

Weed control and desiccation strategies in chickpea

Executive Summary

Broadleaf weed control is the number one priority for chickpea growers according to surveys from 2000 to 2005. Broadleaf weeds such as kochia, wild buckwheat, Russian thistle, and mustard species present the greatest challenge to chickpea production. The loss of pyridate in 2003 for postemergence weed control limits current herbicide options to soil-applied herbicides only. Most chickpea acres are grown under no-till conditions, which make weed control options even more limited. Chickpea exhibits an indeterminate plant growth habit and may not mature and senesce under warm, moist conditions. Chickpea growers may find it necessary to facilitate harvest by applying a pre-harvest desiccant. This study was initiated to 1) evaluate weed control with several labeled and experimental herbicides in conventional and no-till systems, 2) determine chickpea tolerance to these herbicides, and 3) evaluate several herbicides for proper timing and effectiveness of pre-harvest desiccation.

Studies were conducted at Minot and Williston, ND and Bozeman, MT from 2002-2004. Sulfentrazone, isoxaflutole, ethalfluralin, and pyridate caused very little chickpea injury in any year. In conventional-till studies, soil-applied and postemergence metribuzin generally caused significant crop injury and tended to have reduced stands and reduced yields. In contrast, there was generally much less crop injury in the no-till system from soil-applied metribuzin at 0.25-0.33 lb/A. Postemergence metribuzin in the no-till system generally resulted in significant crop injury with a trend toward reduced yield. Other than metribuzin, none of the herbicide treatments reduced chickpea yield.

At Minot, weed control varied by year and herbicide. Weed control with sulfentrazone generally increased with rate. Sulfentrazone alone provided poor to good wild buckwheat and pigweed control in 2002, but good to excellent control in 2004. Sulfentrazone provided excellent kochia control in 2003 and 2004. Weed control in the conventional-till studies was generally equal to or slightly better than control in no-till. In general, isoxaflutole did not significantly increase broadleaf weed control over that provided by sulfentrazone in any year. In two of four site-years, isoxaflutole increased weed control over that provided by ethalfluralin alone. Metribuzin did not consistently increase broadleaf weed control over that provided by sulfentrazone. Metribuzin significantly increased broadleaf weed control over that provided by ethalfluralin in only one of four site-years. Pyridate applied postemergence following sulfentrazone or ethalfluralin provided good to excellent broadleaf weed control in all years. Ethalfluralin generally provided good to excellent foxtail control in all years. Fall- and spring-applied sulfentrazone did not injure chickpea and provided good to excellent control of kochia, redroot pigweed, and wild buckwheat. At Williston, sulfentrazone alone, tank mixed with isoxaflutole or metribuzin, or followed by pyridate provided good to excellent control of kochia, Russian thistle, and pigweed in all years (no-till only).

In the chickpea pre-harvest desiccation study conducted at Minot and Bozeman, paraquat provided more chickpea desiccation within three days after application compared to other herbicides. By 14-17 days after application, paraquat, glufosinate, and glyphosate provided faster desiccation than carfentrazone, flumioxazin, and lactofen. There were no clear negative effects on yield or seed quality from any treatment.

Bottom line: The registration of sulfentrazone will fill one important weed control gap for chickpea growers as this herbicide will control kochia and Russian thistle. Sulfentrazone and ethalfluralin generally only suppress wild buckwheat and will not control mustard species. If registered in the future, metribuzin use should be limited to no-till systems at no more than 0.33 lb/A. More research is needed on isoxaflutole, which could be useful in areas that have mustard species, prickly lettuce, or false chamomile. More research is also needed to identify an herbicide or control method for wild buckwheat and a postemergence herbicide that will control weeds not controlled by soil-applied herbicides.

Introduction

Weed control in chickpea and tolerance to herbicides:

A 2000 grower survey in North Dakota indicated that weed control and ascochyta control are the most important management factors when raising chickpea. The same survey in 2005 indicated that expanded herbicide availability is still the number one priority for growers. Chickpea is not very competitive with weeds, especially early in the growing season. Weeds not only cause a yield loss due to competition, but can cause harvest problems resulting in lower seed quality.

Weed control options for specific weeds are limited in chickpea. Broadleaf weeds cannot be controlled in-crop with a selective herbicide. Pyridate is an herbicide that provided control of several broadleaf weeds when this study was initiated in 2002, but the herbicide was withdrawn by the manufacturer in 2003. The loss of pyridate limits herbicide options to soil-applied herbicides only. Labeled soil-applied herbicides are either inconsistent or control a limited weed spectrum, especially in minimum tillage or direct seeding systems. There isn't one herbicide that controls all broadleaf weeds in the chickpea growing region of western ND and eastern MT. Effectiveness of all soil-applied herbicides is dependent upon rainfall or mechanical incorporation for maximum activity. In the western North Dakota, Canada thistle, kochia, wild buckwheat, Russian thistle, and mustard species typically present the greatest broadleaf weed problems in chickpea.

Ethalfuralin is labeled for use in chickpea grown in a conventional tillage systems and will provide some control of kochia, wild buckwheat, and Russian thistle. However, most growers prefer to raise chickpea under a no-till system in order to conserve limited moisture, reduce soil erosion, and reduce trips across the field. Ethalfuralin must be mechanically incorporated immediately following application and thus is not a viable option in no-till systems.

Prior to this study, there were no herbicides labeled for preplant or preemergence use in no-till systems. Two experimental herbicides, sulfentrazone and isoxaflutole can be applied directly to the soil without incorporation. This practice has been tried in sunflower and corn (ND, KS, WY) and has worked effectively. Chickpea has shown good tolerance to sulfentrazone and isoxaflutole in preliminary trials in North Dakota. Based on previous studies in sunflower, sulfentrazone should control or suppress kochia, wild buckwheat, Russian thistle, lambsquarters, nightshade, pigweed, and other broadleaf weeds. However, studies have not been conducted in various soil types and precipitation regions to investigate differences in crop tolerance and herbicide efficacy. Sulfentrazone was not labeled in chickpea when this study was initiated, but was registered for use in 2004.

Metribuzin is not labeled for use in chickpea in the U.S., but is labeled in Canada. Previous studies have shown metribuzin applied postemergence can cause slight to moderate crop injury. Metribuzin and isoxaflutole, if shown to be safe on chickpea, could provide control of some weeds such as winter annual mustards that are not controlled by ethalfuralin or sulfentrazone. The objective of this study was to evaluate chickpea response to various herbicides and to evaluate herbicide efficacy under conventional or no-till conditions.

