Winter Wheat (Triticum aestivum) growth stage effect on paraquat bioactivity

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Winter Wheat (*Triticum aestivum*) Growth Stage Effect on Paraquat Bioactivity[1]

RANDY L. ANDERSON and DAVID C. NIELSEN[2]

Abstract. Paraquat was applied at 0.28 and 0.56 kg ai ha^{-1} to winter wheat at five growth stages at 0800, 1300, and 1600 hr to determine whether growth stage or time of application influenced winter wheat response to paraquat. Paraquat bioactivity was affected by growth stage. Biomass reduction by paraquat was 84% when winter wheat was in the 1 to 3 leaf stage, but only 68% when application was delayed until tillering. Paraquat bioactivity continued to decrease at later growth stages. The time of day when paraquat was applied did not affect its bioactivity on winter wheat.
Nomenclature: Paraquat, 1,1′-dimethyl-4,4′-bipyridinium ion; winter wheat, *Triticum aestivum* L. 'Vona'.
Additional index words: Chemical fallow, time of application.

Introduction

Chemical fallow is a viable option for fallow weed control in the Central Great Plains. To be effective, a foliarly active herbicide is used to eliminate postharvest weeds that become established before a soil-residual herbicide is applied. Foliar-active herbicides are also used to control weed escapes in late fall or spring of the fallow season, such as volunteer winter wheat (1). Paraquat is currently used for control of established weeds in fallow, but its bioactivity on volunteer winter wheat is inconsistent.

Possible factors affecting paraquat performance on volunteer winter wheat may include plant growth stage and time of application. O'Sullivan et al. (5) reported decreased paraquat bioactivity at later leaf stages of wild oat (*Avena fatua* L.), spring barley (*Hordeum vulgare* L.), and spring wheat. Paraquat bioactivity is influenced also by time of herbicide application during the day, being most effective when applied in late afternoon or early evening on broadleaf weeds (2) and quackgrass (*Agropyron repens* (L.) Beauv.) (6).

This study evaluated winter wheat response to paraquat at different growth stages and times of application. If these factors affect paraquat bioactivity, then knowledge of this effect could guide producer decisions in improving paraquat performance.

Materials and Methods

The study was conducted at Akron, CO, where average annual precipitation is 416 mm and 80% is received between April and September. Vona winter wheat was planted at 50 kg ha^{-1} on Aug. 1 (Site A) and Sept. 15 (Site B) of 1984, 1985, and 1986. Paraquat was sprayed at five wheat growth stages: 1 to 3 leaves exposed, tiller formation, pseudostem, jointing, and early boot [stages 1, 3, 5, 7, and 9, respectively, as described by the Feekes scale (3)]. The spray dates for each growth stage are listed in Table 1.

On each date paraquat at 0.28 and 0.56 kg ha^{-1} was applied at 0800, 1300, and 1600 hr. Paraquat was applied in 300 L water ha^{-1} with a 4-m boom sprayer equipped with flat fan nozzles. A nonionic adjuvant, allinol[3], at 0.5% v/v was added to the spray. A nonsprayed control was included for comparison. The experimental design for each spray date was a randomized complete block with three replications. Plot size was 4 by 6 m.

Paraquat bioactivity was evaluated 14 d after spraying by measuring the aboveground biomass from a 1 m^2 area in each plot. Data are expressed as percent biomass reduction which was calculated by dividing the biomass of the sprayed plots by the biomass of the nonsprayed control, converting to a percentage, and subtracting from 100.

Results and Discussion

Growth stage effect. The spray date by growth stage interaction was not significant, so data are averaged over spray dates and presented in Table 2. Paraquat was

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[2]Res. Agron., Agric. Res. Serv., U. S. Dep. Agric., Akron, CO 80720.
[3]Activator 90, Loveland Industries, Inc., P.O. Box 1289, Greeley, CO 80632.

Table 1. Paraquat spray dates for each growth stage.

Growth stage	Spray date	
	Site A	Site B
1: 1–3 Leaves	28 Aug., 1985	24 Oct., 1985
3: Tillering	24 Oct., 1985	5 Nov., 1985
5: Pseudostem	22 Apr., 1987	28 Apr., 1987
7: Jointing	30 Apr., 1986	6 Jun., 1985
9: Early boot	11 May, 1987	20 May, 1986

most active on winter wheat at the 1 to 3 leaf stage, with an 84% biomass reduction, but paraquat bioactivity declined with each advance in growth stage. For example, biomass reduction by paraquat was reduced 16% and 44% when wheat was in the tillering and pseudostem growth stages, respectively, at time of application (Table 2).

Effective performance by paraquat results in approximately 75% or more biomass reduction and death of the wheat plant. Thus, paraquat achieves only marginal control after the plant begins to tiller (Table 2). This reduced effectiveness is explained by plant developmental changes. Since paraquat is a contact herbicide that does not translocate (2), tillers just emerging from within the leaf sheath may not be sprayed with paraquat and will survive. These tillers establish new plants and their resultant growth increases wheat biomass. Timing and rate of wheat tillering is strongly influenced by environmental factors, thus tillering can occur in the fall as well as early spring (4, 7). The inability to adequately spray tillers with paraquat explains why paraquat bioactivity has been inconsistent with fall or early spring applications.

Also, applications in late April may result in treating volunteer wheat in the psuedostem growth stage, where biomass reduction was only 40% (Table 2). Growth inhibition at the pseudostem growth stage may seem anomalously low for the pattern of decreasing bioactivity with increasing growth stage. However, this also can be explained by plant development changes. At this growth stage, the wheat spike was below ground when paraquat was sprayed. When biomass was sampled 14 d after spraying, the wheat spike was above ground and added a significant amount of sample weight. Since the non-sprayed spike still has photosynthetic and transpiration capabilities (4), the plant continues to consume soil water, thereby further limiting the utility of paraquat treatment at this growth stage.

Table 2. Effect of winter wheat growth stage and application rate on bioactivity of paraquat. Data means are averaged over times of application within each growth stage.

Growth stage	Paraquat (kg ha^{-1})		
	0.28	0.56	Mean
	% biomass reduction		
1: 1–3 Leaves	79	88	84
3: Tillering	64	71	68
5: Pseudostem	30	50	40
7: Jointing	52	67	60
9: Early boot	33	37	35
Mean	52	63	

$LSD_{(0.05)}$ Growth stage by rate interaction: NS
$LSD_{(0.05)}$ Growth stage: 8
$LSD_{(0.05)}$ Paraquat rate: 5

Table 3. Effect of time of application and rate on bioactivity of paraquat to winter wheat. Data means are averaged over all spray dates.

Time of application	Paraquat (kg ha^{-1})		
	0.28	0.56	Mean
	% biomass reduction		
0800	55	66	61
1200	51	60	56
1600	50	63	57
Mean	52	63	

$LSD_{(0.05)}$ Time by rate interaction: NS
$LSD_{(0.05)}$ Time of application: NS
$LSD_{(0.05)}$ Paraquat rate: 5

We observed slightly higher growth inhibition at all growth stages with the higher rate of paraquat (Table 2), but the rate increase did not compensate for the reduced bioactivity at later growth stages of wheat. Because paraquat is ineffective at later growth stages of volunteer wheat, substituting a systemic herbicide for paraquat after wheat tillers may improve control of this species.

Time of application. Time of day at which spraying occurred did not affect paraquat bioactivity at either rate (Table 3). This is contrary to time effects on paraquat bioactivity on broadleaf weeds (2) and quackgrass (6). Thus, with volunteer wheat, producers have flexibility during the day in timing their paraquat application.

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