Optimizing the performance of glyphosate in field crops

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Reduced supply and increased costs of glyphosate have prompted many to reevaluate how they use this herbicide. The following three questions are most common:

1) How do I optimize the performance of glyphosate, and can I reduce rates and still achieve good weed control?
2) Should I be adding AMS to glyphosate?
3) Are there other herbicides that could be added to lower rates of glyphosate?

To answer these 3 questions, I have referenced both the product labels and peer reviewed scientific literature.

Optimizing glyphosate performance and reducing rates

1) Use a rate that will control the most tolerant species in the field (See Table 1). In general, the species sensitivity to glyphosate from the most sensitive to most tolerant is: volunteer cereals<annual grasses<annual broadleaves< perennials
2) Spray annual weeds when they are no larger than 10 cm (4") tall.
3) Spray between 8:00 am and 8:00 pm. The best control often occurs when applications are made from noon until 6 pm. This assumes that environmental conditions aren't favourable for off target drift at the time of application.
4) The labelled carrier volume in glyphosate tolerant crops ranges from 10-20 gal/acre (100-200 L/ha). Generally, the lower water volume improves glyphosate activity (less hard water antagonism and higher surfactant concentration) but higher volumes are better for dense weed canopies, when weeds are large (>20 cm) or when you're tank-mixing with a contact herbicide like Eragon LQ.

Reducing Rates

The recommend rates in glyphosate tolerant soybean and corn (0.67 L/acre for annual weeds and up to 1.34 L/acre for perennial weeds) controls the greatest spectrum of weed species and height at application, without sacrificing weed control and crop yield. If you wish to be aggressive with reducing rates, the label does support it, but you must be more precise about weed species identification and its height at the time of application. There is less margin for error. Several studies have demonstrated effective weed control at rates lower than 0.67 L/acre. However, I keep going back to an Ontario study that evaluated the rates of glyphosate needed to achieve a minimum of 90% control of annual weeds in glyphosate tolerant corn. There were two key summaries:

1) **Corn yield was maximized when glyphosate was applied to 10 cm tall annual weeds**
2) **0.67 L/acre of glyphosate (540 g/L) applied to 10-20 cm tall annual weeds was sufficient to provide 90% or greater control.**

Table 1. A summary of guidance provided on the Roundup Transorb HC label (glyphosate at 540 g/L) with respect to annual weed species, height, and effective rate.

Annual Grasses	**268* mL/acre**	**510 mL/acre**	**600 mL/acre**	**670 mL/acre**	**930 mL/acre**
Barley, volunteer	8-15 cm	8-15 cm	8-15 cm	8-15 cm[2]	>15 cm
Barnyard grass	-	-	-	< 25 cm	-
Bluegrass, annual	-	-	8-15 cm	8-15 cm	>15 cm
Brome, downy	-	8-15 cm	8-15 cm	8-15 cm	>15 cm
Crabgrass	-	-	8-15 cm	8-15 cm[2]	>15 cm
Fall panicum	-	-	-	< 25 cm	-
Foxtail, giant	-	8-15 cm	8-15 cm	8-15 cm[2]	>15 cm
Foxtail, green	8-15 cm	8-15 cm	8-15 cm	8-15 cm[2]	>15 cm
Foxtail, yellow	-	-	-	< 25 cm	-
Proso millet	-	-	-	< 25 cm	-
Wheat, volunteer	8-15 cm	8-15 cm	8-15 cm	8-15 cm[2]	>15 cm
Wild oats	8-15 cm	8-15 cm	8-15 cm	8-15 cm[2]	>15 cm
Annual Broadleaves	**268* mL/acre**	**510 mL/acre**	**600 mL/acre**	**670 mL/acre**	**930 mL/acre**
Buckwheat, wild	-	3-4 leaf	8-15 cm	8-15 cm	>15 cm
Chickweed	?[1]	?[1]	?[1]	< 25 cm	-
Cleavers	-	8-15 cm	8-15 cm	8-15 cm	>15 cm
Cocklebur	-	-	-	< 25 cm	-
Flixweed	-	8-15 cm	8-15 cm	8-15 cm	>15 cm
Hempnettle	-	8-15 cm	8-15 cm	8-15 cm	>15 cm
Lady's thumb	8-15 cm	8-15 cm	8-15 cm	8-15 cm[2]	>15 cm
Lamb's-quarter	-	8-15 cm	8-15 cm	8-15 cm[2]	>15 cm
Lettuce, Prickly	-	-	8-15 cm	8-15 cm	>15 cm
Mustard, wild	8-15 cm	8-15 cm	8-15 cm	8-15 cm[2]	>15 cm
Nightshade, Eastern black	-	-	-	< 25 cm	-
Pigweed, redroot	-	8-15 cm	8-15 cm	8-15 cm[2]	>15 cm
Ragweed, common	-	<8 cm	8-15 cm	8-15 cm[2]	>15 cm
Shepherd's Purse	-	-	8-15 cm	8-15 cm[2]	>15 cm
Sow-thistle, annual	-	-	8-15 cm	8-15 cm	>15 cm
Stinkweed	8-15 cm	8-15 cm	8-15 cm	8-15 cm[2]	>15 cm
velvetleaf	-	-	-	< 25 cm	-

- no information or guidance provided on the label. * a non-ionic surfactant must be added at a rate of 140 mL/acre

[1] listed in the glyphosate tolerant canola section and only provides crop staging guidance of 0 to 6 leaf canola, so presumably weeds at that crop stage would be <10 cm, but who knows?