Chickpea Desiccation:

Chickpea growers frequently find it difficult to decide when to harvest given that some portions of the field may appear ripe, yet other areas are still somewhat green. Chickpea exhibits an indeterminate plant growth habit, which means that the plant continues to grow if soil moisture and temperature remain high late in the growing season. Several other factors can influence chickpea ripening including uneven soil topography, herbicide injury, disease, etc. Harvested seed that is green will result in significant discounts when graded.

Paraquat and glyphosate are currently registered for pre-harvest use. However, proper timing of application is not well documented. Glyphosate is slow acting and is typically used more for weed control than desiccation. Paraquat is faster acting, but many growers prefer not to use paraquat due to its high toxicity. Paraquat activity can also be reduced significantly by cool temperatures.

More research is needed to determine the proper timing for pre-harvest applications. Growers want to know the best herbicide to use, when to apply the herbicide, and what will be the effect on chickpea yield and quality.

Project objectives:

1. Evaluate chickpea tolerance to sulfentrazone, isoxaflutole, and other herbicides in conventional and no-till systems.
2. Conduct the study at different locations to determine the influence of soil type, soil pH, and organic matter on crop tolerance.
3. Determine the effectiveness of various herbicides for control of region-specific weeds.
4. Evaluate various herbicides for chickpea desiccation and determine the optimum application time.
5. Determine the effect of pre-harvest herbicides on chickpea yield and seed quality.

MATERIALS AND METHODS

Weed control and crop tolerance studies (2002-2004):

Experiments were conducted at Minot and Williston, ND in 2002, 2003, and 2004 in conventional or no-till systems. Individual plots were 10 by 30 ft arranged in a randomized complete block design with three replications. Various herbicide treatments were applied preplant incorporated (PPI), preemergence (PRE), or postemergence (POST) with either a tractor-mounted or bicycle sprayer. Data collected included chickpea density, visible chickpea injury, a visual estimate of weed control, chickpea yield, and test weight. All data were subjected to analysis of variance and mean separation using Fisher's Protected LSD test at $\alpha = 0.05$.

Herbicide treatments included sulfentrazone or ethalfluralin alone, sulfentrazone or ethalfluralin tank mixed with isoxaflutole or metribuzin, and sulfentrazone or ethalfluralin followed postemergence by pyridate or metribuzin. PRE treatments in no-till studies were tank mixed with glyphosate.

Study results from Minot were affected by herbicide carryover in 2003 and by hail in 2004. In late May 2003, the chickpea crop started to exhibit symptoms consistent with clopyralid injury. Unfortunately, it was overlooked that clopyralid & 2,4-D was applied to this field in 2002. Therefore, chickpea tolerance to herbicides in 2003 was not evaluated due to the confounding effect of the herbicide carryover from 2002. Chickpea injury due to clopyralid carryover was not as severe in the no-till study compared to the conventional-till study. As a result of the clopyralid injury, we initiated a second site with chickpea planted May 30, 2003. Throughout this document, the initial study (planted April 28, 2003) will be referred to as Site 1 and the second site (planted May 30, 2003) will be referred to as Site 2.

On June 6, 2004 a hailstorm severely injured the no-till and conventional-till chickpea studies at Minot. Herbicide applications and herbicide injury ratings had to be delayed to allow plants to recover. Chickpea

yields were significantly reduced compared to other years. The chickpea desiccation study described below was not affected as much as the weed control studies.

Chickpea tolerance to fall- vs. spring-applied sulfentrazone (2002-2003).

At Minot, sulfentrazone was applied at various rates in fall 2002 and PRE in spring 2003 to evaluate chickpea tolerance. Sulfentrazone was applied at 3, 4, and 5.33 oz in fall 2002 and at 3 and 4 oz in spring 2003 followed (or not) by a postemergence application of pyridate. Pyridate was also applied as a stand-alone treatment. Individual plots were 10 by 30 ft arranged in a randomized complete block design with three replications. Herbicide treatments were applied fall, preemergence (PRE) or postemergence (POST) with a bicycle sprayer. Data collected included chickpea density, visible chickpea injury, a visual estimate of weed control, chickpea yield, and test weight. All data were subjected to analysis of variance and mean separation using Fisher's Protected LSD test at $\alpha = 0.05$.

Chickpea desiccation study (2003-2004):

Paraquat, carfentrazone, glufosinate, lactofen, glyphosate, and flumioxazin were applied at three different stages to determine the optimum timing for chickpea desiccation and the effect on chickpea yield and seed quality. Individual plots were 10 by 30 ft and arranged in a randomized complete block design and replicated three or four times. Data was collected on chickpea stage at application time, percent visual desiccation, chickpea yield, and test weight. Data was analyzed by ANOVA and treatment differences separated using Fischer's Protected LSD at $\alpha = 0.05$. Studies were conducted in 2003 at Bozeman, MT and in 2004 at Minot, ND.

At Minot, large kabuli chickpea, "Sierra," was planted on April 27, 2004. The study was seeded on barley residue and arranged in a randomized complete block design with three replications. Herbicides were applied with a backpack sprayer delivering 10 gpa at 40 psi through XR8001 nozzles. The six herbicides were applied prior to harvest on Aug 31, Sep 7, and Sep 15. Treatments were evaluated visually for percent desiccation two or three times following application. Plots were harvested on September 30.

In Bozeman, large kabuli chickpea, "Yuma," was planted May 16, 2003. The trial was seeded on fallow and arranged in a randomized complete block design with four replications. Applications were made with a CO₂ backpack sprayer delivering 10 gpa at 40 psi through 8001 flat fan nozzles. The six herbicides were applied prior to harvest on Aug 12, 18, and 25. Treatments were evaluated visually for percent desiccation at 3, 7, and 14 DAT. Plots were harvested on September 11.

RESULTS AND DISCUSSION

Conventional-till chickpea, Minot 2002-04:

Sulfentrazone, isoxaflutole, ethalfluralin, and pyridate caused very little chickpea injury in any year (Tables 1-4). Tank mixes that included metribuzin generally caused significant crop injury. Soil-applied metribuzin at 0.5 lb or postemergence at 0.25 lb caused slight to moderate crop injury. Though the differences were not always significant, treatments that included metribuzin often tended to have reduced stands. Sulfentrazone applied alone, tank mixed with isoxaflutole, or followed by postemergence pyridate caused minimal injury at any rate in all years.

