

# Effects of Ammonium Sulfate on Control of Weeds with Touchdown<sup>®</sup> 5

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## Abstract

The effects of ammonium sulfate (AMS) on the efficacy of Touchdown<sup>®</sup> 5, sulfosate, against selected weeds in prunes and in a non-crop situation were evaluated in Central California. Touchdown<sup>®</sup> 5 provided better weed control at 1.1 kg (AI) / ha than at 0.56 kg (AI) / ha. The addition of ammonium sulfate significantly improved control of most weed species evaluated, with the exceptions of horseweed, wild barley, and yellow nutsedge. A significant interaction between adjuvant (with or without AMS) and herbicide rate indicated that AMS had a greater influence on control of some weed species with lower rather than higher rates of Touchdown<sup>®</sup> 5.

## Introduction

Touchdown<sup>®</sup> 5, sulfosate, is a trimesium salt of N-(phosphonomethyl)glycine, or PMG. This non-selective, systemic herbicide may be used to control a variety of annual and perennial weeds in both agricultural and industrial situations. Figures 1 and 2 illustrate the effects of Touchdown<sup>®</sup> 5 on weeds in corn stubble. Similar to the isopropylamine salt of PMG, glyphosate, the efficacy of sulfosate may be influenced by the presence of hard-water cations such as Ca<sup>+2</sup> or Na<sup>+2</sup> in the spray solution (Buhler and Burnside 1983, Nalewaja and Matysiak 1993, Thelen et al. 1995, Jordan et al. 1997). The basis for this influence is the formation of calcium or sodium salts of PMG that are not taken up by plants as readily as isopropylamine or ammonium salts of PMG (Thelen et al. 1995, Nalewaja et al. 1996).

This effect may be combated either by manipulation of carrier volume or by the addition of cationic surfactants (Buhler and Burnside 1983, Nalewaja and Matysiak 1993, Thelen et al. 1995, Jordan et al. 1997). Buhler and Burnside (1983) demonstrated that glyphosate phytotoxicity to selected annual grass weeds increased with decreasing carrier (water) volume. The authors hypothesized that fewer antagonistic cations were available in the spray solution at lower carrier volumes compared with greater carrier volumes. The addition of a cationic surfactant also was found to increase the phytotoxicity of glyphosate to selected annual grass weeds (Buhler and Burnside 1983). Interestingly, the effects of cationic surfactant was most pronounced at greater carrier volumes. Cationic surfactants, such as ammonium sulfate, act by competing with hard-water cations for binding with PMG. In the case of ammonium sulfate, the ammonium anion binds with PMG, creating a salt that is more readily absorbed by plants than calcium salts (Thelen et al. 1995, Nalewaja et al. 1996). Additionally, Ca<sup>+2</sup> ions are precipitated from solution through the formation of CaSO<sub>4</sub> (Thelen et al. 1995). Because most studies

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concerning the effects of ammonium sulfate have focused on glyphosate, the objective of this study was to evaluate the effects of ammonium sulfate on the efficacy of sulfosate.

## Materials and Methods

Two studies were conducted in Central California during 1998. Both studies were randomized complete block designs with factorial treatment arrangements and 4 replications. Touchdown<sup>®</sup> 5 was evaluated at 0.56 and 1.1 kg (AI) / ha with and without ammonium sulfate (AMS, 2% w/w). In the first study, plots (2.0 m x 15.2 m) were established in 2 year old French variety prunes near Farmersville, CA. Weeds evaluated in the study included annual sowthistle, *Sonchus oleraceus* L., common lambsquarters, *Chenopodium album* L., little mallow, *Malva parviflora* L., horseweed, *Conyza canadensis* (L.) Cronquist, and wild barley, *Hordeum murinum* ssp. *leporinum* L. Treatments were applied on 21 April 98 when weeds were 0.08 to 0.25 m in height using a CO<sub>2</sub> back pack sprayer calibrated to deliver 93 l / ha at 138 kPa. Plots were visually evaluated for percent weed control at 7, 14, and 28 days after application (DAA).

The second study was conducted near Dinuba, CA, on bare ground. Treatments and experimental design were the same in both studies. Plots were 2.1 m x 12.2 m in dimension. The weeds evaluated in this study were southwestern cupgrass, *Eriochloa gracilis* (Fourn.) Hitchc., redstem filaree, *Erodium cicutarium* (L.) L'Hér., and yellow nutsedge, *Cyperus esculentus* L. Treatments were applied on 30 June 1998 when weeds were 0.05 to 0.15 m in height. A CO<sub>2</sub> back pack sprayer calibrated to deliver 93 l / ha at 276 kPa was used to make applications. Plots were visually evaluated for percent weed control at 7, 14, and 21 DAA. Data for both studies were subjected to analysis of variance, and factor (Touchdown<sup>®</sup> 5 rate, presence or absence of AMS) means were separated using Fisher's protected LSD.