[2] When listed in the "weeds controlled" area of the Roundup Ready soybean (section 7.71) and corn (section 7.9) sections of the label, the weed is apparently susceptible up until a height of 25 cm. This contradicts the guidance provided under section 7.1 of the label

Table 2. A summary of guidance provided on the Roundup Transorb HC label (glyphosate at 540 g/L) with respect to perennial weed species, stage, and effective rate when in glyphosate tolerant corn and soybeans.

Perennial weed	Stage/Size	Rate
Adzuki beans, volunteer	Up to 4th trifoliate	0.67 L/acre – applied twice, 2 weeks apart.
Alfalfa, volunteer	>10 cm tall	1.87 L/acre – applied once
Biennial wormwood	2 to 8 leaf	0.67 L/acre
Bindweed, field		1.34 L/acre – applied once or 0.67 L/acre – applied twice, 2 weeks apart
Bromegrass	>10 cm tall	1.87 L/acre – applied once
Burcucumber	1-18 leaf	0.67 L/acre – applied twice, 2 weeks apart.
Canada thistle	Rosette to 50 cm tall	0.67 L/acre
Dandelion	<15 cm diameter	0.67 L/acre
Dandelion	>15 cm diameter	1.34 L/acre
Horse-nettle	2-12 leaf stage	1.34 L/acre
Nutsedge	5-15 cm tall	1.34 L/acre – applied once or 0.67 L/acre – applied twice, 2 weeks apart
Milkweed	15-60 cm	0.67 L/acre
Perennial Sow-thistle	Rosette to 50 cm tall	0.67 L/acre
Quackgrass	< 25 cm	0.67 L/acre
Wirestem muhly	10-20 cm tall	0.67 L/acre

Should I add AMS to glyphosate?

The addition of AMS is not supported on any glyphosate labels approved for use in Canada. Many U.S. extension resources recommend the addition of AMS to water before adding glyphosate. However, most studies that have shown a benefit to adding AMS, have used glyphosate rates that are much lower than what is labelled for use in glyphosate tolerant crops. When reviewing Ontario research on AMS and glyphosate, when weeds are small (<15 cm tall) and a 0.67 L/acre rate of glyphosate (540 g/L) is being used, the addition of AMS has not improved control. A 2008 Michigan and Ontario study conducted by Nurse and his colleagues, demonstrated that the addition of AMS to glyphosate provided no benefit (Table 3).

Table 3. The influence of AMS to condition water prior to adding glyphosate at various rates, its influence on the visual control (%) of velvetleaf, pigweed, lamb's-quarters and annual grasses and the relative cost of each herbicide treatment.

Treatment	Rate (L/ac)	Velvetleaf	Pigweed	Lamb's quarters	Grasses	Cost ($/ac)
Glyphosate	0.17	24%	91%	59%	87%	$2.80
AMS + glyphosate	0.8 + 0.17	45%	89%	68%	85%	$5.20
Glyphosate	0.34	75%	96%	90%	94%	$5.59
AMS + glyphosate	0.8 + 0.34	78%	96%	89%	95%	$7.99
Glyphosate	0.51	94%	99%	92%	95%	$8.39
AMS + glyphosate	0.8 + 0.51	95%	99%	91%	95%	$10.79
Glyphosate	0.67	95%	97%	96%	95%	$11.02
AMS + glyphosate	0.8 + 0.67	95%	99%	93%	96%	$13.02

Notes: glyphosate price = $16.45/L, AMS price = $3/L, water volume was 10 gal/acre, weed height = 15 cm, glyphosate brand used was Roundup Weathermax. It is possible the at glyphosate brands with a lower surfactant load would respond differently

Source: Nurse, Hamill, Kells and Sikkema - Annual weed control may be improved when AMS is added to below-label glyphosate doses in glyphosate-tolerant maize (Zea mays L.) - Crop Protection 27 (2008) 452–458

When it might make sense to experiment with AMS

- When weeds are large (>20 cm) and dense
- When higher water volumes are used (increased risk of hard water antagonism)
- If velvetleaf, field bindweed and lamb's quarters are the primary targets.
- If using glyphosate brands with a low surfactant load. Check with glyphosate manufacturer. Ontario studies typically use Roundup Weathermax or Transorb.

Are there other herbicides that could be added to lower rates of glyphosate and yet achieve the same level of control?

Below are key examples that I can think of based on experience. There may be more that I have not thought of.

1) For dandelion control during a pre-plant burndown in soybean, consider adding Classic, especially when dandelion rosettes are >15cm in diameter (Table 4).
2) If using a post emergent corn herbicide with both contact and residual control (e.g. ACURON, ARMEZON PRO, CORVUS, DESTRA IS, LAUDIS etc.) and you normally tank-mixed with glyphosate, you could be more aggressive with using the lower rates in Table 1, provided the corn herbicide is also effective on the same target weeds.

Table 4. Dandelion control with different burndown treatments

Treatment and Rate/acre	Dandelion Control (%)	Cost ($/ac)
Glyphosate 540 g/L @ 1.34 L	97%	$22
Glyphosate 540 g/L @ 0.67 L + Classic at 14.4 g	89%	$20.50
Glyphosate 540 g/L @ 0.34 L + Express SG at 6 g*	Labelled (15 cm)	$10

*There are no public trials comparing Express SG + glyphosate to the 1.34 L/acre rate of glyphosate 540 g/L or glyphosate + Classic. The price point makes it compelling on paper but relative performance is unknown.