Herbicide impact on chickpea yield varied between years. With the exception of metribuzin, none of the herbicide treatments reduced chickpea yield. In 2002, chickpea yield appeared to be correlated more with level of weed control rather than herbicide injury. In 2003, Site 1 chickpea yields were high, but variable (CV=29) partially due to chickpea injury from clopyralid carryover. Even though metribuzin injury was visible during the growing season, there was no consistent impact on chickpea yield across metribuzin treatments at Site 1. However, in 2003 at Site 2 and in 2004, there was a trend for reduced yield from

POST metribuzin treatments. There may have been some effect on yield from soil-applied metribuzin, but the data are not consistent across metribuzin treatments and are partially confounded by lack of weed control in some treatments.

Weed control varied by year and herbicide (Tables 1-4). Weed control with sulfentrazone generally increased with rate. Sulfentrazone alone provided poor to good wild buckwheat and pigweed control in 2002, but good to excellent control in 2004. Sulfentrazone provided excellent kochia control in 2003 and 2004. Isoxaflutole did not significantly increase broadleaf weed control over that provided by sulfentrazone in any year. In two of four site-years, isoxaflutole increased weed control over that provided by ethalfluralin alone. Metribuzin did not consistently increase broadleaf weed control over that provided by sulfentrazone. Metribuzin significantly increased broadleaf weed control over that provided by ethalfluralin in only one of four site-years. Pyridate applied postemergence following sulfentrazone or ethalfluralin provided good to excellent broadleaf weed control in all years, with the exception of wild buckwheat control from ethalfluralin/pyridate in 2004. Clethodim provided good to excellent foxtail control in 2002 and 2003, but provided poor to fair foxtail control in 2004. Poor foxtail control in 2004 may have been due to cold, windy conditions at application time. Ethalfluralin generally provided good to excellent foxtail control in all years.

No-till Chickpea, Minot 2002-04:

Preemergence herbicide treatments included sulfentrazone applied alone, sulfentrazone tank mixed with isoxaflutole or metribuzin, or sulfentrazone followed postemergence by pyridate or metribuzin (Tables 5-8). All PRE treatments were tank mixed with glyphosate at 0.375 lb ae. Clethodim was applied postemergence to control grasses.

Sulfentrazone applied alone or with isoxaflutole caused minimal chickpea injury at any rate in any year. Metribuzin applied PRE at 0.50 lb in 2002 and at 0.33 lb in 2003 and 2004 caused less than 10% visual chickpea injury. Chickpea yield was not affected in 2002 or 2003 by metribuzin applied PRE. In 2004, chickpea yield was slightly reduced; however, these yields may have been confounded by a severe hailstorm on June 6, 2004. Metribuzin applied POST at 0.25 lb caused moderate visible chickpea injury in 2003 (Site 1) and 2004, but caused minimal visible injury in 2002 and 2003 (Site 2). However, even though apparent crop injury was minimal in some years, chickpea yield was significantly reduced in three of the four site-years. Chickpea densities in metribuzin treatments tended to be lower in 2002 and 2004. The untreated check could not be harvested in 2002 or 2003 (Site 1) due to excessive weed densities.

In 2002, only sulfentrazone (PRE) followed by pyridate (POST) provided greater than 80% wild buckwheat control. Sulfentrazone alone or with metribuzin provided only fair wild buckwheat control. Metribuzin tank mixed with clethodim may have resulted in antagonism of grass control. Very dry soil conditions likely contributed to high variability in weed control.

In 2003 at Site 1, all treatments provided excellent (>90%) kochia and redroot pigweed control, with the exception of the low sulfentrazone rate (2.67 oz), which provided good control (80-89%). All treatments provided excellent biennial wormwood control with the exception of the two lower sulfentrazone rates (2.67 and 4 oz). At Site 2, all herbicide treatments, which included clethodim applied POST, provided excellent foxtail control. There were few broadleaf weeds present at Site 2.

In 2004, all treatments provided good to excellent kochia and wild buckwheat control. Sulfentrazone applied alone or with isoxaflutole or metribuzin provided fair to good redroot pigweed control, with the exception of the low sulfentrazone rate, which provided poor pigweed control. Sulfentrazone followed by postemergence pyridate or metribuzin provided significantly better pigweed control. The poor foxtail control may have been due to cold, windy conditions at application time.

No-till chickpea, Williston 2002-04:

Preemergence herbicide treatments included sulfentrazone applied alone, sulfentrazone tank mixed with isoxaflutole or metribuzin, or sulfentrazone followed postemergence by pyridate or metribuzin (Tables 9-11). All PRE treatments were tank mixed with glyphosate at 0.375 lb ae. Clethodim was applied postemergence to control grasses.

Sulfentrazone applied alone or with isoxaflutole caused minimal chickpea injury at any rate in any year. Metribuzin applied PRE at 0.50 lb caused 53% visual chickpea injury in 2002, but caused less than 5% injury at 0.25 lb in 2003 or 2004. Chickpea injury from soil-applied metribuzin at 0.50 lb plus sulfentrazone in 2002 reduced chickpea yield approximately 300 lb/A compared to other treatments. Metribuzin applied POST caused moderate visible chickpea injury (15-19%) in all three years; however, chickpea yield was significantly reduced only in 2003. In 2004, there were no significant differences in yield between any of the herbicide treatments.

All herbicide treatments provided good to excellent control (>86%) of redroot pigweed, Russian thistle, kochia, and green foxtail in all three years.

Chickpea tolerance to fall- and spring-applied sulfentrazone (Minot 2002-03).

There was no visible chickpea injury with any treatment at any evaluation date (Table 12). This study and others have demonstrated that chickpeas have excellent tolerance to sulfentrazone.

Most herbicide treatments in this study provided good to excellent control of kochia, redroot pigweed, and wild buckwheat. Weed control with the low sulfentrazone rate (3 oz) applied in the fall began to falter late in the growing season. Weed control was best where pyridate was applied postemergence following sulfentrazone. Pyridate applied alone provided excellent kochia and pigweed control, but did not control wild buckwheat.

There was a significant difference in chickpea yield between herbicide treatments; however, treatment yields were affected by where the individual plots were located within each replication. Yields tended to be higher on the southern half of the study area, which remained more moist during the growing season. Therefore, we recommend that yield differences be disregarded.

Chickpea pre-harvest desiccation, Minot 2004 and Bozeman 2003.

