# Stalk Persistence of Interseeded Wheat and Rye Cover Crops Treated at Two Growth Stages and Six Rates of Glyphosate

**J. W. Sij**
*Texas Agricultural Experiment Station, Vernon, TX 76385*
**B. L. S. Olson**
*Kansas State University Northwest Research and Extension Center, Colby, KS 67701*
**J. P. Ott**
*Texas Cooperative Extension, Hondo, TX 78861*
**T. A. Baughman**
*Texas Cooperative Extension, Vernon, TX 76385*

## ABSTRACT

**Cotton seedlings are easily damaged by wind and wind blown soil in the semiarid Southern Great Plains. Cover crops offer protection to seedling cotton. The 3-year study was conducted near Vernon, Texas to determine biomass persistence of chemically terminated wheat and rye cover crops following six application rates of glyphosate. Treatments were applied at the boot or at the 50% heading stage of growth. The amount of standing biomass at 0 to 1 ft, 1 to 2 ft, and > 2 ft was estimated 4 wks after application and expressed as a percentage of the total biomass or percent persistence. Percent control or kill was also recorded. A successful treatment was defined as >90% control and >15% standing residue above 1 ft. Results indicate that rye and wheat provided acceptable stubble persistence when terminated with at least 0.38 lb ai/ac glyphosate at 50% heading. Higher application rates of glyphosate did not increase control (>90% kill) of the cover crop, were less cost effective, and resulted in decreased stalk persistence. Observations on early plant development, increased biomass, stand establishment under adverse environments, and seedling survival under cold, wet conditions favor rye as the cover crop of choice in semiarid environments.**

**KEYWORDS:** conservation tillage, cover crops, soil erosion, stalk persistence, glyphosate, seedling protection

## INTRODUCTION

The use of cover crops has been mostly confined to regions in the U.S. that generally receive adequate seasonal rainfall for dryland production. In the southeastern U.S., wheat (*Triticum aestivum* L.) and rye (*Secale cereale* L.) have been studied as fall/winter cover crops prior to planting summer crops, like cotton (*Gossypium hirsutum*

L.), soybean [*Glycine max* (L.) Merrill], and corn (*Zea mays* L.) (Gallaher, 1977; Moschler et al., 1967; Munawar et al. 1990). Cover crops are terminated in early spring with a herbicide, usually glyphosate [N-(phosphono-methyl)glycine] or paraquat (1, 1' dimethyl-4, 4'-bipyridinium ion). Rye, wheat, oat (*Avena sativa* L.), barley (*Hordeum vulgar* L.), triticale (x *Triticosecale* Wittmack), or mixtures with legumes have been used with success as cover crops (Clark et al., 1994; Coale et al., 2001; Daniel et al., 1999a, b; Moschler, et al., 1967). Cover crops used in conservation tillage systems are known to result in many benefits for subsequent crop production in the same year of production in regions of high rainfall or under irrigation in semiarid environments. However, there is limited research on the use of cover crops in dryland crop production systems in semiarid environments like the Texas Rolling Plains.

In the southeastern U.S., rye has been shown to be superior to other winter cover crops because of its winter hardiness, susceptibility to chemical termination, and production of large amounts of biomass (Bauer and Reeves, 1999; Daniel et al., 1999a; Moschler et al., 1967). Although legumes initially provide comparable biomass and nitrogen for the subsequent crop, they do not persist following chemical termination as well as small grains (Clark and Barnett, 1995; Daniel et al., 1999a).

Cover crops offer wind protection, help capture and retain soil moisture, and prevent soil erosion. In a semiarid environment like the Southern Great Plains, soil moisture is the most limiting factor in cotton production. Soil moisture conservation afforded by a cover crop is critical for summer crop production (Daniel et al., 1999b; Gallaher, 1977). However, cover crops must extract a portion of the soil moisture for their development. The type of cover crop and the timing of its termination are critical to maximizing biomass production while minimizing soil moisture loss. Munawar (1990) reported soil moisture content was significantly higher for early-season termination than late-season termination of rye due to depletion of soil moisture by the growing cover crop. Winters and Musick (1993) in the semiarid High Plains of Texas observed that wheat extracted soil water to a depth of 7.9 ft at anthesis. Thus, a small grain cover crop can certainly impact soil moisture availability to the succeeding crop.

