QUACKGRASS MANAGEMENT IN FOUR CORN HYBRID TECHNOLOGIES

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Introduction

While quackgrass is probably less of a problem on most Wisconsin farms today than in the past, it is still a weed of concern. Excellent older herbicides (atrazine and glyphosate) and newer ones (ACCase inhibitors for use in soybeans and alfalfa and sulfonylureas for use in corn) have certainly contributed to reducing quackgrass abundance. While atrazine is no longer an effective quackgrass herbicide due to rate limitations, we have an array of options for quackgrass control in corn. And in recent years, corn breeders have used traditional and transgenic techniques to develop hybrids that tolerate new herbicides such as glufosinate and imidazilinones and the older one, glyphosate, which previously were not used postemergence in corn. An in-depth comparison of these new maize genetics technologies for quackgrass control is needed.

Growers hopefully practice crop and herbicide rotation to enhance yields and minimize the risk of weed shifts and herbicide resistance problems. We need to know if the maize technologies and herbicides available to control quackgrass differ. Does it matter which hybrid technology or herbicide a grower starts with? Will one or more technology or herbicide be better than another in the long term? Which scenario is the most economical? The objectives of this study were to assess various herbicide treatments for quackgrass control when Liberty Link, Roundup Ready, ClearField and conventional corn hybrids in rotation with soybeans and hybrid technology for a five-year period.

Methods

A five-year study was initiated at the Arlington Agricultural Research Station by planting corn into an alfalfa-quackgrass sod in 1999. Crops then rotated between corn and soybean through 2003. After tilling the site with a heavy duty tandem disk and a field cultivator on May 3, corn was planted on May 4, 1999. No tillage was done after planting in 1999. Subsequent corn planting dates were May 2, 2001 and April 29, 2003. The hybrids used are listed in Table 1. Corn rows were 30-inches apart. Plots were six rows wide (15 feet) by 25 feet and treatments were replicated three times. Plots were six rows wide for two reasons: to be able to harvest uninjured rows from the center of the plot area in the event of herbicide drift and to ensure that the long-term observations were not biased by quack-grass invading from adjacent plots which would confound the results. To further minimize the risk of herbicide drift onto sensitive hybrids, those with the same genetics were planted in blocks.

Table 1. Corn hybrids used in the long-term quackgrass trial in 1999, 2001 and 2003.

Year	Liberty Link	Roundup Ready	ClearField	Conventional
1999	Croplan N42 42BT	DeKalb 493RR	Pioneer 37J 99	DeKalb 493
2001	Pioneer 35P 17	DeKalb 493RR	Pioneer 37M 38	DeKalb 507
2003	Pioneer 37H 26	DeKalb 493RR	Pioneer 37J 99	Pioneer 37H 26

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To minimize annual weed interference, soil active herbicides were applied preemergence after planting in 1999 and with the burndown herbicide in 2001 and 2003. The corn hybrids were rotated in 2001 so that neither the same hybrid technology nor herbicide modes of action were used consecutively. In 2003, the hybrid technology returned to the same plots as in 1999. (See Tables 3 and 6 for the sequence of hybrid rotation.) The trial site received a preplant broadcast application of 34-0-0 at 300 lb/acre and 200 lb/acre of starter (6-24-24) each year corn was planted. Soybeans received no fertilizer. No insecticides were applied in any year. Two center rows of corn were harvested mechanically and the moisture content of each hybrid measured. Yields were converted to a standard moisture content of 15.5%.

In 2000 and 2002, soybeans were planted without tillage in 7-inch rows to the entire plot area. Paraquat and soil residual herbicides with no quackgrass activity were applied one or two days before planting soybean. No postemergence herbicides were used when soybeans were grown. Soybean yield was not determined.

Herbicide rates and spray tank adjuvants used are given in Table 2. More treatments were applied than listed in Table 2 as some were split or delayed applications (see Tables 3 and 6 for a complete list of treatments applied each year). All treatments were applied in 20 gal/acre of water with flat fan nozzle tips when quackgrass was at the appropriate growth stage (almost always 6- to 10-inch tall quackgrass). A check treatment was included for each of the corn hybrid technologies. While the corn genetics in 2003 were planted in the same plots as in 1999, the herbicide treatments were not necessarily in the same plots as the first year.

Table 2. Herbicide rates and additives used in corn for the long-term quackgrass study.