At Minot, paraquat provided more chickpea desiccation within 3 DAT than other treatments (Table 14). Paraquat and glufosinate provided faster desiccation than glyphosate at 7-10 DAT. Glufosinate and glyphosate provided similar desiccation by 17-21 DAT. Carfentrazone, flumioxazin, and lactofen did not provide adequate desiccation within 17 DAT. There were no clear adverse effects on yield or seed quality from any treatment.

At Bozeman, paraquat provided faster desiccation by 3 DAT; however, by 14 DAT glufosinate and glyphosate provided similar or better desiccation (Table 15). Carfentrazone, flumioxazin, and lactofen provided less desiccation. There were no adverse effects on yield or seed quality from any treatment.

Paraquat was more consistent across locations and generally provided faster desiccation compared to other treatments. Given the faster desiccation and lower cost, paraquat would be considered the most cost-effective treatment for chickpea desiccation in this study (Table 13). Although glufosinate performed well, the current cost would be prohibitive (\$18.85). Paraquat and glyphosate are much less expensive (~\$7.00).

Table 1. Weed control in conventional-till chickpea (Minot 2002).

Treatment ^{ab}	Rate	Timing	Chickpea									
			Wibw ^e		Rrpw		Yeft		Injury		Stand Yield	
			Jun 15	Jul 10	Jun 15	Jul 10	Jun 15	Jul 10	Jun 15	Jul 10	Jun 28	Sep 3
	product/A		—————% control—————				—%—		pl/m ^f		lb/A	
Sulf	2.67 oz	PRE	70	47	63	28	60	78	3	0	7.9	1773
Sulf	4 oz	PRE	83	68	75	56	70	81	4	0	7.2	2080
Sulf	5.33 oz	PRE	87	81	81	65	75	89	4	1	6.6	2235
Isox + Sulf	1.5 oz + 4 oz	PRE	83	72	74	61	68	94	3	1	6.6	2014
Isox + Ethal	1.5 oz + 2 pt	PPI	89	82	97	98	97	100	5	1	7.5	2354
Sulf + Metri	4 oz + 0.5 lb	PRE	81	85	77	54	78	88	6	25	6.3	1832
Sulf + Ethal	4 oz + 2 pt	PPI	90	80	99	85	98	100	8	3	7.0	2456
Ethal + Metri	2 pt + 0.5 lb	PPI	93	80	100	96	99	100	15	24	5.5	2201
Ethal	2 pt	PPI	90	83	100	95	98	100	5	1	6.6	2423
Ethal / Pyridate	2 pt / 1.5 pt	PPI/POST	90	92	99	100	98	98	4	3	6.1	2313
Sulf / Pyridate	4 oz /1.5 pt	PRE/POST	83	94	80	98	73	85	4	1	6.7	2270
Sulf + Ethal/ Metri + Cleth	5.33 oz+2 pt/ 0.25 lb	PPI/ POST	90	92	95	98	97	98	6	20	6.6	2517
Sulf + Ethal/ Metri / Cleth ^c	5.33 oz+2 pt/ 0.25 lb	PPI/ POST / II	92	93	95	100	99	100	6	24	6.1	2388
Sulf/ Metri + Cleth ^c	4 oz/ 0.25 lb	PPI/ POSTII	78	84	73	94	71	91	3	31	5.5	2175
Handweeded check ^d			100	100	100	100	100	100	4	0	6.1	2341
LSD (0.05)			7	12	7	10	7	7	3	10	NS	309
CV			5	9	5	7	5	5	35	67	16.2	8

^aSulf = sulfentrazone, Isox = isoxaflutole, Ethal = ethalfluralin, Metri = metribuzin, Cleth = clethodim

^bClethodim + COC (5 fl oz + 1%) was applied POST to all treatments on June 14 unless noted otherwise.

^cClethodim + COC (5 fl oz + 1%) was applied POST II on June 20.

^dSulfentrazone + trifluralin followed by pyridate + clethodim + COC were applied to aid handweeding.

^eWibw = Wild buckwheat, Rrpw = Redroot pigweed, Yeft = Yellow foxtail.

^fpl/m = plants per meter of row.

Table 2. Weed control in conventional-till chickpea (Minot 2003 – Site 1).

Treatment ^{ab}	Rate	Timing	Kocz ^f		Rrpw		Biww		Dns ^g	Test Yield Wt	
			Jun 7	Jun 20	Jun 7	Jun 20	Jun 7	Jun 20	May 27	Aug 25	
	product/A		-----% control-----						pl/m	lb/A	lb/bu
Sulf	2.67 oz	PRE	99	98	93	87	97	94	6.6	3018	62.3
Sulf	4 oz	PRE	98	100	92	82	96	95	7.1	3130	61.4
Sulf	5.33 oz	PRE	100	100	100	100	100	100	6.3	2597	61.4
Isox + Sulf	2 oz + 4 oz	PRE	100	100	100	96	100	100	6.6	2959	62.4
Isox + Ethal	2 oz + 2 pt	PPI	99	96	100	97	100	100	5.6	2112	62.1
Sulf + Metri	4 oz + 0.33 lb	PRE	100	100	98	96	100	100	7.0	3199	61.4
Sulf + Ethal	4 oz + 2 pt	PPI	94	93	100	100	93	81	5.6	2521	60.9
Ethal + Metri	2 pt + 0.33 lb	PPI	90	86	99	96	100	96	5.8	2271	62.2
Ethal	2 pt	PPI	47	47	83	73	27	20	7.0	--- ^e	---
Ethal / Pyridate	2 pt / 1.5 pt	PPI	90	100	100	100	100	100	6.4	2309	60.8
Sulf / Pyridate	4 oz / 1.5 pt	PRE/ POST	100	100	100	100	100	100	7.2	2714	61.8
Sulf + Ethal/ Metri + Cleth	5.33 oz + 2 pt / 0.25 lb + 5 fl oz	PPI/ POST	97	100	100	100	100	100	6.2	2460	62.6
Sulf + Ethal/ Metri / Cleth ^c	5.33 oz + 2 pt / 0.25 lb / 5 fl oz	PPI/ POST / II	95	98	98	99	98	99	6.4	2731	62.7
Sulf/ Metri + Cleth ^c	4 oz / 0.25 lb + 5 fl oz	PPI/ POSTII	92	95	95	97	93	100	6.4	2359	61.7
Handweeded ^d			100	100	100	100	100	100	5.8	2656	61.8
Untreated			0	0	0	0	0	0	7.1	559	62.8
LSD (0.05)			9	11	13	20	8	7	1.1	1129	1.6
CV			6	8	8	13	5	5	10	29	1.6

^aSulf = sulfentrazone, Isox = isoxaflutole, Ethal = ethalfluralin, Metri = metribuzin, Cleth = clethodim

^bClethodim + COC (5 fl oz + 1%) was applied POST to all treatments on June 2 unless noted otherwise.

