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[Lutte au chiendent (*Elytrigia repens*) dans les cultures de pomme de terre (*Solanum tuberosum*) avec le cléthodime]

Jerry A. Ivany et J. Brian Sanderson

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Résumé de l'article

Les producteurs de pommes de terre ont besoin d'un moyen efficace de lutte au chiendent (*Elytrigia repens*) pour obtenir des rendements maximaux. Nous avons étudié l'efficacité du cléthodime en en examinant les effets sur plusieurs paramètres de croissance du chiendent et nous avons comparé le cléthodime à d'autres herbicides. La destruction des parties aériennes du chiendent avec le cléthodime appliqué au stade cinq feuilles a été moindre qu'au stade trois feuilles pour tous les taux d'application. Pour les deux stades d'application, la repousse des tiges et la production de rhizomes se sont produites avec des taux d'application de 0,075 à 0,150 kg m.a. ha^{-1}, mais dans une mesure beaucoup moindre au taux plus élevé de 0,240 kg m.a. ha^{-1}. La répression n'a pas été affectée par la longueur des rhizomes avec une destruction égale des parties aériennes et des réductions équivalentes de repousse et de poids des rhizomes, obtenus de plantes produites à partir de morceaux de rhizome contenant deux ou dix noeuds, pour des taux de 0,120 kg m.a. ha^{-1} ou plus. L'enlèvement des tiges de chiendent 6 heures après le traitement a occasionné une repousse et un poids de rhizomes plus importants à tous les taux d'application, mais cette réponse a été graduellement atténuée avec l'augmentation du taux d'application. L'enlèvement des tiges de chiendent 24 ou 96 heures après le traitement n'a pas eu d'effet négatif sur la réduction de la croissance du chiendent, ce qui indique qu'il y a une translocation rapide du cléthodime en conditions de serre. Sur le terrain, le cléthodime a réprimé à plus de 80 % le chiendent au stade trois à quatre feuilles avec un taux de 0,150 kg m.a. ha^{-1} lorsque combiné au sulfate d'ammonium.

Quackgrass (*Elytrigia repens*) control in potatoes (*Solanum tuberosum*) with clethodim

Jerry A. Ivany and J. Brian Sanderson[1]

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Potato growers require effective control of quackgrass (*Elytrigia repens*) so as to obtain maximum yield. We examined the effect of different quackgrass growth parameters on effectiveness of clethodim and compared clethodim to selected herbicides. Reduction of the initial top growth of quackgrass with clethodim applied at the five-leaf stage was less than at the three-leaf stage at all rates of application. Shoot regrowth and rhizome production occurred at rates of application from 0.075 to 0.150 kg a.i. ha^{-1} but only to a very minor level at the highest rate of 0.240 kg a.i. ha^{-1} at either stage of application. Control was not affected by rhizome length with equal reduction in initial growth, regrowth, and rhizome weight obtained on plants grown from two-node and ten-node rhizome pieces at rates of 0.120 kg a.i. ha^{-1} or higher. Removal of quackgrass shoots 6 hours after treatment resulted in increased regrowth and rhizome weight at all application rates but the response was progressively overcome by increasing the rate of application. The removal of quackgrass shoots 24 or 96 hours after treatment had no adverse effect on reduction in quackgrass growth indicating rapid clethodim translocation in the greenhouse. In the field, clethodim provided greater than 80% control of quackgrass at the three to four-leaf stage with 0.150 kg a.i. ha^{-1} when used in combination with ammonium sulphate.