## Results and Discussion

Tables 1 and 2 show the effects of different Touchdown<sup>®</sup> 5 rates on weed control in Farmersville and Dinuba, respectively. The 1.1 kg (AI) / ha rate of Touchdown<sup>®</sup> 5 provided good to excellent control of all weeds evaluated. Good control also was obtained with the 0.56 kg (AI) / ha rate of Touchdown<sup>®</sup> 5 for annual sowthistle, common lambsquarters, horseweed, wild barley, and redstem filaree. The higher rate of Touchdown<sup>®</sup> 5 [1.1 kg (AI) / ha] produced higher percentages of weed control than the lower rate [0.56 kg (AI) / ha] for all weeds evaluated except where control approached 100%. However, these differences were not significant for several weeds evaluated at the Farmersville, CA site, including annual sowthistle at 7 and 28 DAA, horseweed at 7 and 28 DAA, and for wild barley at 7 DAA (Table 1). All weed control differences between Touchdown<sup>®</sup> 5 rates at the Dinuba, CA site were significant. This disparity in significance probably is because weeds at the Dinuba site were hardened-off from high summer temperatures and required higher Touchdown<sup>®</sup> 5 rates to achieve control than those at the Farmersville site.

Tables 3 and 4 show the effects of AMS on Touchdown<sup>®</sup> 5 efficacy at the Farmersville and Dinuba sites, respectively. The addition of AMS significantly improved weed control with Touchdown<sup>®</sup> 5 for annual sowthistle, common lambsquarters, little mallow, southwestern cupgrass, and redstem filaree. The effects of AMS appeared to be most pronounced at 7 to 14

DAA, with only little mallow and redstem filaree showing significant AMS effects at more than 21 DAA. Control of horseweed, wild barley, and yellow nutsedge with Touchdown<sup>®</sup> 5 did not appear to be influenced by the addition of AMS. Wild barley control with Touchdown<sup>®</sup> 5 approached 100% at 7 DAA with and without AMS. It would, therefore, be difficult to detect significant differences among adjuvant treatments for wild barley. Such an explanation, however, is not valid for horseweed and yellow nutsedge. Other authors have demonstrated species-specific control responses to AMS plus glyphosate (Buhler and Burnside, 1983, Nalewaja and Matysiak 1992, Jordan et al. 1997). However, these authors offered no explanation for the observed species-specific responses to AMS. Some plant species, such as the Malvaceae, exude calcium and magnesium as bicarbonate salts. These salts further interfere with glyphosate and sulfosate, leading to species-specific responses to AMS (Ceris Jones, Zeneca Ag Products, personal communication). Additionally, hirsute plant species, such as horseweed, may impede herbicide penetration.

Water analysis from the two sites suggested that ions such as Ca<sup>+2</sup> and Na<sup>+2</sup> were present at sufficient levels to interfere with Touchdown<sup>®</sup> 5 activity. Water used for applications at the Farmersville site contained 43.9 mg / L Na<sup>+2</sup> and 82 mg / L Ca<sup>+2</sup> (A&L Western Agricultural Laboratories, Modesto, CA). Applications at the Dinuba site were made using water that contained 39.1 mg / L Na<sup>+2</sup> and 112 mg / L Ca<sup>+2</sup> (Valley Tech Agricultural Laboratory Services, Tulare, CA). Nalewaja and Matysiak (1993) demonstrated that when no ions were present in the spray solution, glyphosate decreased wheat, *Triticum aestivum* L., fresh weight by 81%. However, when 100 mg/L of Ca<sup>+2</sup> was added to the spray solution, glyphosate decreased wheat fresh weight by only 67%. Additionally, when 100 mg / L each of Ca<sup>+2</sup> and Na<sup>+2</sup> were added to the spray solution, glyphosate reduced wheat fresh weight by only 60% (Nalewaja and Matysiak 1993).

Factorial analysis of data from the Farmersville site revealed a significant interaction between adjuvant and rate for common lambsquarters at 7 DAA (df = 1, 6; F = 5.56; *p* = 0.05), and for little mallow at 14 DAA (df = 1, 6; F = 14.29; *p* = 0.009). Significant interaction between adjuvant and rate for data from the Dinuba site were detected for southwestern cupgrass at 7 (df = 1, 6; F = 11.57; *p* = 0.008), 14 (df = 1, 6; F = 22.22; *p* = 0.001), and 21 DAA (df = 1, 6; F = 5.69; *p* = 0.04), and for redstem filaree at 7 (df = 1, 6; F = 19.11; *p* = 0.002), 14 (df = 1, 6; F = 60.28; *p* < 0.001), and 21 DAA (df = 1, 6; F = 15.51; *p* = 0.003). In each of the above cases, AMS increased weed control by a greater amount at lower Touchdown<sup>®</sup> 5 rates than at higher Touchdown<sup>®</sup> 5 rates. This finding is significant because it demonstrates the increased utility of AMS at lower versus higher Touchdown<sup>®</sup> 5 rates.