^cClethodim + COC (5 fl oz + 1%) was applied POST II on June 11.

^dSulfentrazone + trifluralin followed by pyridate + clethodim were applied to aid hand weeding.

^ePlot was not harvestable due to lack of weed control, primarily kochia.

^fKocz = Kochia, Rrpw = Redroot pigweed, Biww = Biennial wormwood.

^gDns = Chickpea density in plants per meter of row.

Table 3. Weed control in conventional-till chickpea (Minot 2003 – Site 2)

Treatment ^{ab}	Rate	Timing	Green foxtail	Common lambsquarters	Chickpea			
			Aug 20			Injury	Yield	Test Wt
			—% control —			—% —	lb/A	lb/bu
Sulf	2.67oz	PRE	95	95	0	1563	63.2	
Sulf	4 oz	PRE	99	83	0	1363	63.0	
Sulf	5.33 oz	PRE	99	95	0	1492	62.5	
Isox + Sulf	2 oz + 4 oz	PRE	100	100	0	1536	62.8	
Isox + Ethal	2 oz + 2 pt	PPI	100	100	0	1462	62.7	
Sulf + Metri	4 oz + 0.33 lb	PRE	96	100	2	1390	63.6	
Sulf + Ethal	4 oz + 2 pt	PPI	100	100	3	1503	63.2	
Ethal + Metri	2 pt + 0.33 lb	PPI	100	98	5	1111	63.1	
Ethal	2 pt	PPI	99	91	0	1250	63.0	
Ethal / Pyridate ^c	2 pt / 1.5 pt	PPI / POSTII	100	100	3	1477	62.9	
Sulf / Pyridate ^c	4 oz / 1.5 pt	PRE / POSTII	94	100	2	1566	62.7	
Sulf + Ethal/ Metri + Cleth ^c	5.33 oz + 2 pt/ 0.25 lb + 5 fl oz	PPI/ POST II	100	100	10	972	61.2	
Sulf + Ethal/ Cleth / Metri ^c	5.33 oz + 2 pt/ 5 fl oz / 0.25 lb	PPI/ POST / II	99	100	3	1165	62.8	
Sulf / Metri + Cleth	4 oz/ 0.25 lb + 5 fl oz	PPI/ POST	74	100	0	1324	63.1	
Handweeded ^d			100	100	1	1453	62.5	
Untreated			0	0	0	850	62.1	
LSD (0.05)			13	10	4	385	NS	
CV			9	7	146	17	1.2	

^aSulf = sulfentrazone, Isox = isoxaflutole, Ethal = ethalfluralin, Metri = metribuzin, Cleth = clethodim

^bClethodim + COC (5 fl oz + 1%) was applied POST to all treatments on June 9 unless noted otherwise.

^cClethodim + COC (5 fl oz + 1%) was applied POST II on June 24.

^dSulfentrazone + trifluralin followed by pyridate + clethodim were applied to aid hand weeding.

Table 4. Weed control in conventional-till chickpea (Minot 2004).

Treatment ^{ab}	Rate	Timing	Chickpea											
			Grft ^e		Rrpw		Wibw		Kocz	Injury		Dns ^f	Test Yield Wt	
			Jun 15	Aug 17	Jun 15	Aug 17	Jun 15	Aug 17	Aug 17	Jul 13	Aug 17	Jun 23	Oct 5	
	product/A		—% control—						—%—	m	lb/A	lb/bu		
Sulf	2.67 oz	PRE	67	45	98	88	100	87	100	0	0	4.3	754	58.6
Sulf	4 oz	PRE	87	66	100	98	100	95	100	0	0	4.0	746	58.4
Sulf	5.33 oz	PRE	90	58	100	96	100	96	100	0	0	4.0	718	58.4
Isox + Sulf	3 fl oz + 4 oz	PRE	93	72	100	95	100	92	100	0	0	3.6	755	58.4
Isox + Ethal	3 fl oz + 2 pt	PPI	93	93	95	81	73	62	90	0	0	3.5	608	57.8
Sulf + Metri	4 oz + 0.33 lb	PRE	83	68	97	95	94	87	98	14	10	3.9	1022	58.7
Sulf + Ethal	4 oz + 2 pt	PPI	93	92	93	85	93	83	95	0	0	4.0	612	58.4
Ethal + Metri	2 pt + 0.33 lb	PPI	92	89	83	57	77	50	63	21	18	2.9	498	58.0
Ethal	2 pt	PPI	89	95	86	63	62	47	53	0	0	3.8	645	57.8
Ethal / Pyridate	2 pt / 1.5 pt	PPI / POST	94	90	91	93	67	70	88	0	0	4.3	745	58.3
Sulf / Pyridate	4 oz / 1.5 pt	PRE / POST	82	47	70	98	99	93	100	0	0	4.2	743	58.7
Sulf + Ethal / Metri + Cleth	5.33oz + 2pt / 0.25 lb	PPI / POST	94	73	94	91	91	90	98	63	55	3.6	96	--- ^g
Sulf + Ethal / Metri / Cleth ^c	5.33oz + 2pt / 0.25 lb	PPI / POST / II	93	93	99	92	94	92	98	45	30	3.4	398	58.4
Sulf / Metri + Cleth ^c	4 oz / 0.167 lb	PPI / POSTII	77	48	92	94	98	94	97	61	47	4.9	286	---
Handweeded check ^d										0	0	3.8	733	58.6
Untreated			0	0	0	0	0	0	0	0	0	3.9	209	---
LSD (0.05)			7	15	22	15	20	16	7	11	8	0.9	267	NS
CV			5	13	15	11	14	13	5	50	45	13	27	0.8

^aSulf = sulfentrazone, Isox = isoxaflutole, Ethal = ethalfluralin, Metri = metribuzin, Cleth = clethodim

^bClethodim + COC (5 fl oz + 1%) was applied POST to all treatments on June 17 unless noted otherwise.

^cClethodim + COC (5 fl oz + 1%) was applied POST II on June 25.

^dSulfentrazone + trifluralin followed by pyridate + clethodim were applied to aid handweeding.

^eGrft = Green foxtail, Rrpw = Redroot pigweed, Wibw = Wild buckwheat, Kocz = Kochia.