[Lutte au chiendent (*Elytrigia repens*) dans les cultures de pomme de terre (*Solanum tuberosum*) avec le cléthodime]

Les producteurs de pommes de terre ont besoin d'un moyen efficace de lutte au chiendent (*Elytrigia repens*) pour obtenir des rendements maximaux. Nous avons étudié l'efficacité du cléthodime en en examinant les effets sur plusieurs paramètres de croissance du chiendent et nous avons comparé le cléthodime à d'autres herbicides. La destruction des parties aériennes du chiendent avec le cléthodime appliqué au stade cinq feuilles a été moindre qu'au stade trois feuilles pour tous les taux d'application. Pour les deux stades d'application, la repousse des tiges et la production de rhizomes se sont produites avec des taux d'application de 0,075 à 0,150 kg m.a. ha^{-1}, mais dans une mesure beaucoup moindre au taux plus élevé de 0,240 kg m.a. ha^{-1}. La répression n'a pas été affectée par la longueur des rhizomes avec une destruction égale des parties aériennes et des réductions équivalentes de repousse et de poids des rhizomes, obtenus de plantes produites à partir de morceaux de rhizome contenant deux ou dix

1. Crops and Livestock Research Centre, Agriculture and Agri-Food Canada, 440 University Avenue, Charlottetown, Prince Edward Island, Canada C1A 4N6; e-mail: IvanyJ@agr.gc.ca

noeuds, pour des taux de 0,120 kg m.a. ha^{-1} ou plus. L'enlèvement des tiges de chiendent 6 heures après le traitement a occasionné une repousse et un poids de rhizomes plus importants à tous les taux d'application, mais cette réponse a été graduellement atténuée avec l'augmentation du taux d'application. L'enlèvement des tiges de chiendent 24 ou 96 heures après le traitement n'a pas eu d'effet négatif sur la réduction de la croissance du chiendent, ce qui indique qu'il y a une translocation rapide du cléthodime en conditions de serre. Sur le terrain, le cléthodime a réprimé à plus de 80 % le chiendent au stade trois à quatre feuilles avec un taux de 0,150 kg m.a. ha^{-1} lorsque combiné au sulfate d'ammonium.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a major crop throughout the world with 44,000 ha produced each yr in Prince Edward Island (P.E.I) alone for processing use, table use, and for seed. Quackgrass [*Elytrigia repens* L. (Nevski)] is a problem perennial weed which is highly competitive with potatoes (Baziramakenga and Leroux 1998; Ivany 1986) when it infests fields at levels which require control measures to be applied. Sethoxydim and fluazifop-p-butyl give control of quackgrass in potatoes on P.E.I. when applied post-emergence to the weed and crop (Ivany 1984, 1988); however, control with sethoxydim has sometimes been less than desired and often not season-long. Fluazifop-p-butyl generally gives better control of quackgrass than sethoxydim under P.E.I. conditions. Conflicting results have been found in western Canada with fluazifop-p-butyl providing better control in one study (Harker and O'Sullivan 1993) and comparable control in a second study (Harker 1995a). Studies in France found that a single high rate of application of clethodim to quackgrass, 10 to 25 cm tall, gave control comparable to fluazifop-p-butyl (Szilvasi 1995). Excellent control of quackgrass has been reported with clethodim at rates of application of 0.18 to 0.24 kg a.i. ha^{-1} when applied with an oil concentrate and potatoes are reported to be highly tolerant (Kincade *et al.* 1987). A search of the literature found no other published papers on response of potatoes to clethodim.

Clethodim has been reported to give better control of rhizome johnsongrass (*Sorghum halepense* L.) than sethoxydim and comparable control to fluazifop-p-butyl in soybeans (*Glycine max* (L.) Merr.) (Johnson and Frans 1991; Jordan *et al.* 1997). Clethodim gave greater than 90% control of rhizome johnsongrass when applied at 70 g a.i. ha^{-1} at the 3 to 4-leaf stage and higher rates increased control only slightly when applied up to the 8-leaf stage (Rosales-Robles *et al.* 1999).

Potato growers require safe and effective herbicides to control quackgrass and growers need to know how long after herbicide application they must wait before cultivating or killing the crop so as to not negatively affect quackgrass control. The objectives of this research were to determine the effect of quackgrass leaf stage at application, rhizome size from which shoots emerged, and speed of uptake of clethodim by quackgrass. Field studies were conducted to determine the effect of an addition of ammonium sulfate on clethodim and to compare clethodim to other herbicides.

