WINTER ANNUAL WEEDS EFFECT ON CORN RESPONSE TO NITROGEN

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Abstract

The timing to control winter annual weeds is a management concern for producers. In regards to corn response to nitrogen, the objective was to determine how important the timing of winter annual weed control is for no-till, rainfed corn production following soybeans by assessing: soil water and nitrate; early growth and nitrogen uptake of corn; nitrogen status of corn at silking-blister; and grain yield. Field research was conducted in 2010 at seven locations in Kansas. There were four different burndown times: fall, early pre-plant (2-4 weeks prior to planting), planting (within one week of planting), and emerged (at V2, two visible leaf collars). After the last burndown treatment, five nitrogen rates of 0, 17, 34, 67, and 135 kg N ha^{-1} were applied. High density stands of winter annual weeds contained 12 to 30 kg N ha^{-1} at maturity in their above-ground biomass. There was no time of burndown by nitrogen interaction for any dependent variables measured. Delaying burndown until planting or after did cause reduced early growth (V5-V8) and early season nitrogen uptake. In early June, gravimetric water content was higher as a result of delaying burndown. Soil nitrate-nitrogen taken in early June was not significantly different among burndown timings. Nitrogen status (assessed by chlorophyll meter readings) at the silking-blister stage of corn was only reduced if burndown was delayed until May after the emergence of corn. Grain yield was not significantly impacted by burndown timing. Corn responded early in the growing season to various burndown timing of winter annual weeds, but the effects diminished by harvest.

Introduction

A no-till (NT) corn-soybean rotation on well-drained soils in the Midwest is a very profitable cropping system (Stanger et al., 2008). Total area under NT production has been substantially increasing over the last decade. Reduced tillage, lack of winter crops, herbicide programs, and late spring weed control are some factors contributing to the increasing prevalence of winter annual weeds (WAWs) in NT corn-soybean rotations. WAW pressure is being perceived as an economic and agronomic concern by many producers and agriculture industry professionals. Winter annuals weeds commonly germinate in the early fall, overwinter, flower and produce seeds in mid to late spring, after which they senesce and die. No-till practices in a summer annual rotation of corn-soybean helps create a niche that favors winter annual broadleaf species such as henbit (*Lamium amplexicaule*) and shepherd's-purse (*Capsella bursa-pastoris*) (Derksen et al., 2002). Addressing the management of winter annual weeds prior to corn is particularly important in Kansas as the planted corn acres have nearly doubled in the last twenty years. Evidence suggests that dense stands of WAWs slow the warming and drying of soil in the spring, interfere with planting equipment, cause allopathic effects, and increase damage from lepidopteron in corn (Monning et al., 2007). However, the effects of WAWs using of nitrogen (N) and water prior to corn production are two additional factors that may negatively impact yield. In corn, water facilitates the use of both soil and fertilizer derived N as well as N increasing water use efficiency (Kim et al., 2008). In many areas of Kansas, preseason precipitation from October to April is needed to recharge soil moisture for good corn production. However, winter annuals' early spring water use can have varied effects on ensuing soil moisture condition when increased surface residue from late killed WAWs could maintain soil moisture by reducing soil surface evaporation and increasing infiltration rates later in the year. Very little attention has been given to WAWs inorganic N uptake, immobilization, and the corresponding N mineralization in NT corn-soybean rotations. No-till research conducted in Georgia found that henbit and cut-leaf evening primrose (*Oenolthea laciniate*) dominated stands can uptake 17 to 36 kg N ha^{-1} when biomass yields are 899 to 1685 kg ha^{-1} (Sainju and Singh, 2001). In Kansas, biomass yields of WAWs are relatively undocumented by research. The aboveground biomass C:N ratios of henbit/cut-leaf evening primrose dominated stands was 20 to 24 in Georgia (Sainju et al., 2007). In North Carolina, henbit and chickweed (*Stellaria media*) had C:N ratios of 15, 22, and 24-37 during December, March, and April respectively (Ranells and Wagger, 1997). When C:N ratios are below 25, it is generally stated that release of N occurs early in the decomposition process (Ranells and Wagger, 1997; Sainju and Singh, 2001). Based on these low C:N ratios, some WAWs may release N during the corn growing season, possibly reducing preseason N losses and improving N synchronization. However, very little information is known about N mineralization of WAW residue in NT CS rotations. The C:N ratio may not be a good measure of the N mineralization rate of WAWs. Therefore, assessing nitrogen availability through growth and N uptake in corn reflects these nitrogen dynamics. It is quintessential that no-till producers maximize the benefits (erosion control) and minimize the drawbacks of WAWs. There are no guidelines for adjusting corn N rates due to WAW densities. In regards to corn response to nitrogen, the objective of the study is to determine how important the timing of WAW control is for no-till, rainfed corn production following soybeans by assessing: soil water and nitrate-nitrogen, early growth (V6) and nitrogen uptake of corn, nitrogen status at silking (R1), and grain yield.