^fDns = Chickpea plant density in plants per meter of row.

^gHarvest sample not large enough to determine test weight.

Table 5. Weed control in no-till chickpea (Minot 2002).

Treatment ^{ab}	Rate	Timing	Wild buckwheat		Yellow foxtail		Chickpea				
							Dns ^c	Injury		Yield	Test Wt
			Jun 14	Jul 29	Jun 14	Jul 29	Jun 28	Jun 14	Jul 29	Sep 3	Sep 3
	product/A		—% control —				pl/m	—% —		lb/A	lb/bu
Sulf	2.67 oz	PRE	42	58	40	83	6.6	1	0	1529	60.8
Sulf	4 oz	PRE	47	70	43	80	7.2	2	0	1524	61.3
Sulf	5.33 oz	PRE	60	70	63	82	7.0	5	0	1843	61.1
Sulf + Isox	4 oz + 1.5 oz	PRE	57	65	60	80	7.0	3	0	1464	60.5
Sulf + Metri	4 oz + 0.5 lb	PRE	58	67	55	73	7.0	7	0	1479	60.7
Sulf / Pyridate	4 oz / 1.5 pt	PRE/POST	43	83	50	78	6.3	2	0	1426	60.7
Sulf / Metri	4 oz / 0.25 lb	PRE/POST	48	70	53	52	5.8	2	0	1026	56.5
Handweeded ^d							6.8	4	0	1773	62.1
LSD (0.05)			20	19	NS	18	NS	2	NS	NS	4.1
CV			20	15	18	13	9	34	0	17	3.9

^aSulf = sulfentrazone, Isox = isoxaflutole, Metri = metribuzin, Cleth = clethodim

^bGlyphosate + AMS (0.375 lb ae + 1% w/w) was applied PRE to all treatments. Clethodim + COC (5 fl oz +1%) was applied POST to all treatments on June 14.

^cDns = Density in plants per meter of row.

^dGlyphosate + sulfentrazone followed by pyridate + clethodim were applied to aid in handweeding.

Table 6. Weed control in no-till chickpea (Minot 2003 – Site 1).

Treatment ^{ab}	Rate	Timing	Kochia		Redroot pigweed		Biennial wormwood		Chickpea		
									Dns	Yield	Test wt
			Jun 7	Jun 20	Jun 7	Jun 20	Jun 7	Jun 20	May 27	Aug 25	Aug 25
	product/A		—% control —						m ^d	lb/A	lb/bu
Sulf	2.67 oz	PRE	79	84	88	85	77	78	6.5	2309	61.0
Sulf	4 oz	PRE	94	96	95	96	92	81	6.0	2440	63.4
Sulf	5.33 oz	PRE	100	97	100	98	99	96	7.0	2669	63.3
Sulf + Isox	4 oz + 2 oz	PRE	100	100	100	99	100	100	6.8	2722	62.2
Sulf + Metri	4 oz + 0.33 lb	PRE	97	98	100	98	100	98	7.5	2633	62.7
Sulf / Pyridate	4 oz / 1.5 pt	PRE / POST	100	100	100	100	100	100	7.1	2696	62.5
Sulf / Metri	4 oz / 0.25 lb	PRE / POST	95	100	98	100	100	100	8.0	2438	62.7
Handweeded ^c			100	100	100	100	100	100	6.3	2638	62.2
Untreated			0	0	0	0	0	0	7.7	--	--
LSD (0.05)			6	5	7	4	4	3	1.2	NS	NS
CV			4	3	5	2	3	2	10	8	1.8

^aSulf = sulfentrazone, Isox = isoxaflutole, Metri = metribuzin, Cleth = clethodim

^bGlyphosate + AMS (0.375 lb ae + 1% w/w) was applied PRE to all treatments. Clethodim + COC (5 fl oz +1%) was applied POST to all treatments on June 2.

^cGlyphosate + sulfentrazone followed by pyridate + clethodim were applied to aid in handweeding.

^dDns = Chickpea density in plants per meter of row on May 27.

Table 7. Weed control in no-till chickpea (Minot 2003 – Site 2)

Treatment ^{ab}	Rate	Timing	Green foxtail		Injury	Yield	Test Wt
			20 Aug			25 Aug	
	product/A		% control		%	lb/A	lb/bu
Sulf	2.67 oz	PRE	100		0	2042	62.4
Sulf	4 oz	PRE	100		0	1793	62.8
Sulf	5.33 oz	PRE	100		0	2117	63.1
Sulf + Isox	4 oz + 2 oz	PRE	100		0	1876	63.0
Sulf + Metri	4 oz + 0.33 lb	PRE	100		1	2213	63.0
Sulf / Pyridate	4 oz / 1.5 pt	PRE / POST	94		0	1601	63.2
Sulf / Metri	4 oz / 0.25 lb	PRE / POST	93		2	1342	62.7
Untreated			0		0	1056	61.2
LSD (0.05)			0		0	618	NS
CV			6		NS	21	1.2

^aSulf = sulfentrazone, Isox = isoxaflutole, Metri = metribuzin, Cleth = clethodim

^bGlyphosate + AMS (0.375 lb ae + 1% w/w) was applied PRE to all treatments. Clethodim + COC (5 fl oz +1%) was applied POST to all treatments on June 24.

Table 8. Weed control in no-till chickpea (Minot 2004).

Treatment ^{ab}	Rate	Timing	Chickpea													
			Foxtail		Redroot pigweed		Wild buckwheat		Kochia		Dns	Inj	Yield	Test wt		
			Jun 15	Aug 17	Jun 15	Aug 17	Jun 15	Aug 17	Jun 15	Aug 17	Jun 23	Aug 17	Oct 5	Oct 5		
	product/A		% control										m ^c	%	lb/A	lb/bu
Sulf	2.67 oz	PRE	49	60	70	52	97	82	97	90	4.3	0	954	58.5		
Sulf	4 oz	PRE	58	60	93	78	100	89	98	98	4.1	0	936	58.0		
Sulf	5.33 oz	PRE	73	68	92	80	98	88	100	98	4.2	0	1123	57.4		
Sulf + Isox	4 oz + 3 fl oz	PRE	70	76	91	79	100	88	100	100	4.4	0	1161	57.6		
Sulf + Metri	4 oz + 0.33 lb	PRE	78	73	83	80	100	91	100	100	4.1	3	673	58.5		
Sulf / Pyridate	4 oz / 1.5 pt	PRE / POST	67	45	92	93	98	93	100	100	4.2	0	789	58.1		
Sulf / Metri	4 oz / 0.25 lb	PRE / POST	82	50	96	91	97	83	100	98	3.8	30	276	58.7		
Handweeded check ^d											3.5	0	1104	57.3		
Untreated			0	0	0	0	0	0	0	0	4.3	0	366	57.1		
LSD (0.05)			24	18	25	10	5	11	4	6	1.1	4	298	NS		
CV			23	19	18	8	3	8	2	4	16	52	21	1.3		

^aSulf = sulfentrazone, Isox = isoxaflutole, Metri = metribuzin, Cleth = clethodim

^bGlyphosate + AMS (0.375 lb ae + 1% w/w) was applied PRE to all treatments. Clethodim + COC (5 fl oz +1%) was applied POST to all treatments on June 17.

