Timing of Nitrogen Application Affects Downy Brome (*Bromus tectorum*) Growth in Winter Wheat[1]

RANDY L. ANDERSON[2]

Abstract. Field studies were conducted to determine if varying the time N fertilizer was applied would affect downy brome interference in winter wheat. Five treatments were compared: four broadcast application times of NH_4NO_3 at 56 kg N ha^{-1} during the fallow-crop cycle: 1) during fallow; 2) at planting; 3) during crop dormancy; 4) before winter wheat jointing; and 5) a control where no N was applied. Downy brome was least responsive to N applied during fallow. All N applications during the growing season of winter wheat increased downy brome biomass and culms m^{-2}. Downy brome interference prevented winter wheat from responding positively to N. For example, when crop season precipitation was only 70% of normal, applying N reduced grain yield of winter wheat infested with downy brome from 12 to 28%. This study indicates that N manipulation offers potential for reducing downy brome interference in winter wheat. **Nomenclature:** Winter wheat, *Triticum aestivum* L. 'Sandy'; downy brome, *Bromus tectorum* L. #[3] BROTE.
Additional index words: Yield components, precipitation effect, community yield, BROTE.

INTRODUCTION

The prevalent crop rotation in the western part of the central Great Plains is winter wheat-fallow, a rotation stimulating downy brome proliferation. Because suitable and/or economical herbicides are lacking for in-crop downy brome control, producers are seeking cultural practices that enhance winter wheat's tolerance to downy brome.

Manipulating N fertility alters the interaction between weed species and crops (5, 10, 19). Increasing N rates reduced the detrimental effects of foxtail (*Setaria* spp.) interference in corn (*Zea mays* L.) (9). Applying N at planting, however, reduced grain yield of winter wheat infested with Italian ryegrass (*Lolium multiflorum* Lam.) (1) and did not increase yield when downy brome was present (11, 20).

Another cultural option, altering the timing of N application, also influences crop-weed interactions. For example, applying N after barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.) had headed benefited rice (*Oryza sativa* L.) more than earlier applications (14).

Generally, winter wheat response to N fertilizer is not affected by timing of application. Applications of N in the fall or spring of the crop season increased grain yields similarly (3, 16, 17). Various N application times during the preceding fallow also produced similar grain yields in winter wheat (12, 13).

Downy brome responds dramatically to N (4, 6, 15), but two growth characteristics of this species (shallow root development and earlier plant development compared with winter wheat) suggest possible application times when downy brome response could be minimized. Applying N during fallow before May 15 resulted in N accumulation at a depth of 60 to 120 cm (13). Downy brome roots seldom penetrate deeper than 33 cm (7, 15), thus N at lower depths would be less available to downy brome. Winter wheat roots absorb N at the lower depths later in the growing season and yields are similar to at-planting N application (12, 13).

Also, downy brome joints (stem elongation) 2 to 3 wk earlier than winter wheat (15). Jointing is a period of rapid N uptake (18), thus N applied after downy brome jointing but before winter wheat jointing occurs may reduce downy brome growth in comparison with winter wheat.

The objective of this field study was to determine if varying the time N was applied during the fallow-crop cycle would affect downy brome interference in winter wheat.

MATERIALS AND METHODS

This experiment was conducted during two fallow-crop cycles in 1985–1987 (Study 1) and 1987–1989 (Study 2) at Akron, CO. The soil was a Weld silt loam (fine, montmorillonitic, mesic Aridic Paleustoll), with

[1]Received for publication Apr. 8, 1991, and in revised form July 3, 1991. Contribution from the Agric. Res. Serv., U.S. Dep. Agric., Northern Plains Area.
[2]Res. Agron., Agric. Res. Serv., U.S. Dep. Agric., Akron, CO 80720.
[3]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 309 W. Clark St., Champaign, IL 61820.

Table 1. Precipitation received during the experiment and 82-yr average for Akron, CO.

Period	Precipitation		
	Study 1	Study 2	82-yr avg
	mm		
Fallow			
July 15 to Apr. 15	328	285	224
Apr. 16 to Sept. 15	215	302	298
Fallow total	543	587	522
Crop season			
Sept. 15 to Dec. 31	45	21	62
Jan. 1 to Mar. 31	74	31	38
Apr. 1 to June 30	183	148	184
Crop season total	302	200	284

1.2% organic matter and a pH of 7.0. The site had been in a winter wheat-fallow rotation for several years, with downy brome present in several areas. Downy brome control during fallow was maintained by sweep plowing.

Crop season precipitation was 106% of the long-term average in Study 1, but only 70% in Study 2 (Table 1). Fallow precipitation was near normal for both studies.