Additional environmental factors in the semiarid Southern Great Plains include high winds and blowing sand that can damage or destroy seedlings (Reichenberger, 2003) and cause extensive soil erosion. Intense rainfall events in this region also contribute to soil erosion. Extending soil cover duration offers more effective soil erosion control, particularly within row crops with slow seedling development and on erosion prone soils (Tiki, 2003). However, a full cover crop may not be necessary to protect soil from erosion. Sij et al. (2003) found interseeding two rows of rye between 40-inch cotton rows (which produces 50% ground cover) in the fall reduced seasonal sediment displacement and water run off by 63% and 53%, respectively, compared with conventional production practices.

To be effective for an extended period of time, a cover crop must have some degree of persistence during cotton seedling development. Little research has been conducted on persistence of a small grain cover crop following chemical termination at different growth stages, an important consideration in conservation tillage systems in semiarid environments. In Louisiana, Williams et al. (2001) found that the growth stage at the time of glyphosate application was the most critical factor in attaining a satisfactory level of growth termination. Since cover crops must extract valuable soil moisture in order to develop, minimizing water use while maximizing biomass and persistence of the biomass is extremely important in low rainfall regions where dryland crop production is practiced. Hence, the growth stage of the cover crop at which it is terminated is important in maximizing stalk persistence while minimizing soil moisture extraction. If termination of the cover crop is too early, there is little standing biomass to protect seedlings from damaging winds and conserve soil moisture. Late termination of a cover crop results in excessive use of valuable soil moisture that would be available to the subsequent crop (Clark and Barnett, 1995). Since fiber development increases as plants mature (Bolsen, 1984), increased stalk persistence is a function of plant growth stage. Therefore, the timing of termination should allow for persistence of the cover crop while minimizing soil moisture use by limiting excessive plant development.

The objective of the three-year field study was to determine which of the cover crops, rye or wheat, has superior stalk persistence following various application rates of glyphosate at the boot or the 50% heading stage of growth. Six herbicide rates were included to offer the grower an assessment of the most economical treatment that terminates each cover crop, yet allows acceptable persistence of the cover crop.

## MATERIALS AND METHODS

This study was initiated in the fall of 2000 at the Texas Agricultural Experiment Station near Vernon, Texas, a semiarid region typical of the southern Great Plains. The study was conducted over 3 yr to determine stalk persistence of terminated wheat and rye when treated with different rates of glyphosate. All the plots were established in mid-October on conventionally-prepared ground each year. The soil is classified as a Miles fine sandy loam (fine-loamy, mixed, thermic Udic Paleustalf). Paired rows on 10-in centers were planted on a 40-in spacing to either wheat or rye at 60 lb/ac to simulate a small grain crop interseeded between crop rows (in this case only 50% of the land area has cover). ‘TAM 202’ wheat and ‘Bates’ rye were used and no fertilizer was applied. Each plot consisted of one set of paired rows 15 ft long with a set of paired rows between each plot as a border to minimize herbicide drift between plots. All treatments were replicated four times. The study area was maintained weed free during the experiment via mechanical or hand hoeing. No nutrient deficiencies were observed during the course of this study.

Glyphosate was applied at the boot or 50% heading growth stage of each small grain using a two-nozzle $CO_2$ backpack sprayer equipped with XR110015 tips and calibrated to deliver 15 gal/ac at 40 PSI. Treatments included 0.13, 0.25, 0.38, 0.50, 0.75, and 1.0 lb ai/ac glyphosate plus 17 lbs ammonia sulfate/100 gal of finished spray solution. A wooden panel was sectioned into 6- x 6-in squares and inserted between the treated rows. The amount of standing biomass above 2 ft, between 1 and 2 ft, and below 1 ft was determined visually and expressed as a percentage of the total plot biomass. Stalk persistence and percent control (i.e. kill), were recorded 4 weeks following each herbicide treatment.

Data were subjected to analysis of variance for a randomized complete block arrangement of treatments. Year was considered a random variable. Means were separated using protected LSD and were considered different at $P < 0.10$, unless otherwise noted. Treatments were defined successful with > 90% control (kill) and > 15% biomass above 1 ft.