MATERIALS AND METHODS

Greenhouse

In the greenhouse, three experiments were conducted to determine the response of quackgrass to clethodim ((E,E)-(±)-2-[1-[[3-chloro-2-propanyl)oxy]imino]propyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one) as affected by: (a) leaf stage at application; (b) rhizome size from which plants grew; and (c) effect of shoot removal after treatment.

Plastic pails 18 cm tall by 21.5 cm in diam, with holes pre-punched for drainage, were used in all experiments and were filled with greenhouse soil mix (equal parts of soil/sand/peat moss with pH adjusted to 6.0) and planted with 10 quackgrass rhizome sections each with two nodes, except in the rhizome size experiment. The pails were maintained in a greenhouse at 26°C day temperature and 20°C night temperature under a 12 h day length.

The leaf stage at application experiment was designed as a five by two factorial with five rates of clethodim application of 0, 0.075, 0.120, 0.150 and 0.240 kg a.i. ha^{-1} and two leaf stages of 3-leaf and 5-leaf emerged at application. The rhizome size experiment was designed as a five by two factorial with the five rates of clethodim as above and two rhizome sizes of two and ten nodes in length. The clethodim was applied at the 3-leaf stage of quackgrass. The shoot removal experiment was designed as a five by four factorial with the five rates of clethodim as above and four shoot removal treatments of: not removed, removed 6, 24 or 96 h after treatment. The experiment was designed to determine the rate of translocation of clethodim from treated shoots. Shoots of quackgrass were removed at the times indicated by cutting at the soil surface. All treatments with clethodim contained a petroleum oil concentrate (Assist) (83% paraffin base mineral oil and 17% surfactant blends; BASF Canada Inc., Toronto, Ontario, M9W 6N9) at 1.0% by volume of spray solution when the quackgrass had three leaves in the rhizome size and shoot removal experiments.

Herbicide treatments were applied using a moving belt sprayer applying 620 L ha^{-1} using a flat-fan type spray tip at 275 kPa. In all experiments, green shoots per pot were harvested and dry weight determined at 45 to 50 d after treatment. Pots were retained for regrowth determination and, 30 to 40 d after the first harvest, the experiments were terminated and dry weights of regrowth green living shoots and rhizome pieces per pot were determined. Rhizome pieces which were severely discoloured or obviously dead were not included in the rhizome weight per pot.

Field

In the field, experiments were conducted to determine the effect of the addition of ammonium sulphate on the activity of clethodim at several rates of application applied with petroleum oil concentrate and to compare it to sethoxydim (2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one) and fluazifop-p-butyl ((R)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid) for control of quackgrass.

All field experiments were conducted on fine, sandy loam soil which had a natural quackgrass infestation of 25 to 100 shoots per square meter. In all yr, Russet Burbank cv potatoes were planted at 45 cm spacing in the rows and rows were spaced 0.9 m apart. Treatments were replicated four times in a randomized complete block design, and plots consisted of one row six m long with a shared guard row on each side. Fertilizer was banded at planting at a rate of 130, 57 and 109 kg ha^{-1} of N (nitrogen), P (phosphorus), and K (potassium), respectively. Metribuzin [(4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one)] was applied at 0.42 kg a.i. ha^{-1} as a pre-emergence treatment to control broadleaf weeds. With the exception of the clethodim and other herbicide treatments, cultural practices were the same as those recommended for commercial production. Clethodim was applied with a tractor mounted, CO_2 sprayer which delivered a spray volume of 300 L ha^{-1} and at a pressure of 275 kPa using a 8003 flat-fan type spray tip. Treatments of clethodim were applied with an oil concentrate (same as in greenhouse experiments) at 1.0% by volume of spray solution with the herbicides applied at the 3 to 4-leaf stage of quackgrass growth. The level of quackgrass control was visually rated on a linear scale of 0 to 100 where 0 = no control and 100 = complete kill between 20 and 28 July in both yr of the study. Because of the differences in control between yr, yearly analysis of the data was conducted and presented. At maturity, the whole plot row was harvested using a one-row mechanical harvester to obtain potato tuber yield.

