

WEED CONTROL, CLOVER INJURY, AND RESULTING YIELD FROM GF-3731 IN ROTATIONALLY GRAZED PASTURES

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Introduction

Adding legumes to grass pastures can result in multiple benefits including increased forage nutritive value (Sleugh et al., 2000), extended grazing season (Gibson and Cope, 1985; Sleugh et al., 2000) and increased grass yield due to N fixation (Sanderson et al., 2005). White clover (*Trifolium repens* L.), a short-lived perennial with prostrate growth habit, is one of the most important and widely adopted legume in grass-legume mixtures worldwide (Ball and Lacefield, 2000). In addition, red clover (*Trifolium pretense* L.), another short-lived perennial, is widely grown in grass-clover mixtures in Wisconsin.

However, one long-lasting management problem that often limits adoption of mixed swards by producers is selective broadleaf weed control. Previous research has demonstrated that most legumes are highly sensitive to herbicides (e.g., triclopyr, fluroxypyr, dicamba and aminopyralid) commonly used for weed-management in pastures (Beeler et al., 2003; Payne et al., 2010). Ways of which desirable legumes may be negatively impacted include direct herbicide injury, or injury from soil residual activity, leaving producers with few weed-management tools for broadleaf weed control in these production systems (Enloe et al., 2014).

With the goal to address this weed management challenge, Corteva Agriscience is developing a new product currently designated as GF-3731 (florpyrauxifen-benzyl and 2,4-D). This product, if released, will contain the first new active ingredient introduced in the Range and Pasture market in nearly 15 years (i.e. florpyrauxifen-benzyl). It has been shown to provide broadleaf weed control in pastures with limited injury to select clover species. The possibility of effective broadleaf weed control without significant negative impacts on clover may help producers to optimize forage productivity and quality while at the same time decrease fertilizer and reseeding costs (Enloe et al., 2014). Given that little information is available on GF-3731 safety to white and red clover species, efficacy on common pasture weeds and resulting yield under rotationally grazed pastures, our objective was to evaluate these parameters in rotationally grazed cool-season grass-clover mixed swards located in the Midwestern United States.

Material and Methods

Experiments were conducted from June 2019 through September 2019 in pastures located near Lancaster (LARS) and Prairie Du Sac (PDS), Wis. The main clover species present at LARS and PDS were white clover (*Trifolium repens* L.) and red clover (*Trifolium pretense* L.). Other main plant species present at both locations included tall

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fescue (*Festuca arundinaceae*), orchard grass (*Dactylis glomerate L.*) and smooth brome (*inermis Leyss*) (Tables 1 and 2). Overall, broadleaf weeds at the time of herbicide application was 25 and 10% at PDS and LARS, respectively. The predominant weed species are described in Tables 1 and 2.

Treatments included GF-3731 at 24.0 Fl oz acre⁻¹ (1.75 L ha⁻¹) and a control, in a randomized complete block design with four replications at each site. Plot size was 33 by 33 m (100 by 100 ft). Herbicide treatment was applied after emergence of weeds (first week of May and June at PDS and LARS, respectively). Grazing was implemented approximately 30 d after herbicide application to a residual height of 10.0 cm (4.0 inches). There was a total of three grazing events at both locations.

The percentage of vegetative cover was estimated prior to each grazing event using a line-intercept method. Plant species that intersected points at 90-cm intervals along a 33-m transect were recorded along three transects (100 points per plot) in each plot. Cover data was separated into four plant classes (clover, perennial grasses, annual grasses, and broadleaf weeds) for statistical analyses. Aboveground biomass was measured just prior to every grazing event by clipping three representative 0.25-m² quadrats per plot. After biomass collection, biomass samples were sorted into the same four plant classes used for vegetative cover data. Biomass was summed across all grazing events.

Statistical analyses were performed using the open-source statistical software R 3.6.1 (R Core Team, 2014). All response variables were analyzed by fitting mixed-effects models using the package “*lme4*” and function “*lmer*” in R. The model statement for all response variables included treatment (herbicide vs control) as a fixed effect; whereas block and location were considered random effects. Treatments (herbicide vs control) were considered different when $P \leq 0.05$. All reported means are least squares means. To satisfy the assumptions of analysis of variance, data were square root or arcsine square root transformed when necessary, but nontransformed means were reported.