Herbicide	Rate (product/acre)	Additive
Liberty	28 and 34 oz	ams
Liberty + atrazine	28 oz + 1.11 lb	ams
Roundup Ultra	32 oz	ams
Lightning	.056 oz	ams, mso
Beacon	.75 oz	ams, mso
Accent	.667 oz	ams, mso
Beacon + Accent	.375 + .33 oz	ams, mso
NorthStar + Accent	2.5 + .33 oz	ams, mso
Basis Gold	14 oz	
Basis Gold + Accent	14 + .25 oz	ams, mso
Accent Gold + Accent	2.9 + .25 oz	ams, mso

Quackgrass control was monitored routinely during the season of application and the level of infestation (called pressure) was assessed each October and the following spring. The fall and spring assessments of quackgrass pressure were remarkably similar, thus only the fall data are presented. Quackgrass pressure is a measure of its abundance and health; it incorporates the area covered with an assessment of quackgrass density, height and vigor. A quackgrass pressure of 100% would be a solid stand of healthy, tall, vigorous quackgrass. In relative terms, quackgrass pressure less than 5% would be very light, 6 to 10% would be light, 10 to 20% would be moderately light; 21 to 40%

would be moderate, 41 to 60% would be serious, 61 to 80% would be high and above 80% would be severe. Producers would consider levels of 6 to 10% or more of economic concern in the long term (bioeconomic threshold) and levels of 20% or more of immediate concern (economic threshold).

Observations

Quackgrass control. The quackgrass pressure ratings for October 1999 to 2003 are presented in Table 3. In 1999, quackgrass control was excellent for all treatments in the Roundup Ready, ClearField and conventional hybrids but not in the Liberty Link hybrid treated once with glufosinate, which averaged 39% quackgrass pressure at the October evaluation. (Control ratings are not presented but correlate very well with the end-of-season pressure data in Table 3.) Control from the imidazolinones and most of the sulfonylurea herbicides was noticeably slower than that of glyphosate and glufosinate.

Soybeans were planted in 2000 and only Liberty plus atrazine in postemergence followed by Liberty in late postemergence maintained excellent quackgrass suppression in the Liberty Link system. Quackgrass suppression continued to be excellent and similar for all treatments in the Roundup Ready, ClearField and conventional maize hybrids even though no quackgrass herbicides were applied in 2000. Quackgrass pressure in October 2000 was generally less than 5% for all treatments within these systems and was 45 to 65% for the check treatments. Thus, narrow row soybean in a no-till system with a contact burndown herbicide maintained quackgrass at relatively low levels.

In 2001, all treatments applied in 1999 except Liberty alone and NorthStar continued giving excellent quackgrass control through the end of June. These treatments were retreated in 2001, along with one of the check treatments in each maize technology. Adding Accent at 0.33 oz/a to Liberty resulted in 93% control 30 days later and only 1% pressure in October. Quackgrass control from Touchdown gave only fair control by the end of June and had 12% pressure in the fall.

As observed in 2000, soybeans planted in 7-inch rows in 2002, combined with the effect of a burndown application of paraquat and a hot, dry summer, kept quackgrass levels of infestation constant for most treatments from the fall of 2001, into June and October of 2002. Quackgrass pressure increased in 2002 following a split application of Liberty + atrazine, Beacon, and Accent Gold in 1999. For all other treatments applied in 1999 and not retreated in 2001, quackgrass suppression continued the fall of 2002.

All ALS inhibiting herbicides applied in 2003 gave excellent quackgrass suppression (less than 5% quackgrass pressure in October) except Beacon, NorthStar, and Accent Gold. In 2003, the weakness of glufosinate as a quackgrass herbicide continued to be evident. The treatments of Liberty plus atrazine in 2003 failed to reduce quackgrass pressure at the end of the season below 10%.

In general, quackgrass control with glyphosate was excellent when applied in Roundup Ready corn in 1999 as no retreatment was needed in 2001. However, all 1999 glyphosate treatments needed additional glyphosate in 2003. Glyphosate applied in 2001 to a 1999 check plot also required retreatment in 2003. Perhaps this is due to not reducing the water volume to the recommended 10 gal/acre when applying 0.75 lb ae/acre and to the fact that after 1999, the site was not tilled (higher rates of glyphosate are recommended in no-till systems). Glyphosate applied in 2003 gave excellent quackgrass suppression into October that year.

Table 3. Quackgrass pressure in October 1999 to 2003 in a long-term quackgrass management trial in a no-till corn and soybean rotation system.