Statistical Analysis

All greenhouse experiments were a factorial combination of treatments with four replications and repeated twice over time. Each set of experiments was checked for the assumptions of ANOVA, and data from the repetitions were combined and subjected to a factorial analysis of variance. First, a contrast was developed to test the control versus the mean of clethodim application rates. Next, a regression analysis was used to evaluate the response to rates of clethodim over the range of 0.075 to 0.240 kg a.i. ha^{-1}. In experiment three, the removal times were separated in three orthogonal contrasts: C1: 6h removal versus mean of rest; C2: no removal vs mean of 24 and 96 h removals; and C3: 24 vs 96 h removal. The no removal time was considered as infinite time in this combination of contrasts. The data from the field experiments were analyzed by ANOVA techniques as a randomized complete block design with four replications, each yr being presented separately.

RESULTS AND DISCUSSION

Greenhouse

Clethodim applied with crop oil concentrate significantly reduced quackgrass initial top growth, regrowth and rhizome weight when averaged over stages of application (Table 1, Contrast C). Application of clethodim at the 5-leaf stage was less effective than application at the 3-leaf stage in reducing initial top growth. Regrowth and rhizome weight were not influenced by stage of application. Quackgrass initial top growth, regrowth and rhizome weight decreased linearly with rates of application from 0.075 to 0.240 kg a.i. ha^{-1} (Table 1, Contrast L), with no interaction with stage of application.

The size of the rhizome from which quackgrass shoots arose had no effect on quackgrass initial top growth, regrowth and rhizome weight (Table 2). Clethodim applied with crop oil concentrate significantly reduced quackgrass initial top growth, regrowth and rhizome weight when averaged over stages of application (Table 2, Contrast C). Quackgrass initial top growth, regrowth and rhizome weight decreased

Table 1. Effect of clethodim rate of application when applied at different leaf stages on dry weight of quackgrass initial shoot growth, shoot regrowth and rhizome in the greenhouse, combined over two runs

Rate applied[a] (kg a.i. ha^{-1})	Initial growth[b] (g/pot)	Shoot regrowth[c] (g/pot)	Rhizomes[c] (g/pot)
0.0	37.2	14.1	38.0
0.075	20.5	9.6	10.4
0.120	12.8	8.2	4.5
0.150	11.0	7.2	5.2
0.240	5.0	0.2	0.3
SEM[d]	1.95	1.09	1.26
Significant contrasts[e]	C, L	C, L	C, L
Leaf stage			
3	7.7	7.0	4.4
5	17.0	5.6	5.8
SEM	1.38	0.77	0.89
Significance	**	ns	ns

[a] All treatments contained petroleum oil as an adjuvant at a rate of 1.0% (v:v) of spray solution.
[b] Harvested 45 to 50 days after treatment with clethodim.
[c] Harvested 30 to 40 days after first harvest.
[d] SEM, standard error of mean with 0 rate excluded from analysis.
[e] C: 0 rate versus mean of applied rates; L: linear component for rates 0.075 to 0.240 kg a.i. ha^{-1}.

Table 2. Effect of clethodim rate and quackgrass rhizome size on dry weight of quackgrass initial shoot growth, shoot regrowth and rhizome in the greenhouse

Rate applied[a] (kg a.i. ha^{-1})	Initial growth[b] (g/pot)	Shoot regrowth[c] (g/pot)	Rhizomes[c] (g/pot)
0.0	25.24	16.56	43.31
0.075	4.80	1.74	1.13
0.120	3.48	0.58	0.59
0.150	3.21	0.56	0.69
0.240	1.89	0.02	0.04
SEM[d]	0.35	0.38	0.34
Significant contrasts[e]	C, L	C, L	C, L
Node number			
2	3.38	1.08	0.92
10	3.32	0.37	0.31
SEM	0.25	0.27	0.24
Significance	ns	ns	ns

[a] All treatments contained petroleum oil as an adjuvant at a rate of 1.0% (v:v) of spray solution.
[b] Harvested 45 to 50 days after treatment with clethodim.
[c] Harvested 30 to 40 days after first harvest.
[d] SEM, standard error of mean with 0 rate excluded from analysis.
[e] C: 0 rate versus mean of applied rates; L: linear component for rates 0.075 to 0.240 kg a.i. ha^{-1}.

linearly with rates of application from 0.075 to 0.240 kg a.i. ha^{-1} (Table 2, Contrast L), with no interaction with stage of application.