Four application timings of NH_4NO_3 at 56 kg N ha^{-1} were compared: during fallow (Apr. 15, 1986 and Apr. 15, 1988); near planting (Sept. 16, 1986 and Oct. 5, 1988); during dormancy (Jan. 30, 1987 and Nov. 22, 1988); or before winter wheat jointing (during spring tillering) (Mar. 26, 1987 and Mar. 23, 1989). A control treatment where no N was applied also was included. Treatments were applied to two adjacent sites: one being weed-free and a second infested with downy brome. The weed-free site was established where downy brome was not observed during the previous wheat crop. If downy brome emerged in this site, it was hand weeded.

Treatments were arranged in a randomized complete block design with four replications for each site. Plot size was 4 by 4 m.

Sandy winter wheat, a standard height cultivar, was planted with a hoe drill at 50 kg ha^{-1} in rows 30 cm apart on 12 Sept., 1986 and 22 Sept., 1988. A standard height cultivar was grown because it tolerates downy brome interference more than a semi-dwarf cultivar (2).

Downy brome emerged within 3 wk of planting for both studies. Because downy brome infested the site in strips across plots, m^2 sites of similar visual infestation levels were designated in late fall of each study. Similar m^2 sites were designated in the weed-free site also.

Agronomic data collected from these designated sites included downy brome culms m^{-2} counted after brome heading. At harvest, downy brome biomass and winter wheat grain yield from the designated sites were measured. In Study 2, winter wheat biomass at harvest also was recorded. Winter wheat yield components were determined by counting all culms within the m^2 site, with the number of kernels per culm and 1000-kernel weight measured from 20 culms selected at random.

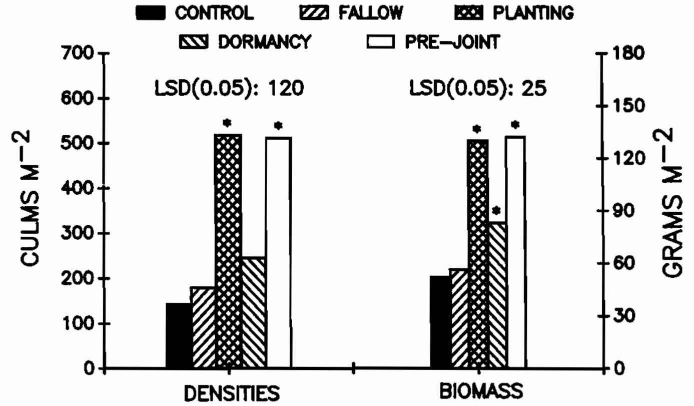

Figure 1. Downy brome response to N application timings in Study 1. * indicates significant difference at the 0.05 level of probability occurred between N timing and control treatments.

All data were subjected to analyses of variance, and differences among means were determined at the 0.05 level of probability. Because the results differed statistically between studies, data were expressed for each study individually.

RESULTS AND DISCUSSION

Study 1: 1985–1987. Weed-free site. N increased winter wheat grain yields by more than 15% at all timings when downy brome was not present (Table 2). The yield increase from N resulted from increased culms m^{-2} and 1000-kernel weight of weed-free winter wheat. **Weed-infested site.** Downy brome responded least to N applied during fallow. Culms m^{-2} and biomass did not increase at this timing compared with other application times (Figure 1). Applying N at any time during the crop season increased downy brome biomass.

N increased grain yield of weed-infested winter wheat only when applied during dormancy (Table 2). This correlates with reduced downy brome growth when N was applied at dormancy compared with applications at planting and before jointing (Figure 1). Reduced downy brome growth associated with the fallow N application did not increase grain yields, however.

Table 2. Effect of timing of N application on grain yield and yield components of weed-free and weed-infested winter wheat.

	Weed-free site				Weed-infested site			
		Yield components				Yield components		
Time of application	Grain yield	Culms m^{-2}	Kernels per culm	1000-kernel wt	Grain yield	Culms m^{-2}	Kernels per culm	1000-kernel wt
	g m^{-2}	no.	no.	g	g m^{-2}	no.	no.	g
1986–1987								
Control	238	438	18.6	29.6	145	327	14.4	28.8
Fallow	271*[a]	507*	19.6	27.4*	143	311	16.4	28.7
Planting	299*	553*	20.6	26.3*	139	336	15.3	27.0*
Dormancy	307*	537*	21.2	27.0*	186*	332	20.3*	27.7*
Pre-joint	289*	527*	20.4	26.9*	151	288	19.4*	27.2*
LSD (0.05)	17	50	NS	0.6	25	NS	2.8	0.9
1988–1989								
Control	200	454	23.1	30.3	138	423	20.3	26.9
Fallow	207	457	22.4	28.9	111*	372	18.1	27.9
Planting	181	466	24.2	27.6	121*	363*	20.3	28.2
Dormancy	197	445	26.0	28.6	100*	339*	20.6	27.4
Pre-joint	227*	490	24.6	28.9	111*	333*	19.4	27.3
LSD (0.05)	20	41	NS	NS	13	54	NS	NS

[a]*Indicates that treatment mean differs significantly from the control mean.