Results

Results from this study indicate that GF-3731 provided effective control of broadleaf weeds at both sites (Table 1-2). Broadleaf weed cover was 3.6, 4.1 and 5.8-fold lower on GF-3731 treated pastures compared to controls at 30, 60 and 90 DAT, respectively (Table 3). This resulted in a 5.0-fold lower broadleaf weed biomass production on treated pastures (104 vs 518 kg DM ha⁻¹ for GF-3731 and control, respectively) (Table 5). White clover cover was not negatively impacted by GF-3731 as it was similar to untreated controls at 30, 60 and 90 DAT. However, red clover was nearly eliminated from the treated pastures as its cover was reduced to $\leq 2.0\%$ throughout 90 DAT. Clover biomass (white plus red clover) was three-fold greater on untreated pastures at 30 DAT but no differences were detected at 60 and 90 DAT. This resulted in lower clover biomass on GF-3731 treated pastures (729 kg DM ha⁻¹) compared to untreated pastures (1,282 kg DM ha⁻¹). In contrast, perennial forage grass cover was greater on GF-3731 treated pastures at 30 DAT, but no differences were detected 60 or 90 DAT in cover or total season perennial grass biomass.

Conclusion

The use of GF-3731 appears to be a promising tool for broadleaf weed management in cool season grass-clover mixed swards in the Midwestern United States. Although clover suppression was observed on GF-3731, pastures maintained significant white clover cover and biomass while reducing broadleaf weeds compared to untreated plots. Results also suggest clover tolerance to GF-3731 is species dependent as white and red clover exhibited different tolerance levels. Future research should investigate the susceptibility of different clover species to GF-3731 and management practices to limit injury of susceptible clovers.

References

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Table 1. List of plant species found at Lancaster throughout the experiment.

Common name	Scientific name	Plant family	Plant class
Red clover	<i>Trifolium pretense L.</i>	Fabaceae	Clover
White clover	<i>Trifolium repens L.</i>	Fabaceae	Clover
Kentucky bluegrass	<i>Poa pratensis L.</i>	Poaceae	Perennial grass
Orchard grass	<i>Dactylis glomerata L.</i>	Poaceae	Perennial grass
Quackgrass	<i>Elymus repens (L.) Gould</i>	Poaceae	Perennial grass
Reed canarygrass	<i>Phalaris arundinacea L.</i>	Poaceae	Perennial grass
Tall fescue	<i>Festuca arundinacea</i>	Poaceae	Perennial grass
Timothy	<i>Phleum pratense L.</i>	Poaceae	Perennial grass
Smooth brome	<i>Bromus inermis Leyss.</i>	Poaceae	Perennial grass
Foxtail spp.	<i>Setaria spp.</i>	Poaceae	Annual grass
Common burdock	<i>Arctium minus (Hill) Bernh.</i>	Asteraceae	Broadleaf weed
Canada thistle	<i>Cirsium arvense (L.) Scop.</i>	Asteraceae	Broadleaf weed
Dandelion	<i>Taraxacum officinale F. H. Wigg.</i>	Asteraceae	Broadleaf weed
Giant chickweed	<i>Cerastium fontanum Baumg.</i>	Caryophyllaceae	Broadleaf weed
Smartweed spp.	<i>Persicaria spp.</i>	Polygonaceae	Broadleaf weed

Table 2. List of plant species found at PDS throughout the experiment.

Common name	Scientific name	Plant family	Plant class
Red clover	<i>Trifolium pretense L.</i>	Fabaceae	Clover
White clover	<i>Trifolium repens L.</i>	Fabaceae	Clover
Kentucky bluegrass	<i>Poa pratensis L.</i>	Poaceae	Perennial grass
Orchard grass	<i>Dactylis glomerata L.</i>	Poaceae	Perennial grass
Quackgrass	<i>Elymus repens (L.) Gould</i>	Poaceae	Perennial grass
Tall fescue	<i>Festuca arundinaceae</i>	Poaceae	Perennial grass
Large crabgrass	<i>Digitaria sanguinalis (L.) Scop.</i>	Poaceae	Annual grass
Dandelion	<i>Taraxacum officinale F. H. Wigg.</i>	Asteraceae	Broadleaf weed
Giant chickweed	<i>Cerastium fontanum Baumg.</i>	Caryophyllaceae	Broadleaf weed
Speedwell spp.	<i>Veronica spp.</i>	Plantaginaceae	Broadleaf weed
Smartweed spp.	<i>Persicaria spp.</i>	Polygonaceae	Broadleaf weed
Bull thistle	<i>Cirsium vulgare (Savi) Ten.</i>	Asteraceae	Broadleaf weed
Plumeless thistle	<i>Carduus acanthoides L.</i>	Asteraceae	Broadleaf weed