Tmt[1]	Corn genetics[2]		Quackgrass herbicide[3]			Quackgrass pressure in October				
	1999/ 2003	2001	1999	2001	2003	1999	2000	2001	2002	2003
						----------%----------				
1	LL	CV	Liberty/Liberty	Accent	none	25	24	1	3	25
2	LL	CV	Liberty + Atrz/ Liberty + Atrz	none none	Liberty + Atrz/ Liberty + Atrz	2	3	5	11	12
3	LL	CV	Liberty + Atrz	Accent	none	44	35	1	3	10
4	LL	CV	Lib	Beacon	none	47	45	1	2	12
5	LL	CV	Check	NorthStar	Liberty + Atrz	72	53	1	2	9
6	LL	CV	Check	Check	Check	85	63	53	57	83
7	RR	CV	Rndup	none	Rndup	0	4	9	13	1
8	RR	CV	Rndup	none	Rndup	0	2	3	4	0
9	RR	CV	Rndup	none	Touchdown	0	6	7	5	0
10	RR	CV	Rndup	none	Rndup	0	2	6	12	1
11	RR	CV	Check	Acnt+Beac	none	85	63	0	1	3
12	RR	CV	Check	Check	Check	82	65	63	67	84
13	CF	RR	Lightning	none	Lightning	0	1	4	5	2
14	CF	RR	Lightning	none	Option	0	1	5	7	0
15	CF	RR	Lightning	none	Steadfast	0	1	6	9	0
16	CF	RR	Lightning	none	none	0	0	3	3	1
17	CF	RR	Check	Touchdown	Accent	85	69	12	13	1
18	CF	RR	Check	Check	Check	80	57	52	55	77
19	CV	CF	Beacon	none	Beacon	1	2	9	16	8
20	CV	LL & CF	Accent	none	none	0	1	2	3	8
21	CV	CF	Beac+Acnt	none	none	0	0	2	1	5
22	CV	LL & CF	Beac+Acnt	none	none	0	1	0	0	3
23	CV	LL & CF	NorthStar	mixed[4]	NorthStar	1	8	[4]	20	7
24	CV	LL & CF	NthStar+Acnt	none	none	0	1	1	0	1
25	CV	LL & CF	NthStar+Acnt	none	none	0	1	2	4	7
26	CV	LL & CF	BasisGd+Acnt	none	BasisGold	1	3	5	8	3
27	CV	LL	AcntGd+Acnt	none	AccentGold	2	2	6	11	14
28	CV	LL & CF	BasisGd	none	none	1	1	3	3	9
29	CV	LL	Check	Lib + Accent	none	83	43	1	2	8
30	CV	LL & CF	Check	Check	Check	80	64	45	40	67
		average quackgrass pressure for only the check treatments				82	62	53	50	78
LSD (10%)						14	15	9	12	15

[1] All Liberty and Roundup treatments applied with 2.5 lb/acre AMS. All imi and sulfonylurea treatments applied with 1.0% MSO and 2.5 lb/acre AMS.

[2] Genetic codes: LL = Liberty Link; CV = conventional; RR = Roundup Ready; CF = ClearField

[3] Herbicide codes: Rndup= Roundup Ultra; AG= Accent Gold; BasGd= Basis Gold; Touchdn = Touchdown; none = not needed; NthStar = NorthStar; Atrz = atrazine; Beac = Beacon; Acnt = Accent

[4] Treatment 23 received specific herbicides 2001because a mixture of hybrid technologies was planted across the three plots in this treatment. Plot 123 (ClearField hybrid) received Lightning (96% control in June; 0% pressure in Oct; plot 206 (Liberty Link hybrid) received Liberty (30% control in June; 22% pressure in Oct.); plot 308 (ClearField hybrid) did not need treating (18% pressure in June; 20% pressure in Oct.)

Quackgrass retreatment. In 2001, treatments that averaged 10% or greater quackgrass pressure the previous fall were treated with an effective quackgrass herbicide with a different mode of action from the one used in 1999. Of the 22 treatments applied in 1999 (eight check treatments were included the first year), only four required retreatment in 2001. Three of these followed a single Liberty application in 1999 and the other followed NorthStar (Table 5).

In 2003, treatments that averaged 5% or greater quackgrass pressure the previous October were treated. We lowered the treatment threshold compared to the 2001 treatments because allowing a 10% level of quackgrass pressure to go untreated may result in a rapid increase in quackgrass abundance.

A total of 14 treatments exceeded the 5% threshold and were retreated in 2003. This means that 12 treatments were below the 5% threshold and were not sprayed in 2003. It is particularly noteworthy that a single application of seven of the 1999 treatments had less than 5% quackgrass pressure in Oct. 2002 (the threshold to trigger treatment in 2003) (Table 3). The long-term effectiveness of sulfonylurea treatments in a conventional hybrid that included nicosulfuron was impressive.

