INTERACTION OF CROP PROTECTANTS WITH POTATO NITROGEN MANAGEMENT

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Nitrogen is an essential nutrient for potatoes. In addition to affecting crop yield and quality, appropriate nitrogen management can significantly influence overall crop health and responses to other management. Mismanagement of this element can result in decreased yields, groundwater contamination, and financial loss to producers. Maximizing nitrogen use efficiency is, therefore, an important component of profitability in potato production as well as limiting groundwater contamination. This study specifically examined two aspects of potato nitrogen management intended to improve the fertilizer nitrogen use efficiency in combination with fumigation and/or fungicide treatment. The specific experiments were (1) Evaluation of the interaction of fumigation on potato N source and rate responses; and (2) Evaluation of Quadris on optimal N rate and timing.

Soil fumigation is frequently used to control soil pathogens (i.e., *Verticillium*) in Wisconsin potato fields. Furthermore, although ammoniacal nitrogen sources may reduce N leaching potential on sandy soils, studies where ammonium was the only N form available to the plant, and was kept as ammonium with a nitrification inhibitor, have shown negative impacts on yield and grade. Since fumigation may also impact the soil microorganisms (nitrifying bacteria) responsible for the conversion of ammonium to nitrate, selection of N source for fumigated fields may be an important management decision. It is also likely that the effects of fumigation on nitrifying bacteria within a potato field may be different if the field is fall versus spring fumigated. Although most Wisconsin potato fields are fumigated in the fall, some continue to be done in the spring. Therefore, from 1998 to 2000, we evaluated several rates of N with and without fumigation, all applied as ammonium sulfate to see if a high rate resulted in some yield or quality problems. The second portion of this fumigation interaction trial compared a less-than-optimum rate of N (120 lb N/acre) when applied as several N sources (ammonium sulfate, urea, or ammonium nitrate).

The availability of new crop protectant materials such as Quadris, along with fumigation, has the capability to maintain vigorous vine growth much longer in the season, especially with late or indeterminate varieties such as Russet Burbank. This has caused growers to ask if they should be altering their nitrogen management program to try to capture this late-season growth or perhaps use less N to allow the plants to naturally senesce before harvest. Similarly, they have also asked if they need to be making a later N application to take advantage of the stronger late-season growth. From an environmental perspective, questions regarding the plants' ability to transfer N to the tuber and the amounts of N at harvest in various parts of the crop have also been asked. Therefore in 2000 and 2001, we attempted to determine if the use of weekly sprays of Quadris alternated with Bravo for 6 weeks, compared to Bravo alone, results in a need for a higher or lower optimum N rate, and to determine if including Quadris in the weekly spray program changes the optimum timings for N applications including if a late-season application is warranted.

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METHODS AND MATERIALS

Fumigation Experiment:

From 1998 to 2000, experiments were conducted on a new set of plots each year at the Hancock, WI, Agricultural Research Station. The soil is very sandy (Plainfield loamy sand) and irrigated by overhead sprinklers. Plots for these experiments were laid out in a split plot design in randomized complete blocks. Fumigation treatments were main plots and N treatment the splits within each main plot. Fall fumigation was not included in 1998, but in the other 2 years the fumigant was applied in both fall and spring. Both spring and fall fumigations were applied with and without the addition of Agmor's NEB-26 feeding stimulant. This material has labeled ingredients of 13.34% carbohydrates and lesser amounts of minerals, proteins, and fats. It claims to improve the yield and vigor of plants by helping plants utilize nutrients, stimulating microbial populations, giving relief from stress, and serving as a food source for mycorrhizae.

The measurements made from this experiment included potato tuber yield, grade-out, size grades, yield of prime-sized tubers, and hydrometer readings (specific gravity) for all plots. Soil samples were taken to 1 foot prior to the second N application and 2 and 4 weeks following the second N application and measured for NO_3-N. Nitrogen analysis of the harvested tubers was conducted and uptake calculated. Petiole NO_3-N samples were taken every 2 weeks starting at hilling + 2 weeks for three or four samplings to monitor crop N status. Early season plant measurements such as tuber set, early season growth, and early season whole plant analysis were also done. Disease evaluations were conducted by D. Rouse, Plant Pathology, University of Wisconsin-Madison.