## RESULTS AND DISCUSSION

There was a significant rate by cover crop by timing interaction for percent control. The 0.13 lb ai/ac treatment averaged about 50% control for both growth stages and cover crop species. Control at the 0.13 lb ai/ac rate differed between application time and species (Fig. 1).

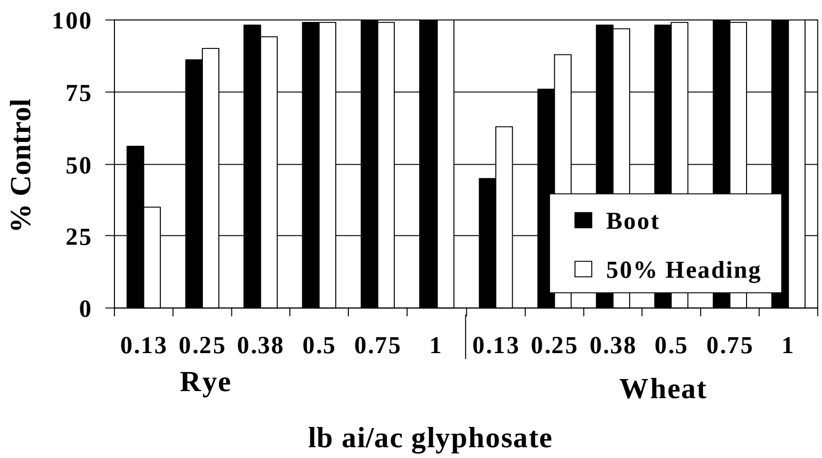


Figure 1. Percent control at two plant growth stages for wheat and rye terminated with six rates of glyphosate. Data were taken 4 weeks after treatment.

Wheat treated at the boot stage did not differ in percentage control from rye treated at 50% heading, averaging 45% and 35% control, respectively. Conversely, rye treated at the boot stage (resulting in 56% control) did not differ in percentage control from wheat treated at 50% heading (63% control). However, all glyphosate application rates greater than 0.13 lb ai/ac followed a similar pattern between species with regard to application time.

For rye, a 0.25 lb ai/ac rate applied at boot increased control to 86% and to 90% when applied at 50% heading. For wheat, the 0.25 lb ai/ac rate applied at boot increased control to 78% and to 89% when applied at 50% heading. However, effective control (> 90% kill) of the standing cover crop was not achieved at either application stage or with either species until 0.38 lb ai/ac of glyphosate was applied. This is half the rate Williams et al. (2001) suggested was required for control of wheat in the boot to early heading in Louisiana. Our results indicated higher rates of glyphosate did not significantly ($P > 0.10$) increase the level of control 4 wk post treatment (Fig. 1). Cultivar tolerance to glyphosate or environmental factors may have contributed to differences in small grain sensitivity between the two locations.

The timing of glyphosate application on percent stalk persistence was significant. Stalk persistence of wheat and rye above 1 ft decreased linearly (boot stage:

y = -0.75x + 33.67, $R^2$ = 0.90; 50% heading stage: y = -0.87x + 46.38, $R^2$ = 0.99) with increasing rates of glyphosate, regardless of the crop's growth stage at the time of application (Fig. 2).

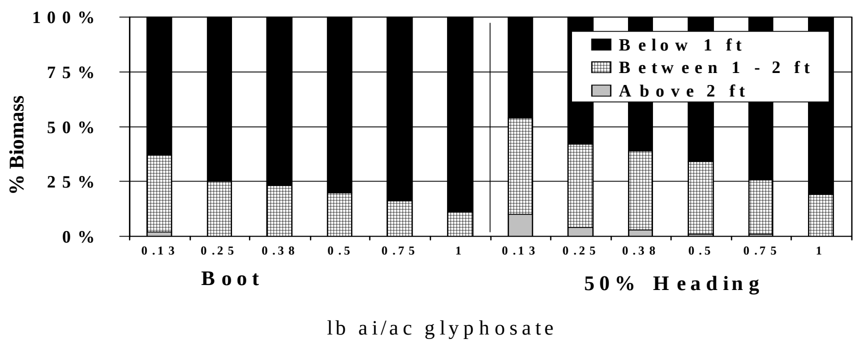


Figure 2. Average percent biomass at two plant growth stages for wheat and rye following termination with different rates of glyphosate. Data were taken 4 wk after treatment.