When downy brome was present, winter wheat culms m^{-2} were not affected by N, but 1000-kernel weight was reduced when N was applied during the crop season (Table 2). The winter wheat yield increase when N was applied during dormancy likely resulted from increased kernels per culm.

Study 2: 1987–1989. Weed-free site. Winter wheat grain yield response to N differed in Study 2 compared with Study 1. The grain yield of weed-free winter wheat was increased only when N was applied at the pre-joint stage (Table 2). This overall lack of response to N reflects the lower precipitation received during Study 2 (Table 1). The positive yield response to N applied before jointing may have resulted from late-season precipitation, as 75% of the April 1 to June 30 precipitation was received during June. The other N application timings may have stimulated excessive plant growth earlier, resulting in less available water later during the crop season. The lack of yield response to N in Study 2 also was reflected in yield component data, as no differences were detected (Table 2).

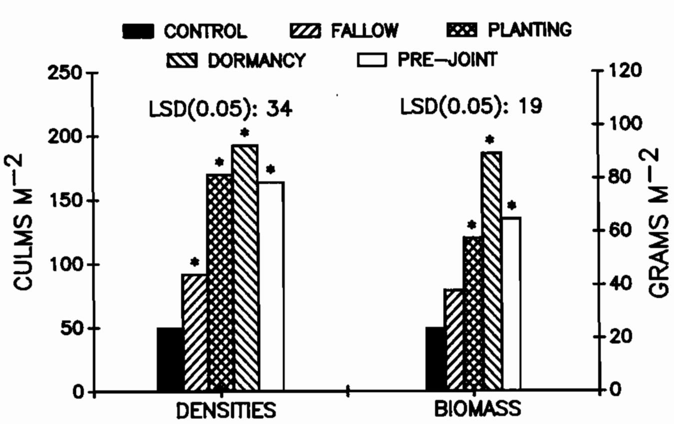

Figure 2. Downy brome response to N application timings in Study 2. * indicates significant difference at the 0.05 level of probability occurred between N timing and control treatments.

Weed-infested site. Downy brome was again least responsive to N when applied during fallow (Figure 2). The number of downy brome culms m^{-2} was greater for the fallow N application compared to the control, but less than the number of culms from crop season N applications. However, downy brome biomass production from the fallow N application was similar to the control treatment. Downy brome growth was increased by N at all application times during the crop season.

When downy brome was present, applying N decreased grain yields at all application times (Table 2). Precipitation during Study 2 was only 66% of Study 1, and 70% of the long-term average for this site (Table 1). Under these drought conditions, N increased downy brome competitiveness to winter wheat, resulting in winter wheat grain yield losses. The downy brome component of community yield in Study 2 significantly increased from 5% in the control to 9, 13, 20, and 14% for the fallow, planting, dormancy, and before jointing applications, respectively (data not shown). Downy brome appears to be more drought tolerant than winter wheat, thus providing more competition to winter wheat when seasonal precipitation is below normal.

Downy brome interference when N was applied reduced culms m^{-2}, thus decreasing grain yield (Table 2).

Management implications. Downy brome responds dramatically to N fertilizer by increasing shoot biomass and seed production, whether growing alone (6, 15) or within a winter wheat canopy. This response within the winter wheat canopy occurred regardless of precipitation level.

N broadcast applications during the crop season to heavily infested fields would not be advisable, as the resultant downy brome growth prevents winter wheat from responding favorably to N. Also, this detrimental effect of N-enhanced downy brome interference on winter wheat grain yield is magnified during years of below normal precipitation, as shown in Study 2. Applying N during fallow (Apr. 15), however, stimulated downy brome production the least, and may offer potential for producers to minimize downy brome interference.

This study reaffirms that manipulating N offers a potential option in downy brome management, as other N cultural practices also are effective in reducing interference. For example, banding N by the winter wheat seed reduced downy brome density 29% and biomass 50% and increased winter wheat grain yield 32% compared with a broadcast application at planting (8).