The data from the fumigation experiment were analyzed as two separate experiments, namely a fumigant^5 x N rate^4 study with ammonium sulfate as the N source, and a fumigant^5 x N source^3 experiment using a rate of N that is believed to be at or slightly below the critical application for Russet Norkotah (the variety of potatoes used in this experiment), namely 120 lb N/acre.

Fungicide x Fumigation Experiment:

In 2000, we initiated a new experiment to determine if the use of weekly sprays of Quadris alternated with Bravo results in a higher or lower optimum N rate than when Bravo only is used, and to determine if including Quadris in the weekly spray program changes the optimum timings for N applications including if a late-season application is warranted. An identical experiment was conducted on a new plot area in 2001.

Data for the Quadris experiment were also analyzed as two separate trials, namely a fumigation^2 x fungicide application^2 x N rate^4 split-split plot with fumigation as the main plot and fungicide treatment as the first split and N rate as the second split. The second experiment is also analyzed as a split-split plot (fumigation^2 x fungicide application^2 x N rate^2 x N time^3) in randomized complete blocks with N rate and timing randomized in the last split. The fumigation treatment was replicated twice, but all other treatments were replicated four times with Russet Burbank the variety used. Fungicide treatment included Quadris alternated weekly with Bravo for the first 6 weeks versus Bravo alone. Nitrogen rates ranged from 160 to 280 lb N/acre and N timings split two, three, or four times.

All nitrogen treatments were hand-applied (banded for the emergence and hilling treatments and broadcast for the later treatments) as $(NH_4)_2SO_4$ for the first application and NH_4NO_3 for all subsequent applications.

Measurements included periodic disease evaluations by W. Stevenson (Plant Pathology, UW-Madison) and staff. Yield, grade-out, size grade, hollow heart, and tuber dry matter were determined for all plots. Potato petioles (25 per plot) were taken at 7- to 10-day intervals, starting at 50 days after emergence to monitor the crop N status for three samplings. The harvested tubers were analyzed for N content and uptake calculated. At this time, petiole NO_3-N data are only available for the work done in 2000.

RESULTS AND DISCUSSION

Fumigation Experiment:

Although early-season plant evaluation (plant height and weight, stem number, tuber weight and number) were conducted, in none of the 3 years of this experiment did spring or fall fumigation affect results, nor was there ever a significant N rate or source by fumigation interaction (data not shown). Although N rate had a significant effect on early-season growth, the effect of fumigation was much less apparent. There is some tendency for fall fumigation to increase vegetative dry weight, but differences in other parameters were not detected. In general, the major N rate effect for these early-season evaluations was seen at the highest rate of N above the control, and in some years, N addition tended to reduce tuber number. There was also no consistent effect of N source on early-season plant growth. Considering that fumigation did not seemingly interact (especially with the ammonium N sources), these results suggest growers can let other factors determine which N source they will use.

Table 1 shows the average yield and tuber quality results for the 3 years of the N rate component of the study. Since the trends (statistically significant increases due to fumigation in 2 of 3 years and N rate in all 3 years, and there were no significant fumigation x N rate interaction), were similar for all 3 years, these are presented as averages across the study time. Furthermore, since the addition of NEB26 had no impact on yield or quality in any of the years, data are averaged across these treatments. The tuber yield and quality results show that fumigation was very important, with absolute yields increased by over 100 cwt/acre where fumigant was used with adequate nitrogen. No clear advantage was shown by fall versus spring fumigation treatments. As expected, most tuber parameters were also significantly increased by N additions and responses were generally seen to the highest rate of N applied. These data appear to indicate that the fumigation and N responses are independent of each other, with the magnitude of the N response from the 0 to high N rate about the same with and without fumigation. If problems were to surface, they might be expected in this situation. Statistically this observation is supported by the general lack of significance in the interaction terms.

