosion, increasing soil organic C, and reducing N leaching (Blanco-Canqui et al. 2015; Appelgate et al. 2017). Cereal rye (*Secale cereale* L.) has become a common CC option as it is winter hardy and relatively easy to establish into standing corn and soybean or after corn and soybean harvest. It can also produce a great amount of biomass and seeds are generally less expensive compared with other CC species (Hayden et al. 2012; Appelgate et al. 2017). When planted as part of a CC mix, cereal rye tends to predominate over other CC species and thus research has demonstrated that CC mixtures do not often provide measurable benefits beyond a productive CC monoculture (Appelgate et al. 2017).

Winter annual weeds are species that typically emerge in the fall and senesce by late spring or early summer (Werle et al. 2014). Winter annual weeds have become prolific in North American agriculture as a result of the increased adoption of conservation tillage practices (e.g., lack of fall and (or) spring tillage allow these small-seeded species to establish and reproduce; Swagata et al. 2009). Winter annual weeds can act as alternative hosts for major pests including the soybean cyst nematode (*Heterodera glycines*, SCN; Venkatesh et al. 2000). Once they reproduce, winter annual weeds can be an annual problem as their seeds may last several years in the seedbank. To reduce problems associated with winter annual weeds, producers can apply herbicides in late fall or early spring. Herbicides applied in the fall can satisfactorily control winter annual weeds and be more beneficial compared with an early spring application, especially during wet years, by allowing producers to better spread their workload over time (Hasty et al. 2004). During late spring, herbicide application may not result in the desired control if the weeds are at an advanced growth stage. Some winter annual weeds have evolved resistance to herbicides commonly applied in the fall or early spring (e.g., glyphosate-resistant horseweed [*Conyza canadensis* (L.) Cronq.]; Heap 2018), which makes the management of such species difficult and costly.

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**R. Werle.** Department of Agronomy, University of Wisconsin–Madison, Madison, WI 53706, USA.

**C. Burr.** West Central Research and Extension Center, University of Nebraska–Lincoln, North Platte, NE 69101, USA.

**H. Blanco-Canqui.** Department of Agronomy and Horticulture, University of Nebraska–Lincoln, Lincoln, NE 68583, USA.

**Corresponding author:** Rodrigo Werle (email: rwerle@wisc.edu).

Given the increased number of herbicide-resistant weeds and lack of new herbicides (Heap 2018), it is important that herbicide usage be minimized and alternative strategies sought as part of an integrated weed management approach. Cover crops can suppress weeds (e.g., reduce weed density and biomass) directly by competing for space, light, water and (or) nutrients, and indirectly by releasing allelopathic compounds and acting as a physical barrier for weed establishment. Hayden et al. (2012) reported that CCs can be an effective strategy for weed suppression in the winter and spring. When planted late in the summer or in the fall, the life cycle of cereal rye directly overlaps with the life cycle of winter annual weeds; thus, a well-established stand of cereal rye could suppress winter annual weeds, replacing the need for a herbicide application in the fall or early spring. Our hypothesis is that fall-seeded cereal rye CC can reduce winter annual weed density and biomass when compared with winter fallow (no cereal rye CC). Thus, the objective of the study was to evaluate the impact of cereal rye CC planted after corn silage harvest on winter annual weed density and biomass in the spring.

## Materials and Methods

Winter annual weed density (plant $m^{-2}$) and biomass (g $m^{-2}$) data were collected prior to spring herbicide burndown treatment from a cereal rye CC research project established at the West Central Research and Extension Center (WCREC; 41.09°N 100.78°W; Cozad silt loam soil) in North Platte, NE, and at a producer's field 10 km east of North Platte (hereafter referred as Producer; 41.09°N 100.66°W; Wann fine sandy loam soil). The 30-yr annual average temperature and precipitation for the region are 9.3 °C and 514 mm, respectively (High Plains Regional Climate Center; hprcc.unl.edu). Treatments were comprised of cereal rye CC and winter fallow (no CC). The study was conducted as a randomized complete block design with three replications. Both sites were under irrigated no-till continuous corn. Cereal rye CC was drilled (19 cm row spacing) at 67 kg $ha^{-1}$ on 17 Oct. 2016 at WCREC and 94.1 kg $ha^{-1}$ on 20 Sept. 2016 at Producer, shortly after corn silage harvest at both sites. On 18 Apr. 2017, prior to cereal rye CC termination and winter annual weed burndown at both sites, four 0.25-$m^2$ quadrats were randomly placed within each plot of both treatments and the weed species within each quadrat were identified and counted, clipped at the soil surface and combined as a single biomass sample per quadrat, oven-dried to constant mass at 60 °C, and weighed. Additionally, two 0.25-$m^2$ quadrats were randomly placed within each plot of the cereal rye CC treatment and cereal rye plants were clipped at the soil surface, oven-dried to constant mass at 60 °C, and weighed for CC biomass estimation at herbicide burndown application. Analysis of variance was performed using PROC GLIMMIX in SAS 9.4 (SAS Institute Inc., Cary, NC). For the response variables, winter annual weed density (plants $m^{-2}$) and biomass (g $m^{-2}$), experimental treatments [cereal rye CC and winter fallow (no CC)], and site (WCREC and Producer) were treated as fixed factors, whereas replication blocks were treated as random factors. Means were separated when the interaction or main effect was $p < 0.05$. For the cereal rye biomass (g $m^{-2}$) response variable, site (WCREC and Producer) was treated as a fixed factor whereas replication blocks were treated as a random factor. Means were separated when the main effect was $p < 0.05$. All response variable data were square root transformed prior to analysis to satisfy Gaussian assumptions of normality and homogeneity of variance. All results presented herein originated from the same mixed model analysis. Back-transformed means are presented for ease of interpretation.