Materials and Methods

Site Information and Experimental Design

Field research was conducted in 2010 at seven locations in Kansas under no-till, rainfed corn production following soybeans. Locations were at producers' fields (in Jackson, Jefferson, Marshall, and Osage Counties) and Kansas State University Research Stations (Manhattan, Hutchinson, and Ottawa). Experimental design was a two-factor factorial arrangement in a randomized complete block design with three replications. Plot size was 4.6 by 15.2 m. There were four different burndown times (T): fall, early pre-plant (2-4 weeks prior to planting), planting (within one week of planting), and emerged (at V2, two visible leaf collars). After the last burndown treatment, five N rates of 0, 17, 34, 67, and 135 kg N ha^{-1} were applied via broadcast urea. Corn was planted 12 to 20 April. Two locations (Riley and Franklin Counties) are being analyzed separately given late planting dates of 25 May and 1 June, respectively, and are not part of this analysis.

Soil Measurements

Block soil samples from each site were taken from a 0-15 cm depth in late fall and early spring and analyzed for P, K, pH, and organic matter (OM). This information was utilized in concert with Kansas State University recommendations to apply blanket rates of P, K, and lime. In early June when corn was assessed for above-ground biomass, composite soil samples for NO_3-N (KCL extraction) in each experimental unit were collected at a depth of 0-60 cm with a 1.9 cm inner diameter push probe from the middle-two rows, both in between and near the row. The same soil samples were utilized to determine gravimetric water content.

Winter Annual Weed Measurements

Two 1 m^2 PVC square frames were divided into nine small 0.11 m^2 grids and two grids in each frame was utilized to determine weed density and composition from two fixed locations in the front and back of each plot (outside the grain yield harvest area) prior to each burndown treatment. Weed density and composition was determined prior to each burndown treatment application. The percent weed control was determined during subsequent visits in the same two locations in each plot. Above-ground biomass collection was taken prior to the last burndown treatment using the same method explained above for density and composition. Weed biomass samples were oven-dried at 60 degrees C for 3 days, weighed, ground to pass a 1 mm-screen. Tissue analysis included total carbon and nitrogen by dry combustion. Winter annual weed burndown control was performed with a backpack CO^2 sprayer with 30” nozzle spacing (three 110 degree nozzles, boom width of 2.3 m). Burndown treatments consisted of glyphosate (0.45 kg a.i. ha^{-1}) with or without 2,4-D (0.22 kg a.i. ha^{-1}) depending on planting and emergence timing of corn in accordance with the label.

Corn Measurements

A composite sample (five corn plants) from each plot was assessed for above-ground dry biomass (early growth) and nitrogen content of when corn was V5-V8. Corn biomass samples were oven-dried at 60 degrees C for 3 days, weighed, and ground to pass a 1 mm-screen. Tissue analysis included total carbon and nitrogen by dry combustion. Corn plant population was determined in the middle two rows at the same time. Chlorophyll content values to determine N status were assessed at R1-R2 from the ear leaf of twenty corn plants in the middle two rows using a SPAD Konica Minolta Meter. Final corn yield was determined by hand harvesting the middle two rows for 7.6 m of each plot. Grain yield was corrected for moisture at 15.5%.