The disease severity ratings conducted by D. Rouse (UW-Plant Pathology) confirm the additive effects of these two types of treatment. As shown in Table 2, the end-of-season ratings in both 1998 and 1999 decreased with fumigation and with increasing N rate. Furthermore, the magnitude of the improvements associated with increasing N rate was about the same (about 30 percentage points decrease in disease severity) irrespective of fumigation treatment, but the starting point was much higher when the land was not fumigated. In 2000, however, significantly more disease pressure was present and although fumigation had a major effect of reducing disease, adding N fertilizer appeared to exacerbate the problem. Others have also generally observed results similar to our findings in 1998 and 1999 that N tends to reduce the expression of *Verticillium* symptoms. We have no insights as to why the anomalous results in 2000.

The influence of fumigation and N rate on petiole NO_3-N levels and tuber N content is shown in Table 3. As expected, N rate clearly increased these parameters, but fumigation did not seem to impact tissue N content. This is somewhat of a surprise since we might have expected some tissue N dilution with the much higher yields associated with fumigation.

Nitrogen source had no obvious influence on harvested tubers in any of the years (Table 4). It would be difficult from these data to argue that ammonium sulfate would cause a problem when used with spring or fall fumigation. These data are particularly significant for the spring fumigation because this treatment was only applied 2 to 3 weeks before planting, and it means that even in this extreme situation, there is little added risk associated with using ammonium N fertilizers in combination with fumigation. The sometimes observed trend for larger tuber size when all ammoniacal N sources are used did not hold true in this trial.

The application of N as ammonium sulfate resulted in slightly higher soil NH_4-N and lower soil NO_3-N levels in the 0- to 12-inch soil layer (Table 5). Fumigation, however, did not seem to have an effect, nor did it impact levels of N within the plant (data not shown). We, therefore, concur with others that the choice of N fertilizer should be based on factors (i.e., soil characteristics, convenience, cost, leaching potential) other than inclusion of fumigant in the crop management program.

Fungicide x Fumigation Experiment:

The interaction of fungicide program with fumigation treatment and their effect on optimum N rate for 2000 and 2001 as assessed by tuber yield and quality is shown in Table 6. Since the results from both years are similar, they are averaged over the 2 years. It is clear from these data that not fumigating prior to raising the crop severely repressed the crop responses to both fungicide treatment and N rate and that fumigating increased yields by over 130 cwt/acre. On average, the use of Quadris resulted in a 20 cwt/acre gain; however, where fumigation was applied, yields of the Bravo alone versus the Quadris/Bravo treatments were about 43 cwt/acre lower (420 versus 463 cwt/acre). We also saw N responses to a higher N rate (280 lb N/acre versus 200 lb N/acre) where fumigation was used. This was likely due to the higher yield potential associated with the fumigation.

The fungicide by N rate interaction by itself is not significant, but the fumigation x fungicide x N rate term is significant. This is likely an additional reflection that the yield benefit from

N and early blight treatment (Quadris) can only be expressed when other yield-limiting factors such as verticillium are controlled by fumigation.

Table 6 also shows that fumigation and N rate increased the percent U.S. No. 1 tubers harvested, mostly by reducing the proportion of small B-sized tubers. These were the same factors that affected the sizing of the U.S. No. 1 tubers. Yield of prime-sized tubers was similarly affected, but there was a distinct trend for more response where fumigation was applied. It is interesting to note that fumigation significantly increased tuber dry matter and that N rate did not decrease this parameter. The former is perhaps due to diluting out the excess N with the added yield.

Table 7 shows the results of the disease evaluations conducted in late July of 2000 and 2001. As expected, these evaluations show an advantage to including Quadris against early blight (9.4 vs. 4.4% averaged over the 2 years) and against verticillium when the area was fumigated (47 versus 10% when rated in 2001). Unlike other studies, this study did not show a benefit to increasing N rate on decreasing verticillium symptoms.