When treatments of the sulfonylurea herbicides Accent, Accent + Beacon, NorthStar + Accent, and Basis Gold were applied in 1999, retreatment was not needed in 2001 nor 2003. Thus, the sulfonylurea herbicides applied in a conventional hybrid suppressed quackgrass longer than glyphosate in a Roundup Ready hybrid and longer than Lightning applied to a ClearField hybrid. Two sulfonylurea herbicides were less effective than others: Beacon and NorthStar applied in 1999 required retreatment in 2003.

Corn yield. Corn yields for all treatments are presented in Table 6. Because there were 30 treatments and three years of corn yield data, summaries of the yield data are discussed based on averages tabulated in Tables 4 and 5. The average yield of corn treated with effective quackgrass herbicides within each hybrid technology tested and the check treatments are given in Table 4. The percentage yield reduction due to quackgrass competition in the check treatments within each type of hybrid over the three years is presented in Table 5. These data were derived by calculating the average corn yield for each set of quackgrass treatments with a single corn hybrid technology and comparing this value to the yield of the check treatment within the same genetic group.

Table 4. Corn yields in 1999, 2001 and 2003 averaged over all quackgrass treatments within a hybrid genetics group. Yield of check treatment within a technology of corn genetics given in parentheses.

Hybrid technology	1999	2001	2003	mean for hybrid tech.
	----------bu/acre----------			
Liberty Link	169 (104)	204 (181)	185 (58)	186 (120)
Roundup Ready	175 (110)	165 (102)	159 (32)	166 (77)
ClearField	165 (135)	200 (181)	186 (87)	183 (139)
Conventional	166 (117)	201 (144)	172 (64)	180 (113)
mean for year	169 (117)	192 (152)	176 (60)	179 (112)

All hybrids yielded similarly in 1999. However, in 2001 and 2003, the Roundup Ready hybrid yielded less than the other three because the yield of the RR hybrid decreased over time. This is not a hybrid trial and perhaps this particular RR hybrid is not well adapted to the conditions of this location. Also, we used the same RR hybrid all three years due to seed availability while different hybrids were used for the other hybrid technologies. Genetic improvements likely are reflected in the yields of the Liberty Link, ClearField and conventional hybrids.

Table 5. Percentage corn yield losses in 1999, 2001 and 2003 due to quackgrass interference within each hybrid technology group.

Hybrid technology	1999	2001	2003	mean
	(% loss compared to treated plots within a technology)			
Liberty Link	38	11	69	39
Roundup Ready	37	38	80	52
ClearField	18	10	53	27
Conventional	30	27	63	40
mean	31	22	66	40

Uncontrolled quackgrass seriously affected corn yields. However, yields would have been lower yet had we not used tillage to prepare a seedbed in 1999 and paraquat as a burndown treatment in 2001 and 2003 to kill quackgrass vegetation prior to planting. In previous trials where neither tillage nor a burndown herbicide were used, yield losses of 80 to 90% have occurred.

The average yield loss in the untreated treatments over all hybrids and years was 40%. Yield losses were greatest in 2003 (66%) due to the very dry conditions in July and August. The uncontrolled quackgrass consumed significant quantities of water earlier in the season. In treatments where quackgrass was controlled in 2003, yields were higher this year than in previous years. The early planting date in 2003 (earlier pollination date) and lack of tillage (moisture conservation) certainly contributed to this phenomenon.

Interestingly the ClearField hybrid suffered the least from quackgrass and annual weed competition in 1999 and 2003 and was equal to the Liberty Link hybrid in 2001. Overall the ClearField technology was the least affected by quackgrass competition and the Roundup Ready was the most affected. Whether this is a repeatable observation or not remains to be seen.

Conclusions

We have many excellent tools to control quackgrass in corn, even in a continual no-tillage system. Also apparent is the fact that when quackgrass is effectively controlled in corn, no quackgrass herbicides are needed in the soybean phase of the rotation. Producers need not adopt transgenic crops to control quackgrass as both yield and performance of conventional and ClearField hybrids were equal to the Liberty Link and superior to the Roundup Ready hybrid. In fact, glufosinate is not the technology of choice if quackgrass is a significant problem. This is consistent with previous research and to be expected as it is a contact herbicide while all the others tested are systemic, reach the rhizomes and give long term control. The longest duration of quackgrass suppression occurred with treatments containing nicosulfuron (except when applied with Basis Gold or Accent Gold).

Was there an advantage of one technology over another and does it matter which technology is

used first? Yes, it would be best to control quackgrass in a conventional, ClearField or Roundup Ready hybrid first and then rotate to a Liberty Link hybrid.