^cDns = Chickpea density in plants per meter of row on June 23.

^dGlyphosate + sulfentrazone followed by pyridate + clethodim were applied to aid in handweeding.

Table 9. Weed control in no-till chickpea (Williston 2002).

Treatment ^{ab}	Rate	Timing	Chickpea		Redroot pigweed		Green foxtail		Russian thistle		Yield	Test wt
			Jun 20	Jul 10	Jun 20	Jul 10	Jun 20	Jul 10	Jun 20	Jul 10	Sep 3	Sep 3
	product/A		% injury		% control						lb/A	lb/bu
Sulf	2.67 oz	PRE	1	0	92	100	74	100	97	100	1663	61.9
Sulf	4 oz	PRE	3	2	95	100	89	99	100	100	1902	62.0
Sulf	5.33 oz	PRE	4	4	96	100	91	100	100	100	1795	62.2
Sulf+Isox	4oz + 1.5oz	PRE	4	3	99	100	94	100	100	100	1751	62.4
Sulf + Metri	4 oz +0.5 lb	PRE	35	53	97	100	94	99	100	98	1405	60.9
Sulf / Pyridate	4 oz / 1.5 pt	PRE/POST	2	3	96	100	89	100	100	99	1724	62.0
Sulf / Metri	4 oz/0.16 lb	PRE/POST	2	15	97	100	88	100	100	100	1803	62.3
Pyridate	1.5 pt	POST	0	2	0	98	0	94	0	99	1692	62.4
Untreated			0	0	0	0	0	0	0	0	1082	61.3
LSD (0.05)			4	12	5	2	5	2	3	2	352	0.7
CV			36	73	4	2	4	1	2	1	12	0.7

^aSulf = sulfentrazone, Isox = isoxaflutole, Metri = metribuzin, Cleth = clethodim

^bClethodim was applied postemergence at 5 fl oz with COC at 1% v/v to all treatments on June 20.

Table 10. Weed control in no-till chickpea (Williston 2003).

Treatment ^{ab}	Rate	Timing	Chickpea	Kocz ^c	Ruth	Grft	Yield	TW
			July 10				Aug 26	
	product/A		% injury	% control			lb/A	lb/bu
Sulf	2.67 oz	PRE	0	89	86	95	1313	62.8
Sulf	4 oz	PRE	0	86	90	93	1353	62.0
Sulf	5.33 oz	PRE	0	89	93	98	1486	63.0
Sulf + Isox	4 oz + 2 oz	PRE	0	91	92	93	1414	62.1
Sulf + Metri	4 oz + 0.25 lb	PRE	5	86	90	95	1270	63.2
Sulf / Pyridate	4 oz / 1.5 pt	PRE / POST	0	95	97	94	1517	63.3
Sulf / Metri	4 oz / 0.16 lb	PRE / POST	18	93	93	92	1084	61.7
Untreated			0	0	0	0	88	54.0
LSD (0.05)			2	10	11	3	222	1.2
CV			35	7	8	2	11	1.1

^aSulf = sulfentrazone, Isox = isoxaflutole, Metri = metribuzin, Cleth = clethodim

^bGlyphosate was applied PRE at 0.375 lb ae with AMS at 2.5 gal/100 gal to all treatments. Clethodim was applied POST at 5 fl oz with COC at 1% v/v to all treatments on June 16.

^cKocz = Kochia, Ruth = Russian thistle, Grft = Green foxtail, Vwht = Volunteer wheat.

Table 11. Weed control in no-till chickpea (Williston 2004)

Treatment ^{ab}	Rate	Timing	Chickpea							
			Grft ^c	Ruth	Kocz	Dens ^d	Injury		Yield	TW
			Jun 30			Jun 2	Jun 6	Jun 30	Aug 26	Aug 26
	product/A		— % control —			pl/m	— % —		lb/A	lb/bu
Sulf	2.67 oz	PRE	98	100	100	6.7	0	0	1793	59.0
Sulf	4 oz	PRE	100	99	100	6.8	0	0	1878	59.4
Sulf	5.33 oz	PRE	100	98	100	6.5	3	0	1920	59.5
Sulf + Isox	4 oz + 3 fl oz	PRE	100	100	100	6.7	2	0	1736	60.4
Sulf + Metri	4 oz + 0.25 lb	PRE	99	99	100	6.7	0	0	1863	60.3
Sulf / Pyridate	4 oz / 1.5 pt	PRE / POST	100	100	100	6.2	0	0	2035	59.3
Sulf / Metri	4 oz / 0.16 lb	PRE / POST	100	97	100	6.5	0	19	1888	60.4
Untreated			0	0	0	7.4	0	0	925	59.1
LSD (0.05)			2	4	NS	NS	NS	1	321	NS
CV			1	3	0	11	248	17	10	2.6

^aSulf = sulfentrazone, Isox = isoxaflutole, Metri = metribuzin, Cleth = clethodim

^bGlyphosate at 0.375 lb ae plus AMS at 2.5 gal / 100 gal was applied PRE with all treatments. Clethodim + COC (5 fl oz + 1%) was applied POST to all treatments on June 14.

^cGrft = Green foxtail, Ruth = Russian thistle, Kocz = Kochia.

^dDens = Chickpea density, number of plants per meter of row.

Table 12. Chickpea tolerance to fall- and spring-applied sulfentrazone (Minot 2002-03).