Cultural practices reducing downy brome interference in winter wheat include planting a summer-annual crop in rotation with winter wheat (20); however, producers participating in government programs are restricted in crop choices. Decision-making strategies for alternative crop rotations to the prevalent winter wheat-fallow rotation are being developed for the Central Great Plains. These strategies base planting decisions on soil water levels in early spring (April–May) to recommend if a spring-planted crop such as corn, proso millet (*Panicum miliaceum* L.), or sorghum (*Sorghum bicolor* Moench.) would be successful. If soil water levels in early spring suggest fallowing until September and then planting winter wheat, downy brome would respond the least to N applied in the spring of the fallow season if the producer planned to broadcast his N fertilizer.

One possible drawback with early N applications during fallow is N movement below the rooting depth of winter wheat during years of above-normal precipitation. By combining fallow applications with banding by the seed at planting, N rate applied during fallow could be reduced, thus reducing this environmental hazard.

LITERATURE CITED

1. Appleby, A. P., P. D. Olson, and D. R. Colbert. 1976. Winter wheat yield reduction from interference by Italian ryegrass. Agron. J. 68: 463–466.
2. Challaiah, O. C. Burnside, G. A. Wicks, and V. A. Johnson. 1986. Competition between winter wheat (*Triticum aestivum*) cultivars and downy brome (*Bromus tectorum*). Weed Sci. 34:689–693.
3. Christensen, N. W., and V. W. Meints. 1982. Evaluating N fertilizer sources and timing for winter wheat. Agron. J. 74:840–844.
4. Eckert, R. E., Jr., and R. A. Evans. 1963. Responses of downy brome and crested wheatgrass to nitrogen and phosphorus in nutrient solution. Weeds 11:170–174.
5. Froud-Williams, R. J. 1988. Changes in weed flora with different tillage and agronomic management systems. p. 213–236 *in* M. A. Altieri and M. Liebman, eds. Weed Management in Agroecosystems: Ecological Approaches. CRC Press, Inc., Boca Raton, FL.
6. Hulbert, L. C. 1955. Ecological studies of *Bromus tectorum* and other annual bromegrasses. Ecol. Monogr. 25:181–213.
7. Klemmedson, J. O., and J. G. Smith. 1964. Cheatgrass (*Bromus tectorum* L.). Bot. Rev. 30:226–262.
8. Miller, S. D. 1990. Integrated weed management in conservation tillage cropping systems. *In* Proc. Conservation Tillage Symposium. Great Plains Agric. Council Publ. 131:253–258.
9. Nieto, J. H., and D. W. Staniforth. 1961. Corn-foxtail competition under various production conditions. Agron. J. 53:1–5.
10. Patriquin, D. G. 1988. Weed control in organic farming systems. p. 303–317 *in* M. A. Altieri and M. Liebman, eds. Weed Management in Agroecosystems:Ecological Approaches. CRC Press, Inc. Boca Raton, FL.
11. Ramig, R. E., and D. E. Smika. 1964. Fallow-wheat sorghum: an excellent rotation for dryland in central Nebraska. Nebr. Agric. Exp. Stn. Bull. 483. 11 p.
12. Smika, D. E., and P. H. Grabouski. 1975. Manage fallow to boost wheat protein. Crops Soils Mag. 27:7–8.
13. Smika, D. E., and P. H. Grabouski. 1976. Anhydrous ammonia application during fallow for winter wheat production. Agron. J. 68:919–922.
14. Smith, R. J., Jr., and W. C. Shaw. 1966. Weeds and their control in rice production. U.S. Dep. Agric. Bull. 292. 64 p.
15. Thill, D. C., K. G. Beck, and R. H. Callihan. 1984. The biology of downy brome (*Bromus tectorum*). Weed Sci. 32, Suppl. 1:7–12.
16. Vaughan, B., D. G. Westfall, and K. A. Barbarick. 1990. Nitrogen rate and timing effects on winter wheat grain yield, grain protein, and economics. J. Prod. Agric. 3:324–328.
17. Vaughan, B., D. G. Westfall, K. A. Barbarick, and P. L. Chapman. 1990. Spring nitrogen fertilizer recommendation models for dryland hard red winter wheat. Agron. J. 82:565–571.
18. Waldren, R. P., and A. D. Flowerday. 1979. Growth stages and distribution of dry matter, N, P, and K in winter wheat. Agron. J. 71: 391–397.
19. Walker, R. H., and G. A. Buchanan. 1982. Crop manipulation in integrated weed management systems. Weed Sci. 30, Suppl. 1:17–23.
20. Wicks, G. A. 1984. Integrated systems for control and management of downy brome (*Bromus tectorum*) in cropland. Weed Sci. 32, Suppl. 1: 26–31.