Even though control was > 90% at the 0.38 lb ai/ac rate, higher rates of glyphosate negatively impacted stalk persistence. Nevertheless, every application rate and time resulted >15% standing biomass above 1 ft, except when $\geq$ 0.25 lb ai/ac glyphosate was applied to rye in the boot stage (11% persistence, Table 1). At any given application rate, stalk persistence was increased when herbicide application was delayed until the 50% heading growth stage ($P \leq 0.05$). Presumably, a greater degree of lignification had taken place between boot and heading resulting in greater straw strength.

There was a significant difference in percent stalk persistence between cover crops and herbicide rate, but no interaction between application timing and herbicide rate. Figure 3 shows a linear decrease in average percent persistence for each cover crop as application rate increased. Stalk persistence of wheat and rye above 1 ft also decreased linearly as application rates increased (rye: y = -1.21x + 43.96, $R^2$ = 0.79; wheat: y = -0.70x + 44.34, $R^2$ = 0.94).

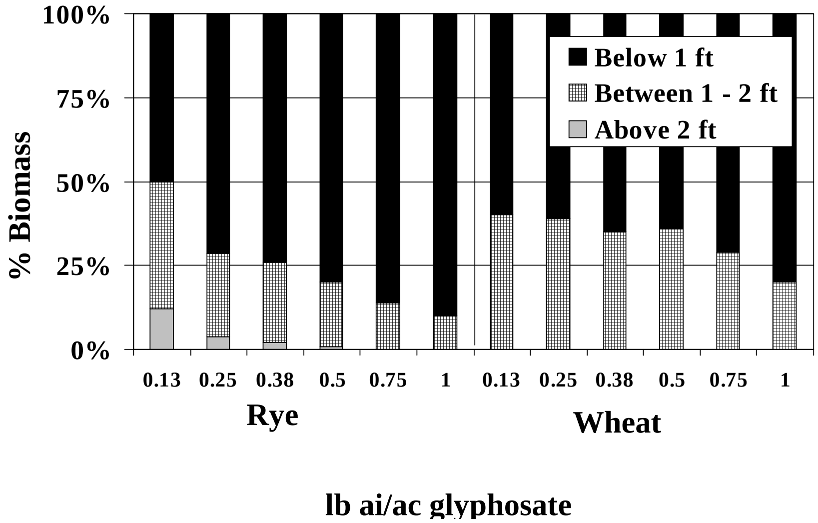


Figure 3. Percent biomass of wheat and rye following termination with different rates of glyphosate averaged across the boot and 50% heading growth stages. Data were taken 4 wk after treatment.

Across all herbicide applications, rye appeared to be more sensitive than wheat to glyphosate in the boot stage. However, rye treated during 50% heading averaged somewhat more standing biomass above 1 ft than wheat (37% for rye versus 31% for wheat, Fig 4).

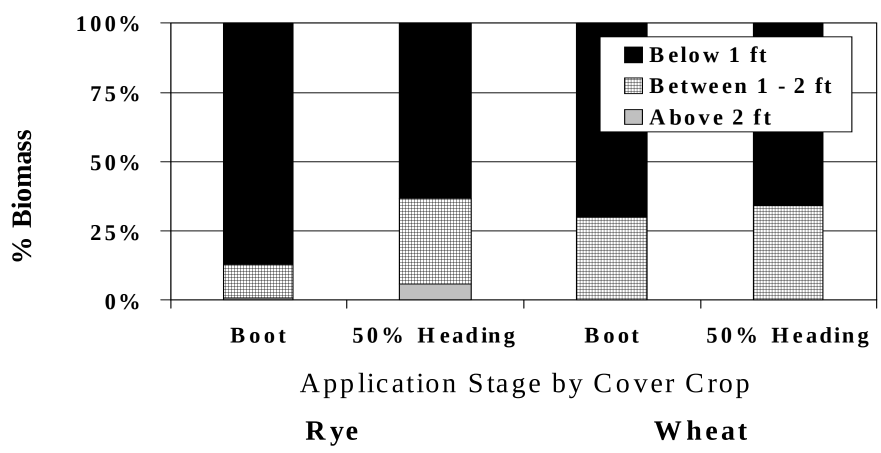


Figure 4. Percent biomass of wheat and rye following termination at two plant growth stages averaged across all rates of glyphosate. Data were taken 4 wk after treatment

Table 1 provides a summary of results and those treatments considered successful in maintaining standing residue of a terminated cover crop.