When the quackgrass shoots were not removed after treatment, all rates of clethodim reduced initial top growth, regrowth and rhizome dry weight relative to no application (Table 3, Contrast C). Overall initial top growth was reduced over the application rates 0.075 to 0.240 kg a.i. ha^{-1}; however, the response was not linear (Table 3, Contrasts L and Q). Removal at 6 h was not as effective as removal at later times (Table 3, Contrasts C1). There was no difference between the 24 and 96 h removal times, however, the no removal was not as effective as removal at 24 and 96 h and varied with rates of application (Table 3, Contrast L*C2). Regrowth was reduced linearly with increased rate of clethodim (Table 3), and 6 h removal had higher regrowth than the other removal times (Table 3, Contrast C1). There was no difference between the 24, 96 h or no removal time on regrowth. Rhizome dry weight decreased with rate of clethodim application. Removal at 6 h was not as effective as removal at later times (Table 3, Contrasts C1). Compared to the 24 and 96 h removal, no removal at 0.075 kg a.i. ha^{-1} was not as effective but the 0.120, 0.150 and 0.240 kg a.i. ha^{-1} rates were more effective (Table 3, L*C1, Q*C2).

Rhizome production was also much greater when shoots were removed at 6 h at all rates of application compared to later removal; however, regrowth was not different between rates of application with removal at 24 or 96 h. The greater initial top growth, regrowth and rhizome weight with shoot removal at 6 h indicates possible reduced clethodim translocation. When shoot removal after treatment was delayed for 24 h, initial top growth, regrowth and rhizome dry weight were generally comparable between rates of application. Delaying shoot removal after clethodim application until 96 h, resulted in maximum initial top growth, regrowth and rhizome reduction at the highest rate of application. This indication of rapid translocation provides evidence that growers could be advised to not cultivate or hill potato crops until at least 96 h after clethodim application.

Field

The first experiment in the field compared rates of application of clethodim

Table 3. Effect of shoot removal at different times after clethodim application on dry weight of quackgrass initial shoot growth, shoot regrowth and rhizome in the greenhouse

		Removal time (h)			
	Rate applied[a] (kg a.i. ha^{-1})	NR[b]	6	24	96
Plant part harvested		(g/pot)	(g/pot)	(g/pot)	(g/pot)
Initial growth[c]	0.0	31.6	19.4	21.2	20.2
	0.075	19.8	13.8	1.9	6.8
	0.120	10.9	8.6	2.4	2.5
	0.150	7.5	8.6	2.3	0.6
	0.240	3.0	9.8	1.2	0.0
SEM[e]			1.99		
Significant contrasts[f]			C, L, Q, C1, C2, L*C2		
Shoot regrowth[d]	0.0	16.7	18.9	18.8	18.7
	0.075	7.7	16.0	5.9	7.2
	0.120	1.2	13.6	8.6	4.1
	0.150	0.3	11.0	6.9	2.7
	0.240	0.0	12.3	4.6	1.2
SEM			2.14		
Significant contrasts[f]			C, L, C1		
Rhizomes[d]	0.0	43.8	28.1	18.9	24.9
	0.075	21.5	18.4	2.9	8.2
	0.12	1.2	11.6	3.7	4.1
	0.15	0.4	13.8	3.0	1.3
	0.24	0.1	14.5	2.3	0.3
SEM			2.57		
Significant contrasts[f]			C, L, Q, C1, C2, L*C2, Q*C2		