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**Table 1. Mean percent weed control with Touchdown® 5 at different rates averaged over all adjuvant treatments (with and without ammonium sulfate), Farmersville, CA, 1998.**

Weed Species	Rate	Percent Control <sup>a</sup>		
		7 DAA <sup>b</sup>	14 DAA	28 DAA
annual sowthistle	0.56 kg (AI) / ha	30.8 a	50.8 b	92.7 a
	1.1 kg (AI) / ha	42.5 a	78.3 a	100.0 a
common lambsquarters	0.56 kg (AI) / ha	43.3 b	90.8 b	96.7 a
	1.1 kg (AI) / ha	66.7 a	100.0 a	96.7 a
little mallow	0.56 kg (AI) / ha	30.0 b	30.8 b	38.3 b
	1.1 kg (AI) / ha	46.7 a	59.2 a	84.7 a
horseweed	0.56 kg (AI) / ha	29.2 a	60.8 b	95.8 a
	1.1 kg (AI) / ha	46.7 a	82.5 a	98.7 a
wild barley	0.56 kg (AI) / ha	92.5 a	100.0 a	100.0 a
	1.1 kg (AI) / ha	100.0 a	100.0 a	100.0 a

<sup>a</sup>Means followed by a different letter in a column for each weed species are significantly different (Fisher's Protected LSD,  $p = 0.05$ ).

<sup>b</sup>Application made April 21, 1998.

**Table 2. Mean percent weed control with Touchdown® 5 at different rates averaged over all adjuvant treatments (with and without ammonium sulfate), Ivanhoe, CA, 1998.**

Weed Species	Rate	Percent Control <sup>a</sup>		
		7 DAA <sup>b</sup>	14 DAA	21 DAA
southwestern cupgrass	0.56 kg (AI) / ha	25.0 b	28.8 b	42.5 b
	1.1 kg (AI) / ha	62.5 a	84.4 a	90.4 a
redstem filaree	0.56 kg (AI) / ha	37.5 b	61.3 b	78.8 b
	1.1 kg (AI) / ha	73.8 a	99.1 a	100.0 a
yellow nutsedge	0.56 kg (AI) / ha	5.0 b	10.8 b	16.3 b
	1.1 kg (AI) / ha	12.5 a	23.8 a	52.5 a

<sup>a</sup>Means followed by a different letter in a column for each weed species are significantly different (Fisher's Protected LSD,  $p = 0.05$ ).

<sup>b</sup>Application made June 30, 1998.

**Table 3. Mean percent weed control with Touchdown<sup>®</sup> 5 alone and plus ammonium sulfate (2.0% w/w) averaged over all Touchdown<sup>®</sup> 5 rates [0.56 and 1.1 kg (AI) / ha], Farmersville, CA, 1998.**

Weed Species	Adjuvant	Percent Control <sup>a</sup>		
		7 DAA <sup>b</sup>	14 DAA	28 DAA
annual sowthistle	None	26.7 b	49.2 b	93.0 a
	Ammonium Sulfate	46.7 a	80.0 a	99.7 a
common lambsquarters	None	38.3 b	94.2 a	98.3 a
	Ammonium Sulfate	71.7 a	96.7 a	98.0 a
little mallow	None	30.8 b	38.3 b	45.8 b
	Ammonium Sulfate	45.8 a	51.7 a	77.2 a
horseweed	None	36.7 a	65.8 a	97.7 a
	Ammonium Sulfate	39.2 a	77.5 a	96.8 a
wild barley	None	92.5 a	100.0 a	100.0 a
	Ammonium Sulfate	100.0 a	100.0 a	100.0 a

<sup>a</sup>Means followed by a different letter in a column for each weed species are significantly different (Fisher's Protected LSD,  $p = 0.05$ ).

<sup>b</sup>Application made April 21, 1998.

**Table 4. Mean percent weed control with Touchdown<sup>®</sup> 5 alone and plus ammonium sulfate (2.0% w/w) averaged over all Touchdown<sup>®</sup> 5 rates [0.56 and 1.1 kg (AI) / ha], Ivanhoe, CA, 1998.**

Weed Species	Adjuvant	Percent Control <sup>a</sup>		
		7 DAA <sup>b</sup>	14 DAA	21 DAA
southwestern cupgrass	None	40.0 b	53.8 b	62.9 a
	Ammonium Sulfate	47.5 a	59.4 a	70.0 a
redstem filaree	None	47.5 b	72.3 b	83.8 b
	Ammonium Sulfate	63.8 a	88.1 a	95.0 a
yellow nutsedge	None	8.8 a	16.2 a	31.3 a
	Ammonium Sulfate	8.8 a	17.5 a	37.5 a

<sup>a</sup>Means followed by a different letter in a column for each weed species are significantly different (Fisher's Protected LSD,  $p = 0.05$ ).

<sup>b</sup>Application made June 30, 1998.