Data Analysis

Data was analyzed using the MIXED procedure of SAS. Block and site were considered as random in the model. Simulation method for pairwise comparisons was used given unequal sample size. Statistical significance was evaluated at $P \leq 0.10$.

Results and Discussion

Winter Annual Weed Density, Biomass, and N Uptake

The most common WAWs were henbit (*Lamium amplexicaule*) and field pennycress (*Thlaspi arvense*). Burndown control was excellent at all locations and timings. Average WAWs density per site ranged from 118 to 376 plants m^{-2}. Average WAW dry biomass per site at maturity in May ranged from 562 to 1124 kg ha^{-1} resulting in 12 to 30 kg N ha^{-1} uptake in above ground WAW biomass. The C:N ratios ranged from 16:1 to 28:1.

Corn Plant Population, Early Growth, N Uptake

Time of burndown by N rate interaction was not significant for any dependent variables measured. Delayed emergence was visually observed with burndown after early pre-plant. Delaying burndown until after corn emergence did not reduce corn plant populations (data not shown). Early growth was significantly affected by burndown timing (Figure 1) and was maximized by an early pre-plant burndown. N concentration in corn tissue was not significantly different for burndown timings. Therefore, N uptake (Figure 2) was mostly due to difference in early biomass accumulation.

Soil Nitrate-Nitrogen and Water Content

Soil nitrate-nitrogen was not significantly different among burndown timings. Soil gravimetric water content increased with delayed burndown (Figure 3). Any excessive water use by WAWs with later burndown control was alleviated in 2010 by above average rainfall in May-June; reduced soil surface evaporation from increased residue cover; and reduced water use by smaller corn plants.

Chlorophyll Meter Readings and Grain Yield

Delaying burndown until May after the corn had emerged significantly lowered the chlorophyll meter reading at R1-R2 over early pre-plant control (Figure 4). This suggests that the N mobilized into above-ground WAW biomass by mid-May in 2010 could significantly reduce cumulative corn N uptake by July (R1-R2). However, grain yield was not significantly impacted by the time of burndown (Figure 5), though it trended toward a similar pattern as the chlorophyll meter reading data (Figure 4).

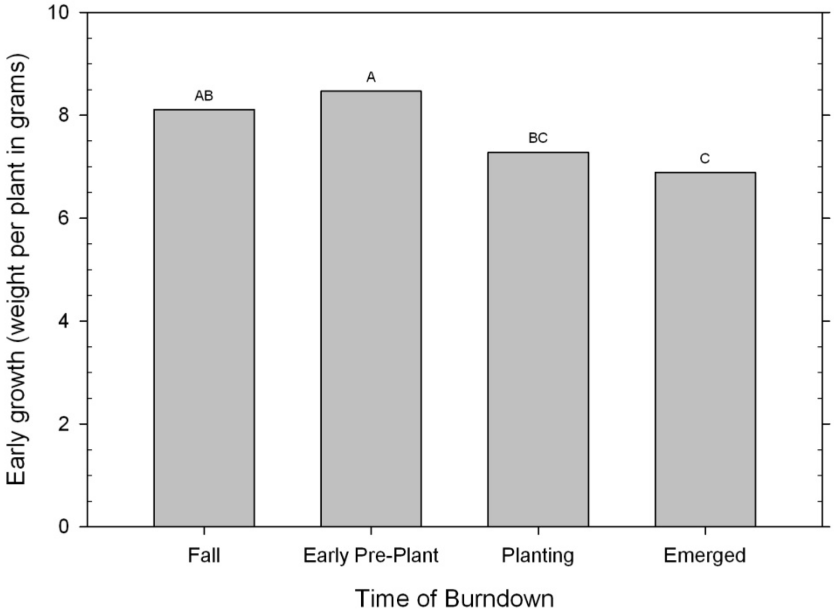

Figure 1. Early growth (V5-V8) of corn.