[a] All treatments contained petroleum oil as an adjuvant at a rate of 1.0% (v:v) of spray solution.
[b] NR = no removal.
[c] Harvested 45 to 50 days after treatment with clethodim.
[d] Harvested 30 to 40 days after first harvest.
[e] SEM, standard error of mean with 0 rate excluded from analysis.
[f] C: 0 rate versus mean of applied rates; L: linear component for rates 0.075 to 0.240 kg a.i. ha^{-1}; Q: quadratic component for rates 0.075 to 0.240 kg a.i. ha^{-1}; C1: contrast of 6 h versus mean of rest of times of removal; C2; contrast of no removal versus mean of 24 and 96 h.

plus crop oil concentrate when applied with or without the addition of ammonium sulphate. As the rate of application of clethodim was increased, the level of quackgrass control was improved in both yr of the experiment (Table 4). In 1987, without ammonium sulfate, quackgrass control attained the commercially acceptable level of 80% or better for all clethodim application rates. In 1988, control was less and the 80% level of control required the 0.240 kg a.i. ha^{-1} rate of application when ammonium sulphate was not used. The difference in the control level between the yr was attributed to the quackgrass being under stress from an extended period of dry weather prior to clethodim application in 1988, and a much slower quackgrass growth occurred than in 1987. Although Jordan *et al.* (1996) noted that in several field experiments on johnsongrass, differences in efficacy could not be explained by visible plant stress or by extremes in temperature or humidity, in this study the dry period was several wk long and markedly affected quackgrass growth and development. The addition of ammonium sulphate improved control in both yr and especially so at rates of application of 0.120, 0.150 and 0.180 kg a.i. ha^{-1} in 1987 and the 0.150 and 0.180 kg a.i. ha^{-1} rates in 1988. Harker (1995b) reported that ammonium sulphate consistently improved the control of barley

Table 4. Effect of addition of ammonium sulphate on control of quackgrass and potato tuber marketable yield with several rates of application of clethodim[a]

Clethodium rate[b] (kg a.i. ha^{-1})	Ammonium sulphate	Quackgrass control 1987 (%)	Quackgrass control 1988 (%)	Potato tuber marketable yield 1987 (t ha^{-1})	Potato tuber marketable yield 1988 (t ha^{-1})
0.120	-	81	-	44.3	-
	+	89	-	45.0	-
0.150	-	87	67	40.1	42.2
	+	91	90	42.2	45.9
0.180	-	87	75	41.2	40.4
	+	92	84	38.8	46.1
0.240	-	94	83	38.1	42.0
	+	95	84	37.7	43.0
Untreated control		0	0	37.3	41.1
LSD, P = 0.05		2	4	5.6	ns

[a] Metribuzin applied pre-emergence at 0.42 kg a.i. ha^{-1} on all plots to provide broadleaf weed control.

[b] All treatments contained petroleum oil as an adjuvant at a rate of 1.0% (v:v) of spray solution to which ammonium sulphate was added as indicated at 2.0 kg a.i. ha^{-1}.

(*Hordeum vulgare* L.) when used with clethodim applied at 0.025 g a.i. ha^{-1} and McMullan (1996) reported that clethodim required an adjuvant for barley control and crop oil concentrate plus ammonium sulphate used with clethodim enhanced activity on barley.

Potato marketable yield was significantly reduced in the control when quackgrass was not controlled in 1987 but not in 1988 (Table 4). When clethodim provided commercially acceptable quackgrass control of 80% or more, potato yield was increased above that of the untreated control only at the 0.120 kg a.i. ha^{-1} rate. In 1987, clethodim at 0.180 and 0.240 kg a.i. ha^{-1} applied with ammonium sulphate had yields that were significantly lower than those at the 0.120 kg a.i. ha^{-1} rate with ammonium sulfate. The 0.240 kg a.i. ha^{-1} rate without ammonium sulphate was also lower than the 0.120 kg a.i. ha^{-1} rate. An examination of the data for each plot showed that one replication of the 0.120 kg a.i. ha^{-1} had higher yield than the other plots - most likely due to extra hills present in the plot. This difference between rates of application is most likely due to this and not to an effect of rate of application, as it was not observed in 1988. The other rates of application had comparable marketable yield in 1987 and there was no difference in yield in 1988.