The N rate applied distinctly affected the amount of nitrate-N in the petioles for all three sampling dates and there are some tendencies that both fumigation and fungicide treatment interacted with N rate, especially for the later two samplings (data not shown). Where fumigation was not used, N levels tended to be higher especially at the higher rates of application. This is likely due to the poor tuber growth on these plots, pulling less N into these storage organs. Interestingly, the use of Quadris appears to result in a greater distinction in petiole NO_3-N levels between N rates. These trends will need to be confirmed by the 2001 data.

The interaction of fumigation, fungicide treatment, two N rates, and various N timings on tuber yield and quality are shown in Table 8. The nitrogen timings used were: (1) one-third at emergence and two-thirds at tuberization; (2) one-third at emergence, one-half at tuberization, one-sixth at tuberization plus 20 days; and (3) one-third at emergence, one-third at tuberization, and one-sixth each at tuberization plus 20 and 40 days. Averaged over the 2 years, timing did not appear to affect tuber yield (Table 8), but in 2000, the two split system was clearly superior. This is consistent with some of our previous work, which shows that extra splitting of N in a non-leaching year actually hurts yield and/or quality. As shown in Table 8, where fumigant is used, irrespective of fungicide treatment, along with the high rate of N, excessive splitting tended to decrease yield by 30 to 40 cwt/acre. Furthermore, averaged over the 2 years, the extra splitting decreased percent U.S. No. 1, increased percent U.S. No. 2 tubers, and decreased the percentage larger-sized tubers. The problem appears to be somewhat more evident for the four-way split. Where Quadris is not used, there is a tendency for a decrease in tuber solids with more splitting of the supplemental N applications, but where Quadris was included splitting had no effect on solids or tended to show an increase.

The dramatic effects of fumigation, fungicide treatment, and N rate were also seen in this trial. Where other management is optimized, the use of Quadris continues to provide an extra 40 to 50 cwt/acre. Nitrogen timing did not influence disease evaluation in either of the years of the study (data not shown). The interactive effects of N timing and the other treatment variables on 2000 season petiole NO_3-N levels and average tuber N content for

2000 and 2001 showed that the splitting resulted in more petiole NO_3-N late in the season and more tuber N (data not shown). In both years, the date of the last N application for the four-split treatment was between the first and second petiole samplings. The higher yields associated with fumigation decreased tuber N content on the fumigated plots. A somewhat similar trend was seen for the fungicide treatments for some of the petiole samplings.

SUMMARY

Results from these experiments confirm some practices that growers have generally been following, such as marked yield improvements associated with fumigation and the inclusion of Quadris in the fungicide program, and the need for somewhat more N associated with these higher yield potentials. In addition, even when the fumigant is spring applied, there did not appear to be any problems associated with using an all-ammoniacal N source. Both N and fumigation are effective in reducing early-dying symptoms, but the benefits from each practice are seemingly independent, since increasing N rate reduced disease severity about 30% both in the fumigated and non-fumigated environments. These data continue to suggest that applying most of the supplemental N by hilling may be an advantage even in these relatively disease-free environments.

Table 1. Interaction of fumigation and N rate on potato yield and quality at Hancock, WI, 1998 through 2000. †

Fumigant	N rate‡	Total yield	U.S. No1	U.S. No 1 >6 oz.	Tuber dry matter
	lb/acre	cwt/acre	%		
None	0	224	58.8	15.6	18.3
	60	305	66.8	31.0	18.2
	120	317	65.3	35.2	18.4
	180	331	70.2	39.4	17.3
Fall	0	304	67.9	30.1	17.7
	60	331	71.3	35.7	17.8
	120	397	75.4	49.8	17.4
	180	413	75.0	52.2	17.4
Spring	0	288	65.1	36.8	18.1
	60	375	71.3	50.4	18.4
	120	392	75.5	49.9	17.7
	180	438	72.7	60.3	17.9
Statistical significance (Pr > F, selected factors)					
Fumigant (F)		0.01	0.18	0.05	0.28
N rate (N)		<0.01	<0.01	<0.01	0.16
F x N		0.50	0.43	0.31	0.11

† Data are 3-year averages.