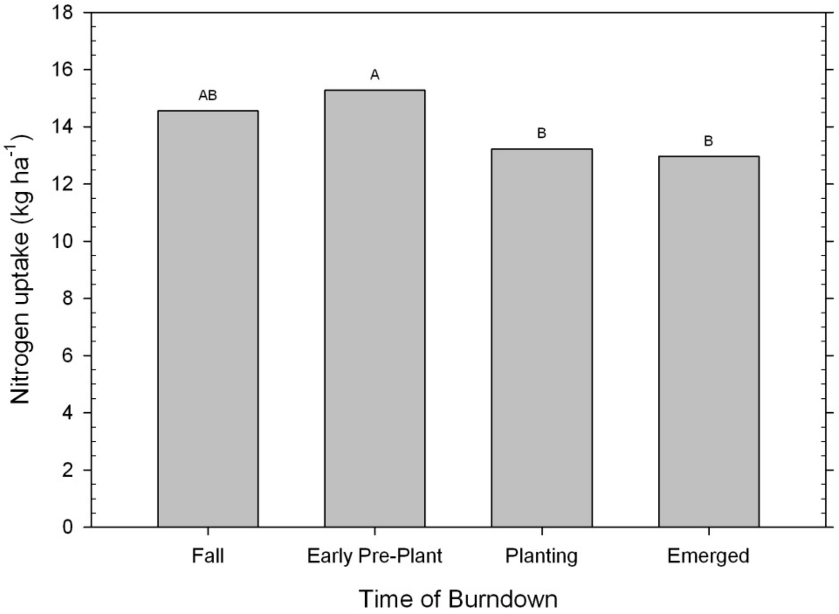

Figure 2. Corn N uptake at V5-V8.

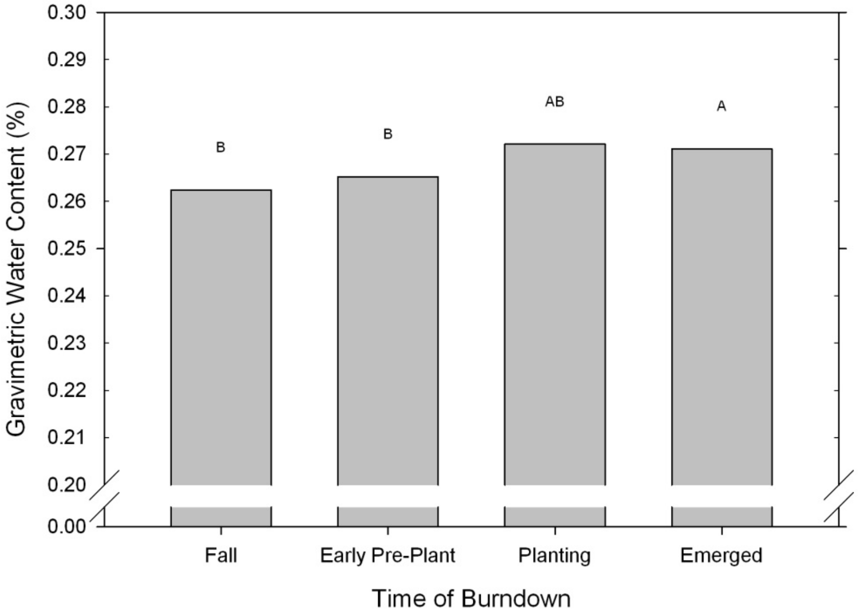

Figure 3. Gravimetric water content (June).