A second field experiment compared quackgrass control and potato yield response of a wider range of rates of application of clethodim to standard rates of sethoxydim and fluazifop-p-butyl. The addition of ammonium sulfate to sethoxydim increased quackgrass control slightly in 1987 and markedly in 1988 (Table 5). In both yr, fluazifop-p-butyl gave better control of quackgrass than did sethoxydim. In both yr, increasing clethodim rate from 0.075 to 0.150 kg a.i. ha^{-1} markedly increased quackgrass control. A further increase to 0.300 kg a.i. ha^{-1} had no effect on control in 1987 but did give greater control in 1988. Increasing the clethodim rate of application from 0.300 to 0.450 kg a.i. ha^{-1} did not provide any increase in quackgrass control in either yr (Table 5). In 1987, the control of quackgrass with clethodim at 0.150 kg a.i. ha^{-1} and sethoxydim at 0.500 kg a.i. ha^{-1} were comparable, but in 1988, clethodim gave better control than sethoxydim at these rates of application. Fluazifop-p-butyl at 0.250 kg a.i. ha^{-1} gave better control of quackgrass than clethodim at all rates of application in

Table 5. Control of quackgrass and marketable potato tuber yield with several rates of application of clethodim and other herbicides[a]

Treatment	Rate applied (kg a.i. ha^{-1})	Quackgrass control 1987 (%)	Quackgrass control 1988 (%)	Potato tuber marketable yield 1987 (t ha^{-1})	Potato tuber marketable yield 1988 (t ha^{-1})
Clethodim [b]	0.075	77	60	43.6	43.5
Clethodim	0.150	86	72	37.1	44.1
Clethodim	0.300	87	88	43.5	45.4
Clethodim	0.450	90	85	43.3	44.0
Sethoxydim	0.500	85	67	45.9	45.3
+Assist oil concentrate	1.0% v:v				
Sethoxydim	0.500	89	77	45.2	44.3
+Assist oil concentrate	1.0% v:v				
+Ammonium sulphate	4 L ha^{-1}				
Fluazifop-p-butyl	0.250	94	88	44.7	48.3
Untreated control		0	0	34.3	42.8
LSD, P = 0.05		3	5	5.7	ns

[a] Metribuzin applied pre-emergence at 0.42 kg a.i. ha^{-1} on all plots to provide broadleaf weed control.
[b] All treatments contained petroleum oil as an adjuvant at a rate of 1.0% (v:v) of spray solution.

1987 and better control than clethodim at 0.150 kg a.i. ha^{-1} in 1988. Potato marketable yield was improved by the use of all three herbicides to control quackgrass in 1987 but there was no difference in yields noted between the herbicides in 1988. The yield reduction noted at higher rates in 1987 (Table 4) appears to be an anomaly as even higher rates used in 1988 had no effect on marketable yield.

The results of this study indicate that clethodim is an effective herbicide for use to control quackgrass and it is safe for use on potato crops. Clethodim, at a rate of 0.150 kg a.i. ha^{-1}, provides quackgrass control that is better than with sethoxydim but not as good as fluazifop-p-butyl. Control of quackgrass was not greatly increased by increasing the rate of application above 0.150 kg a.i. ha^{-1} giving a similar response as did rhizome johnsongrass in other studies (Rosales-Robles *et al*. 1999). All of the herbicides used in this study were adversely affected by stress caused by abnormally dry weather either prior to or after application. Clethodim is rapidly absorbed and translocated after application as removal of treated foliage 24 h or more after application in greenhouse studies had no effect on the level of control obtained, most likely because the adjuvants used mediated rapid uptake in an ideal environment. In the field situation, where greater stress may occur, uptake may not be as efficient and, as noted by Bridges *et al.* (1991), the best adjuvant or combination of adjuvants that contribute to the uptake of clethodim and polar degradation products and minimize photo degradation should be used. Growers who like to cultivate soon after herbicide application need to be aware that, under adverse environmental conditions, uptake and translocation may not be adequate and cultivation should be delayed under these conditions.

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