Treatment ^{ab}	Rate	Timing	Kocz ^c			Rrpw			Wibw		Dns	Yield	TW	
			Jun 7	Jun 17	Jul 7	Jun 7	Jun 17	Jul 7	Jun 7	Jun 17	May 27	Aug 21		
	product/A		% control									m ^d	lb/A	lb/bu
Sulf	3 oz	Fall	93	81	81	93	83	81	97	84	6.3	2320	61.5	
Sulf	4 oz	Fall	99	97	93	100	87	87	95	90	6.1	2411	62.6	
Sulf	5.33 oz	Fall	99	98	99	100	95	94	100	96	7.2	2793	62.4	
Sulf / Pyridate	3 oz / 1.5 pt	Fall/POST	100	100	100	100	100	100	100	100	6.4	2406	62.6	
Sulf / Pyridate	4 oz / 1.5 pt	Fall/POST	100	100	100	100	100	99	99	100	6.6	2048	62.2	
Sulf / Pyridate	5.33oz/1.5 pt	Fall/POST	99	100	100	98	100	100	99	98	6.6	2846	62.4	
Sulf	3 oz	PRE	100	100	96	94	90	91	95	90	6.7	2528	62.5	
Sulf	4 oz	PRE	100	100	100	98	94	94	96	93	6.7	2302	62.4	
Sulf / Pyridate	3 oz / 1.5 pt	PRE/POST	100	100	100	98	98	100	92	92	6.8	2870	62.4	
Sulf / Pyridate	4 oz / 1.5 pt	PRE/POST	100	100	100	100	100	100	97	97	6.3	2777	62.9	
Pyridate	1.5 pt	POST	92	100	100	85	99	98	47	55	5.9	2263	62.5	
Untreated			0	0	0	0	0	0	0	0	6.5	808	61.9	
LSD (0.05)			7	7	9	9	8	6	8	13	NS	658	NS	
CV			4	5	6	6	5	4	6	9	11	16	0.9	

^aSulf = sulfentrazone

^bClethodim + COC (5 fl oz + 1%) was applied POST alone or with pyridate to all treatments to control grasses on June 2.

^cKocz = Kochia, Rrpw = Redroot pigweed, Wibw = Wild buckwheat.

^dDns = Chickpea density in plants per meter of row on May 27, 2003.

Table 13. Approximate costs for herbicides used in chickpea desiccation study.

Treatment*	Rate/A	Cost/A
Paraquat	0.5 lb ai	6.50
NIS	0.25% v/v	0.50
Carfentrazone	0.26 oz ai	5.00
COC	1% v/v	0.70
Glufosinate	0.44 lb ai	16.20
AMS	3 lb/A	2.65
Lactofen	0.195 lb ai	13.67
COC	1% v/v	0.70
Glyphosate	0.75 lb ae	5.70
AMS	8.5 lb/100 gal	0.75
Flumioxazin	0.765 oz ai	5.65
COC	1% v/v	0.70

*NIS - Preference at \$19.50/gal

*COC - Prime Oil at \$7.00/gal

*AMS - liquid at \$3.00/gal

Table 14. Percent desiccation after application in Minot, ND. 2004

Treatment*	Application Date	Product Rate/A	% Desiccation						
			2 DAT	3 DAT	7 DAT	10 DAT	13 DAT	17 DAT	21 DAT
Paraquat	31-Aug	0.5 lb ai		82	92			99	
Carfentrazone	31-Aug	0.26 oz ai		15	23			67	
Glufosinate	31-Aug	0.44 lb ai		50	82			99	
Lactofen	31-Aug	0.195 lb ai		20	33			77	
Glyphosate	31-Aug	0.75 lb ae		22	43			94	
Flumioxazin	31-Aug	0.765 oz ai		20	33			77	
<hr/>									
Paraquat	7-Sep	0.5 lb ai				88		99	
Carfentrazone	7-Sep	0.26 oz ai				27		76	
Glufosinate	7-Sep	0.44 lb ai				94		99	
Lactofen	7-Sep	0.195 lb ai				53		85	
Glyphosate	7-Sep	0.75 lb ae				58		96	
Flumioxazin	7-Sep	0.765 oz ai				47		82	
<hr/>									
Paraquat	15-Sep	0.5 lb ai	85				96		
Carfentrazone	15-Sep	0.26 oz ai	54				76		
Glufosinate	15-Sep	0.44 lb ai	55				97		
Lactofen	15-Sep	0.195 lb ai	42				77		
Glyphosate	15-Sep	0.75 lb ae	37				87		
Flumioxazin	15-Sep	0.765 oz ai	42				78		
LSD (P=.05)			21	8	8	21	8	21	8
C.V.			19	12	9	19	5	19	5

*Paraquat was applied with nonionic surfactant (NIS) at 0.25% v/v. Carfentrazone, lactofen, and flumioxazin were applied with crop oil concentrate (COC) at 1% v/v. Glufosinate and glyphosate were applied with ammonium sulfate (AMS) at 3 lb/A and 8.5 lb per 100 gallons of water, respectively.

Table 15. Percent desiccation after application in Bozeman, MT. 2003

Treatment*	Application Date	Product Rate/A	3 DAT	7 DAT	14 DAT
			% Desiccation		
Paraquat	12-Aug	0.5 lb ai	69	80	91
Carfentrazone	12-Aug	0.26 oz ai	15	20	67
Glufosinate	12-Aug	0.44 lb ai	39	79	96
Lactofen	12-Aug	0.195 lb ai	23	30	74
Glyphosate	12-Aug	0.75 lb ae	33	70	99
Flumioxazin	12-Aug	0.765 oz ai	43	68	88
Paraquat	18-Aug	0.5 lb ai	65	84	80
Carfentrazone	18-Aug	0.26 oz ai	16	76	79
Glufosinate	18-Aug	0.44 lb ai	39	93	94
Lactofen	18-Aug	0.195 lb ai	26	68	73
Glyphosate	18-Aug	0.75 lb ae	26	88	100
Flumioxazin	18-Aug	0.765 oz ai	48	81	74
Paraquat	25-Aug	0.5 lb ai	79	83	88
Carfentrazone	25-Aug	0.26 oz ai	62	66	68
Glufosinate	25-Aug	0.44 lb ai	63	81	95
Lactofen	25-Aug	0.195 lb ai	61	64	72
Glyphosate	25-Aug	0.75 lb ae	61	83	99
Flumioxazin	25-Aug	0.765 oz ai	73	76	80
LSD (P=.05)			11	11	10
C.V.			17	11	8

*Paraquat was applied with NIS at 0.25% v/v. Carfentrazone, lactofen, and flumioxazin were applied with COC at 1% v/v. Glufosinate and glyphosate were applied with AMS at 8.5 lb and 17 lb per 100 gallons of water, respectively.