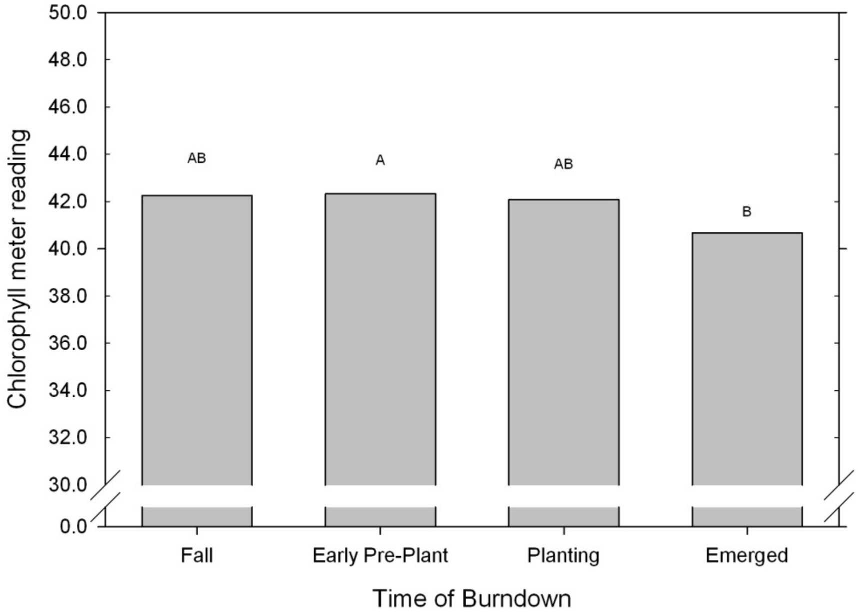

Figure 4. Chlorophyll meter readings at R1-R2.

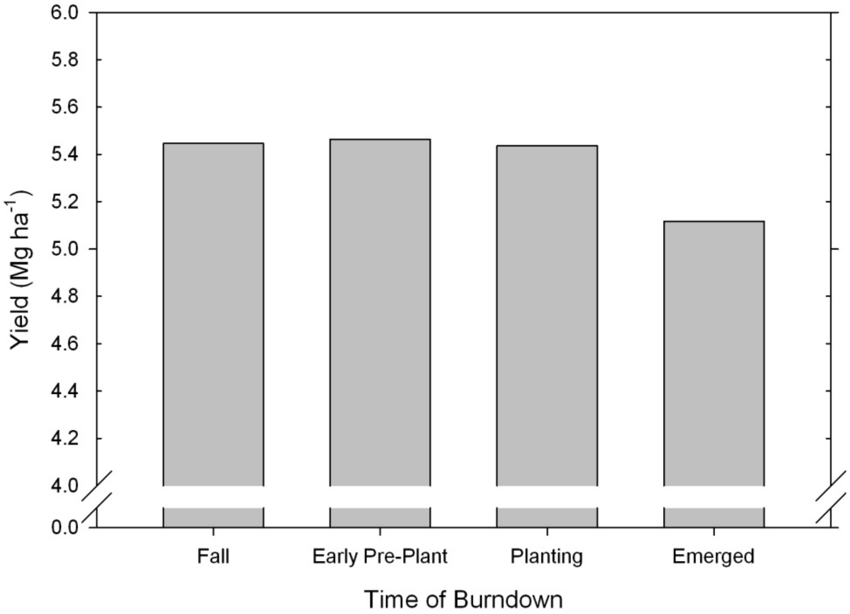

Figure 5. Corn grain yield.

Summary

In 2010, on rainfed no-till corn following soybean in Kansas, high density stands of WAWs can contain 12 to 30 kg N ha^{-1} at maturity in their above-ground biomass. Delaying burndown until planting or after did cause reduced early growth (V5-V8) and reduced early season N uptake. In early June, gravimetric water content was higher as a result of delaying burndown. N status at R1-R2 (assessed by chlorophyll meter readings) was only reduced if burndown was delayed until

May after the emergence of corn. Grain yield was not significantly impacted by the WAW burndown timing. Increased early corn growth did not translate into higher yield in these conditions. Overall, corn responded early in the growing season to various burndown timing of WAWs, but the effects diminished by harvest.

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