‡ All N as $(NH_4)_2SO_4$ split one-third at emergence and two-thirds at tuberization.

Table 2. Effect of fumigation and N rate on early dying disease evaluations at the last sampling date each year, Hancock, WI, 1998 through 2000.

Fumigant	N rate	*Verticillium* severity †		
		31 July 1998	17 August 1999	11 August 2000
	lb/acre	%		
None	0	80.0	78.7	94.7
	60	70.0	61.2	94.7
	120	57.5	60.0	97.2
	180	56.2	48.7	96.0
Fall	0	--	68.7	40.0
	60	--	67.5	57.7
	120	--	52.4	53.1
	180	--	32.5	50.6
Spring	0	55.0	66.8	48.2
	60	44.2	62.5	54.9
	120	31.7	52.5	71.1
	180	31.2	30.6	63.7
Statistical significance (Pr > F, selected factors)				
Fumigant (F)		0.03	0.37	<0.01
N rate (N)		0.01	<0.01	<0.01
F x N		0.87	0.59	0.48

† Ratings based on Horsfall-Barratt severity rating system.

Table 3. Effect of fumigation and N rate on petiole NO_3-N and tuber N concentrations, Hancock, WI, 1998 through 2000. †

Fumigant	N rate	Petiole nitrate-N 5-7 July	Petiole nitrate-N 27-28 July	Tuber N
	lb/acre	%	%	%
None	0	0.20	0.23	1.38
	60	0.36	0.18	1.56
	120	0.94	0.48	1.62
	180	1.52	0.81	1.86
Fall	0	0.16	0.23	1.24
	60	0.45	0.13	1.45
	120	0.91	0.32	1.50
	180	1.50	0.86	1.61
Spring	0	0.11	0.17	1.41
	60	0.39	0.25	1.43
	120	0.99	0.62	1.54
	180	1.56	0.90	1.73
Statistical significance (Pr > F, selected factors)				
Fumigant (F)		0.63	0.46	0.11
N rate (N)		<0.01	<0.01	<0.01
F x N		0.68	0.38	0.44

† Data are 3-year averages.

Table 4. Interaction of fumigation and N source on potato tuber yield and quality at Hancock, WI, 1998 through 2000. †

Fumigant	N source‡	Total yield	U.S. No.1	U.S. No. 1 >6 oz.	Dry matter
		cwt/acre	------------------ %		--------------------
None	AS	317	65.3	35.0	18.4
	Urea	332	71.1	35.9	18.1
	AN	317	67.9	35.4	18.1
Fall	AS	392	71.0	50.4	17.7
	Urea	418	73.3	48.6	17.9
	AN	424	73.9	46.7	17.9
Spring	AS	395	74.7	50.2	17.5
	Urea	401	75.3	50.6	17.8
	AN	407	73.4	50.8	17.8
Statistical significance (Pr > F, selected factors)					
Fumigant (F)		<0.01	0.07	0.08	0.17
N source (S)		0.47	0.39	0.55	0.33
F x S		0.30	0.57	0.64	0.38

† Data are 3-year averages.

‡ AS, ammonium sulfate; AN, ammonium nitrate. All N sources applied at 120 lb N/acre split
between emergence and tuberization.