Table 1. Summary of cover crop response to glyphosate treatments at two growth stages.

| Species | Stage | lb ai/ac | % Control[1] | % Persistence[1] | Successful[2] |
|---|---|---|---|---|---|
| Rye | Boot | 0.13 | 56 | 35 | No |
| | | 0.25 | 86 | 13 | No |
| | | 0.38 | 98 | 11 | No |
| | | 0.50 | 99 | 9 | No |
| | | 0.75 | 100 | 7 | No |
| | | 1.00 | 100 | 2 | No |
| | 50% Heading | 0.13 | 35 | 66 | No |
| | | 0.25 | 90 | 44 | No |
| | | 0.38 | 94 | 41 | Yes |
| | | 0.50 | 99 | 29 | Yes |
| | | 0.75 | 99 | 22 | Yes |
| | | 1.00 | 100 | 18 | Yes |
| Wheat | Boot | 0.13 | 45 | 39 | No |
| | | 0.25 | 76 | 37 | No |
| | | 0.38 | 98 | 34 | Yes |
| | | 0.50 | 98 | 30 | Yes |
| | | 0.75 | 100 | 24 | Yes |
| | | 1.00 | 100 | 19 | Yes |
| | 50% Heading | 0.13 | 63 | 42 | No |
| | | 0.25 | 89 | 40 | No |
| | | 0.38 | 97 | 37 | Yes |
| | | 0.50 | 99 | 38 | Yes |
| | | 0.75 | 99 | 29 | Yes |
| | | 1.00 | 100 | 19 | Yes |

[1] % Control LSD (0.05) = 5; % Persistence LSD (0.05) = 4.
[2] Successful treatment: > 90% control and > 15% residue above 1 ft.

With rye, only the 0.13 lb ai/ac rate resulted in >15% of the residue extending above 1 ft. In wheat, all herbicide treatments at both growth stages resulted in at least 15% residue above 1 ft 4 wk after treatment. For both cover crops, all herbicide treatments at 50% heading resulted in at least 15% of the residue above 1 ft.

None of the application rates were considered effective (> 90% control and > 15% stalk persistence) when applied to rye in the boot stage (Table 1). Even though the 0.13 lb ai/ac treatment on rye in the boot stage achieved greater than 15% stalk persistence, the treatment did not kill >90% of the plant population. An application rate of at least 0.38 lb ai/ac was considered successful for rye at 50% heading and for wheat at boot as well as 50% heading. Delaying application time until the 50% heading growth stage in wheat did not significantly increase stalk persistence above 1 ft, although one can assume soil moisture demand increased during the period of rapid growth between boot and 50% heading. This was also true for the rye crop, but rye reached 50% heading prior to wheat reaching the boot stage when both crops were seeded on the same planting date in the fall. Soil moisture requirements for plant development between the boot and 50% heading stages were not determined in this study.

## CONCLUSIONS

Results from this study show both rye and wheat provided acceptable stubble persistence when terminated with at least 0.38 lb ai/ac glyphosate at 50% heading. Wheat terminated at the boot stage retained more stubble biomass above 1 foot than rye. However, development of rye to the 50% heading stage preceded wheat development to the boot stage by 5 to 7 days. It is unknown if early development of rye would result in soil moisture conservation. Other factors and observations from the present study favor rye as the cover crop of choice in semiarid environments. Rye produced biomass earlier and in greater quantity than wheat; hence, seeding rate could conceivably be less than that of wheat and provide cost savings. Rye is considered more drought tolerant than wheat, and rye can establish stands under less favorable environmental conditions than wheat. Rye also appeared to be more winter hardy and less susceptible to excess soil moisture than the wheat variety used in this study. Based on this study and previous work, the large amount of biomass from rye indicates that seeding an entire area to the cover crop is probably not necessary. Interseeding of a small grain cover crop between rows of the previous summer crop (25 to 50% of the land area) may offer many of the benefits of a complete cover crop but with less expense and presumably less soil moisture extraction, an important consideration in semiarid environments.

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