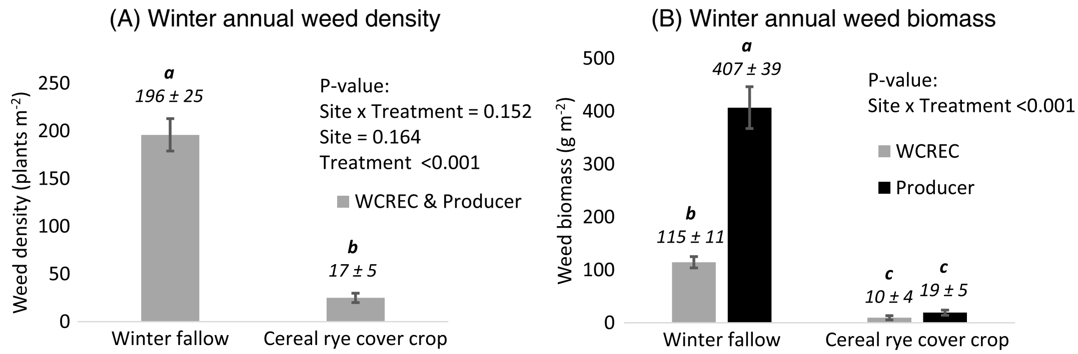
## Results and Discussion

Despite different cereal rye CC planting times at each site, aboveground cereal rye biomass yield on 18 Apr. 2017 was similar at both sites ($p = 0.444$). The amount of CC biomass was 376.6 ± 20.1 g $m^{-2}$ at WCREC and 408.1 ± 32.2 g $m^{-2}$ at the Producer field. There was no treatment × site interaction for the total weed density (weeds $m^{-2}$; $p = 0.152$). Thus, weed density was studied across both sites. Weed density between sites did not differ ($p = 0.164$) but did differ between treatments ($p < 0.001$; Fig. 1). Across sites, cereal rye CC reduced weed density by 91% (17 ± 5 plants $m^{-2}$) compared with winter fallow (196 ± 25 plants $m^{-2}$). There was a treatment × site interaction for the total weed biomass (g $m^{-2}$; $p < 0.001$). Cereal rye CC reduced weed biomass by 91% at WCREC (10 ± 4 g $m^{-2}$) and 95% at the Producer field (19 ± 5 g $m^{-2}$) relative to winter fallow (115 ± 11 and 407 ± 39 g $m^{-2}$, respectively).

Different weed species with different growth rates and stages were observed in this study. Henbit (*Lamium amplexicaule* L.) and horseweed were the main species at WCREC while shepherd's purse [*Capsella bursa-pastoris* (L.) Medik.] and pinnate tansymustard [*Descurainia pinnata* (Walt.) Britt.] were the predominant species at the Producer site. The weeds growing at the Producer site were at an advanced growth stage and large in size. Henbit is a smaller plant species and horseweed plants were starting to bolt at the sampling time at WCREC while shepherd's purse and pinnate tansymustard at the Producer field were at full size and flowering at sampling, which explains the large difference in biomass amount even though density was similar at both sites. Nonetheless, winter annual weed density and biomass yield were reduced by at least 90% when cereal rye CC was present. Corroborating our findings, Hayden et al. (2012) also reported a significant reduction (>90%) of winter annual weeds when cereal rye CC was present.

These results indicate that cereal rye CC could be an effective component of an integrated winter annual weed management program while providing other desired ecosystem services (e.g., erosion control, soil

**Fig. 1.** Winter annual weed (A) density (plants m$^{-2}$) and (B) biomass (g m$^{-2}$) in the winter fallow (no cover crop) and cereal rye cover crop treatment. Cereal rye was planted after corn silage harvest in the fall of 2016. Data were collected on 18 Apr. 2017 at the University of Nebraska–Lincoln West Central Research and Extension Center (WCREC) in North Platte, NE, and at the Producer site (10 km east of North Platte).




organic C accumulation, reduction in N leaching). Moreover, the effective suppression of horseweed, a troublesome weed species, strongly suggests that incorporating cereal rye CC can be a potential management strategy to control herbicide-resistant weeds, a tremendous challenge in row crop production in North America (Heap 2018). Despite the benefits, producers should be mindful that cereal rye must be chemically or mechanically terminated prior to or at crop establishment before it produces seeds. Termination time will depend upon a producer's main objective with the CC and the subsequent crop. In water-limited regions, late termination of cereal rye CC (e.g., after the flowering stage) could reduce subsequent crop yield, particularly in years with below normal precipitation (Ruis et al. 2017).

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