Was rotating hybrid technology advantageous? We cannot prove this one way or another as the trial did not include a rotation variable (hybrids were rotated but we did not have the continuous use of the same hybrid technology as a point of comparison and analysis). Nevertheless, common sense tells us hybrid technology rotation is a wise practice as it helps ensure the rotation of herbicide modes of action as well.

Was there an advantage of rotating modes of action? No, because the control from a single application was sufficient to last until the next time the same technology was used 4 years later. Of course, a different hybrid technology could be used the fourth or later years to allow a rotation of herbicide mode of action. Producers can use the same decision making process we used: assess the abundance and vigor of quackgrass in the fall after soybean harvest and determine the appropriate hybrid and management program accordingly.

The economics of each hybrid technology and associated herbicides are not assessed here. However, it yields of conventional hybrids continue to match those of transgenic hybrids, it seems that the most economical system may well be a conventional or ClearField hybrid treated with an effective ALS inhibiting herbicide. This will also help reduce the consecutive year use of a glyphosate based technology.

The reality is that quackgrass control in a corn-soybean rotation is seldom an issue because 80% of our soybeans are Roundup Ready varieties and any quackgrass present in these fields will be easily controlled along with the annual weeds treated with standard glyphosate rates. Quackgrass remains a weed of concern in alfalfa rotations. Most producers who know quackgrass is present in older hay fields apply glyphosate the fall prior to planting corn the next season. This ensures adequate quackgrass control for at least one year of corn production. If corn will be grown for two seasons before reseeding alfalfa, producers should consider a conventional, ClearField or Roundup Ready hybrid and use the appropriate herbicide to obtain a nearly quackgrass free environment to then plant alfalfa.

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Table 6. Corn yields in 1999, 2001 and 2003 in a long-term quackgrass management trial in a no-till corn and soybean rotation system.

	Corn genetics[2]							
Tmt[1]	1999	2001	Quackgrass herbicide[3]			Corn yields		
	& 2003		1999	2001	2003	1999	2001	2003
						----------bu/acre-------		
1	LL	CV	Liberty/Liberty	Accent	none	184	191	162
2	LL	CV	Liberty + Atrz/ Liberty + Atrz	none none	Liberty + Atrz/ Liberty + Atrz	174	196	190
3	LL	CV	Liberty + Atrz	Accent	none	166	196	189
4	LL	CV	Lib	Beacon	none	151	173	161
5	LL	CV	Check	NorthStar	Lib + Atrz	123	170	225
6	LL	CV	Check	Check	Check	86	157	58
7	RR	CV	Rndup	none	Rndup	186	222	153
8	RR	CV	Rndup	none	Rndup	170	224	177
9	RR	CV	Rndup	none	Touchdown	181	213	153
10	RR	CV	Rndup	none	Rndup	162	202	163
11	RR	CV	Check	Acnt+Beac	none	96	188	149
12	RR	CV	Check	Check	Check	124	130	32
13	CF	RR	Lightning	none	Lightning	163	167	200
14	CF	RR	Lightning	none	Option	192	169	191
15	CF	RR	Lightning	none	Steadfast	152	171	191
16	CF	RR	Lightning	none	none	154	169	179
17	CF	RR	Check	Touchdown	Accent	150	149	172
18	CF	RR	Check	Check	Check	120	102	87
19	CV	CF	Beacon	none	Beacon	168	197	139
20	CV	LL & CF	Accent	none	none	181	188	176
21	CV	CF	Beac+Acnt	none	none	142	202	189
22	CV	LL & CF	Beac+Acnt	none	none	168	197	180
23	CV	LL & CF	NorthStar	mixed[4]	NorthStar	150	171	143
24	CV	LL & CF	NthStar+Acnt	none	none	179	201	177
25	CV	LL & CF	NthStar+Acnt	none	none	163	200	168
26	CV	LL & CF	BasisGd+Acnt	none	BasisGold	172	212	188
27	CV	LL	AcntGd+Acnt	none	AccentGold	158	204	204
28	CV	LL & CF	BasisGd	none	none	178	212	169
29	CV	LL	Check	Lib + Accent	none	131	204	157
30	CV	LL & CF	Check	Check	Check	102	181	64
LSD (10%)						39	34	38

[1] All Liberty and Roundup treatments applied with 2.5 lb/acre AMS. All imi and sulfonylurea treatments applied with 1.0% MSO and 2.5 lb/acre AMS.

[2] Genetic codes: LL = Liberty Link; CV = conventional; RR = Roundup Ready; CF = ClearField

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