Table 5. Effect of fumigation and N source on soil NH_4-N and NO_3-N levels (0 to 12 inches) for the mid-June soil sampling, Hancock, WI, 1998 through 2000. †

Fumigant	N source‡	Soil NH_4-N	Soil NO_3-N
		------------------- ppm	----------------
None	AS	16.1	8.2
	Urea	8.3	16.5
	AN	14.0	18.6
Fall	AS	15.2	6.7
	Urea	14.1	15.0
	AN	14.0	21.3
Spring	AS	16.2	10.0
	Urea	15.3	18.3
	AN	12.0	16.3
Statistical significance (Pr > F, selected factors)			
Fumigant (F)		0.23	0.57
N source (S)		0.01	<0.01
F x S		0.21	0.42

† Data are 3-year averages.

‡ AS, ammonium sulfate; AN, ammonium nitrate. All N sources applied at 120 lb N/ acre split between emergence and tuberization.

Table 6. Effect of fumigant, fungicide, and nitrogen rate on Russet Burbank yield and quality combining 2 years of data at Hancock, WI, 2000 and 2001.

Fumi-gation	Fungi-cide†	N rate	Total yield	Grade			Size grade (oz		Yield U.S. No. 1(oz)			Tuber dry matter	Hollow heart
				A	B	Cull	< 6	6-10	> 10	6-10	6-13		
		lb/acre	cwt/acre	---	---	---	% ---	---	---	-----cwt/acre----		%	%
—	B	160	268	51	38	11	73	26	1	34	36	18.4	0.0
—	B	200	342	56	29	15	60	35	4	68	76	18.1	1.7
—	B	240	324	56	27	17	66	29	4	58	64	18.5	0.0
—	B	280	313	54	32	15	66	31	3	55	61	18.4	0.0
—	B+Q	160	296	51	38	11	77	20	3	30	34	18.9	0.0
—	B+Q	200	314	57	30	14	68	29	3	62	66	18.7	0.0
—	B+Q	240	297	54	34	12	61	35	4	58	63	18.5	0.0
—	B+Q	280	312	51	33	16	66	32	2	50	54	17.9	1.8
+	B	160	408	59	24	17	71	26	3	65	72	19.2	0.0
+	B	200	393	56	25	18	66	29	4	71	79	19.2	0.0
+	B	240	436	60	24	16	66	29	5	78	91	19.2	0.0
+	B	280	445	56	23	21	58	36	7	92	106	19.1	0.0
+	B+Q	160	427	56	25	19	77	20	2	49	54	19.4	0.0
+	B+Q	200	466	60	21	18	62	31	7	87	102	19.5	3.3
+	B+Q	240	479	62	19	19	58	34	7	105	122	19.5	1.7
+	B+Q	280	482	61	21	19	55	36	8	109	127	19.4	0.0
Statistically significant factors ($p \leq 0.05$)			Fm Fg N Fm x Fg Fm x N Fm x Fg x N	Fm N	N Fm x N		N	N	Fm N	Fm N	Fm N	Fm	

† All plots received 500 lb/acre 6-24-24 starter fertilizer in 2000 and 600 lb/acre 6-10-30 in 2001; B=Bravo only, B+Q= Bravo alternated with Quadris for the first six fungicide sprays.

‡ Fm, fumigation; Fg, fungicide; N, N rate.

Table 7. Effect of fumigant, fungicide, and nitrogen rate on Russet Burbank disease severity at Hancock, WI, 2000 and 2001.

			Disease severity†		
			2000	2001	
			Early blight	Early blight	*Verticillium*
Fumigation	Fungicide‡	N rate	27 July	31 July	31 July
		lb/acre	------------------------- % --------------------- -------		
–	B	160	3.2	23.4	53.1
–	B	200	3.8	23.4	48.8
–	B	240	3.8	13.5	22.3
–	B	280	2.3	17.0	61.7
–	B+Q	160	2.3	7.6	41.2
–	B+Q	200	2.1	7.6	60.9
–	B+Q	240	1.5	10.5	31.8
–	B+Q	280	2.6	8.2	53.1
+	B	160	2.9	7.6	14.1
+	B	200	2.3	2.9	7.3
+	B	240	2.6	9.1	16.4
+	B	280	1.8	19.4	7.6
+	B+Q	160	2.0	6.4	16.4
+	B+Q	200	0.6	6.4	6.7
+	B+Q	240	1.1	3.8	6.4
+	B+Q	280	1.8	5.9	3.8
Statistically significant factors ($p \leq 0.05$)			Fg §	Fg	Fm

† Disease severity ratings based on Horsfall-Barratt index of 0-11.