3. White clover, red clover and broadleaf weeds vegetative cover at 30, 60 and 90 d after treatment as affected by herbicide treatment. Values represent means (\pm standard error) pooled across locations.

bicide tment	White clover ¹			Red clover ¹			Broadleaf weeds ¹		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
	... vegetative cover (%) vegetative cover (%) vegetative cover (%) ...		
ol	56 (\pm 12)	61 (\pm 10)	70 (\pm 11)	16* (\pm 6.5)	13* (\pm 5)	8* (\pm 2.5)	40* (\pm 7)	33* (\pm 6)	35* (\pm 5)
731	51 (\pm 9)	51 (\pm 8)	61 (\pm 9)	1 (\pm 0.3)	2 (\pm 1)	1 (\pm 0.4)	11 (\pm 2)	8 (\pm 3)	6 (\pm 2)
alue	0.441	0.145	0.055	<0.001	0.025	0.010	0.003	0.002	<0.001

within plant classes and evaluation timings (columns) with followed by * were significantly greater at $P \leq 0.05$.

4. Perennial and annual grasses vegetative cover at 30, 60 and 90 d after treatment as affected by herbicide treatment. Values represent means (\pm standard error) pooled locations.

bicide tment	Perennial grasses ¹			Annual grasses ¹		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
	... vegetative cover (%) vegetative cover (%) ...		
ol	97 (\pm 0.7)	90 (\pm 2.6)	90 (\pm 4.3)	0	7 (\pm)	10 (\pm 2.4)
731	99* (\pm 0.2)	95 (\pm 1.4)	94 (\pm 2.7)	0	12 (\pm)	20 (\pm 5.8)
alue	0.010	0.071	0.184	-	0.090	0.120

within plant classes and evaluation timings (columns) with followed by * were cantly greater at $P \leq 0.05$.

5a. Clovers (white and red) and broadleaf weeds pre-graze biomass (kg DM ha⁻¹) at 30, 60, and 90 d after ent (DAT), and total season production (sum across months), as affected by herbicide treatment. represent means (\pm standard error) pooled across locations.

bicide tment	Clovers (white and red) ¹			Broadleaf weeds ¹		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
	... Biomass (kg DM ha ⁻¹) Biomass (kg DM ha ⁻¹) ...		
ol	558* (\pm 131)	350 (\pm 82)	374 (\pm 147)	1,282* (\pm 332)	237* (\pm 60)	137* (\pm 54)
731	163 (\pm 61)	249 (\pm 75)	317 (\pm 128)	729 (\pm 223)	69 (\pm 40)	23 (\pm 20)
alue	<0.001	0.204	0.312	0.016	0.025	0.009
						518* (\pm 120)
						104 (\pm 39)
						0.003

Table 5b. Perennial grasses and annual grasses pre-graze biomass (kg DM ha⁻¹) at 30, 60, and 90 d after treatment (DAT), and total season production (sum across months), as affected by herbicide treatment. Values represent means (\pm standard error) pooled across locations.

Herbicide Treatment	Perennial grasses ¹			Annual grasses ¹		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Control	1,796 (\pm 265)	903 (\pm 224)	639 (\pm 97)	0	5 (\pm)	7 (\pm 3)
GF-3731	2,136 (\pm 226)	754 (\pm 137)	811 (\pm 122)	0	11 (\pm)	6 (\pm 10)
P-value	0.143	0.352	0.233	-	0.530	0.935

... Biomass (kg DM ha⁻¹) ...

... Biomass (kg DM ha⁻¹) ...

... Biomass (kg DM ha⁻¹) ...

¹Mean within plant classes and evaluation timings (columns) with followed by * were significantly greater at $P \leq 0.05$.

Table 6. Total season production (sum across months) as affected by herbicide treatment. Values represent means (\pm standard error) pooled across locations.

Herbicide Treatment	Sum of all classes (total biomass) ¹		
	30 DAT	60 DAT	90 DAT
Control	2,592 (\pm 146)	1,402 (\pm 185)	1,158 (\pm)
GF-3731	2,368 (\pm 225)	1,037 (\pm 131)	1,147 (\pm)
P-value	0.336	0.059	0.925

... Biomass (kg DM ha⁻¹) ...

... Biomass (kg DM ha⁻¹) ...

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¹Mean within plant classes and evaluation timings (columns) with followed by * were significantly greater at $P \leq 0.05$.