‡ B=Bravo only, B+Q=Bravo alternated with Quadris for the first six fungicide sprays.

§ Fg, fungicide; Fm, fumigation.

Table 8. Effect of fumigant, fungicide, nitrogen rate and timing of nitrogen application on Russet Burbank yield quality, combining 2 years of data at Hancock, WI, 2000 and 2001. †

Fumigation	Fungicide‡	N rate	N timing	Total yield	Grade A	Grade B	Grade C	Size grade (oz) < 6	Size grade (oz) 6-10	Size grade (oz) > 10	U.S. No. 1A (oz) 6-10	U.S. No. 1A (oz) 6-13	Dry matter	Hollow heart
		lb/acre		cwt/acre	%						cwt/acre		%	
–	B	160	2X	288	50	37	12	77	21	2	36	37	18.7	0.0
–	B	160	3X	268	51	38	11	73	26	1	34	36	18.4	0.0
–	B	160	4X	277	49	39	12	77	20	3	31	34	18.5	0.0
–	B	240	2X	304	53	31	15	65	31	4	62	68	18.7	0.0
–	B	240	3X	324	56	27	17	67	29	4	58	64	18.5	0.0
–	B	240	4X	283	49	35	16	71	28	1	40	41	18.0	0.0
–	B+Q	160	2X	303	52	34	14	69	28	3	42	46	18.4	0.0
–	B+Q	160	3X	296	51	38	11	77	20	3	30	34	18.9	0.0
–	B+Q	160	4X	301	53	36	12	75	24	1	42	44	18.9	0.0
–	B+Q	240	2X	284	51	31	18	61	34	5	55	63	17.9	1.7
–	B+Q	240	3X	297	54	34	13	61	35	4	58	63	18.5	0.0
–	B+Q	240	4X	290	50	34	16	65	31	4	45	51	18.4	0.0
+	B	160	2X	419	57	24	19	69	25	6	61	74	19.1	0.0
+	B	160	3X	408	59	24	17	71	26	3	65	72	19.2	0.0
+	B	160	4X	393	55	27	18	73	25	2	54	56	19.0	0.0
+	B	240	2X	461	60	22	18	61	33	6	94	108	19.2	0.0
+	B	240	3X	436	60	24	16	66	29	5	78	91	19.2	0.0
+	B	240	4X	437	59	23	18	63	33	4	87	96	18.8	0.0
+	B+Q	160	2X	427	61	24	15	65	29	6	79	87	19.3	0.0
+	B+Q	160	3X	427	56	25	19	77	20	2	49	54	19.4	0.0
+	B+Q	160	4X	445	57	25	17	67	26	7	71	86	19.6	0.0
+	B+Q	240	2X	508	59	19	22	55	34	11	104	131	19.5	1.7
+	B+Q	240	3X	479	62	19	19	58	34	7	105	122	19.5	1.7
+	B+Q	240	4X	469	57	24	19	62	31	6	87	100	19.4	0.0
Statistically significant factors ($p \leq 0.05$):				Fm § Fg N FmxN	Fm N T	N T FmxFgxN	N	N	N	Fg N T FmxFgxNxT	Fm N T FmxN FgxNxT	Fm N T Fm x N	Fg x T	Fg x N

† All plots received 500 lb/acre 6-24-24 starter fertilizer in 2000 and 600 lb/acre 5-10-30 in 2001.
‡ B=Bravo only, B+Q=Bravo alternated with Quadris for the first six fungicide sprays. § N, N rate; T, N timing; Fg, fungicide; Fm, fumigation.