This is to certify that the

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Postemergence Weed Control Systems in

Soybeans (*Glycine max* (L.) Merr.)

presented by

Jerry L. Wilhm III

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POSTEMERGENCE WEED CONTROL SYSTEMS IN SOYBEANS (*GLYCINE MAX* (L.) MERR.)

By

Jerry Leo Wilhm III

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ABSTRACT

POSTEMERGENCE WEED CONTROL SYSTEMS IN
SOYBEANS (Glycine Max (L.) Merr.)

By

Jerry L. Wilhm

Postemergence weed control systems for annual weeds and quackgrass (Agropyron repens (L.) Beauv.) were evaluated over two growing seasons. Postemergence applications of tank-mixed grass and broadleaf herbicides controlled annual grasses, but were not as successful in the season-long control of certain broadleaved weeds as were standard preemergence applications of soil applied herbicides.

Excellent quackgrass control was obtained at several locations with fall and spring applications of nonselective herbicides glyphosate (N-(phosphonomethyl)glycine) and SC-0224 (trimethylsulfonium carboxymethyl-aminomethyl phosphonate) applied in several rates and spray volumes in several tillage systems except for spring applications following fall moldboard plowing. At another location, spring applications of these herbicides resulted in poor control of quackgrass growing in 38-cm tall wheat (Triticum aestivum L.) stubble due to poor coverage. Generally, longer control was obtained with non-selective than selective postemergence herbicides. With postemergence herbicides, early applications to quackgrass at the three-leaf

stage were not as effective as later or split applications in spring moldboard plowed soybeans. There were fewer differences due to time of application in spring moldboard plowed soybeans in narrow rows; fall chisel- or fall moldboard plowed soybeans; or in several systems of no-till soybeans. Generally, equally high soybean yields were obtained with non-selective and selective postemergence herbicides as long as quackgrass was controlled before exceeding the five-leaf stage. Poor control of late-season quackgrass regrowth did not influence yield. Acifluorfen (5-(2-chloro-4-trifluoromethyl)phenoxy)-2-nitrobenzoic acid) and bentazon (3-isopropyl-1*H*-2,1,3-benzothiadiazin-4(3*H*)-one-2,2-dioxide) in tank-mix with postemergence grass herbicides resulted in significantly increased late-season regrowth of quackgrass suggesting reduced translocation of grass herbicides. Acifluorfen and bentazon reduced translocation of ^{14}C-haloxyfop-methyl (methyl 2-(4-((3-chloro-5 (trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate) out of the treated area into the lower leaves. Acifluorfen reduced translocation of ^{14}C-DPX-Y6202 (2-(4-(6-chloro-2-quinoxalinyl)oxy)phenoxy)propionic acid, ethyl ester) out of the treated area into the leaf tip and bentazon reduced absorption of ^{14}C-DPX-Y6202 into the quackgrass plant.

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INTRODUCTION

Weed control is an integral part of crop production. Despite the availability and utilization of herbicides, crop losses due to weeds still occur. At the 1984 meeting of the Weed Science Society of America, it was reported that in the United States annual losses of $20 billion could be attributed directly to weeds.

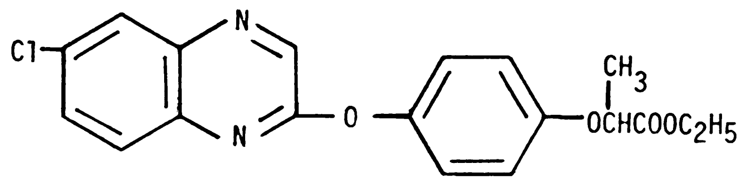
In soybeans, several effective soil applied herbicides are available for the control of annual weeds. Acifluorfen (5(2-chloro-4-(trifluoromethyl)phenoxy)-2-nitrobenzoic acid) and bentazon (3-isopropyl-1*H*-2,1,3-benzothiadiazin-4(3*H*-one-2,2-dioxide) are available for postemergence control of certain broadleaved weed species. Recently, new herbicides have been developed for postemergence control of grass weeds. Two of these, sethoxydim (2-(1-(ethyoxyimino)butyl-5-(2-(ethylthio)propyl)-3-hydroxy-2-cyclohexen-1-one) and fluazifop-butyl (($\pm$)butyl-2-(4-((5-trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate) received registration for use in soybeans in 1983. Several others, including haloxyfop-methyl (methyl 2-(4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate) and DPX-Y6202 (2-(4-((6-chloro-2-quinoxalinyl)oxy)phenoxy)propionic acid, ethyl ester) are still under development. Therefore, a grower may wish to tankmix a postemergence broadleaf and grass herbicide for broad-spectrum weed control.

One area in which the postemergence grass herbicides may be particularly useful is in the control of perennial grasses which are not easily controlled with other herbicides. One of these is quackgrass (*Agropyron repens* (L.) Beauv.). Soybean growers are usually forced to rotate to other crops such as corn, where herbicides such as atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine) are available for quackgrass control. However, this can limit future plantings of soybeans due to herbicide carryover.

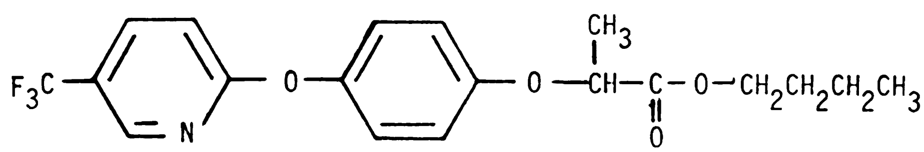
Another quackgrass control measure is the use of preplant and postharvest applications of the non-selective herbicide glyphosate (*N*-(phosphonomethyl)glycine). However, in the temperate North, weather may restrict glyphosate use either due to direct effects or by restricting spring growth such that the quackgrass is not in the proper stage for treatment.

Regardless of the control practices used, they should be compatible with the growers total cropping system. Therefore, the objectives of this research were to (1) evaluate the efficency of postemergence applied herbicides compared to that of soil applied herbicides for the control of annual weeds in soybeans, (2) evaluate quackgrass control at different stages of application of the selective postemergence grass herbicides sethoxydim, fluazifop-butyl, haloxyfop-methyl and DPX-Y6202 under several different tillage and cultural systems, (3) compare quackgrass control from the aforementioned selective herbicides with that from non-selective herbicides glyphosate and the experimental SC-0224 (trimethylsulfonium carboxymethylaminomethyl phosphonate), (4) evaluate the potential reduction in quackgrass control due to addition of acifluorfen and bentazon to applications of postemergence grass herbicides, and (5) determine the effects of acifluorfen and bentazon on the absorption and translocation of ^{14}C-haloxyfop-methyl and ^{14}C-DPX-Y6202 in quackgrass. Chemical structures of the herbicides used in this study are shown in Figure 1.

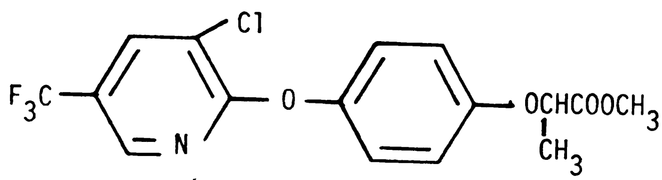
Figure 1. Herbicides discussed in this dissertation.



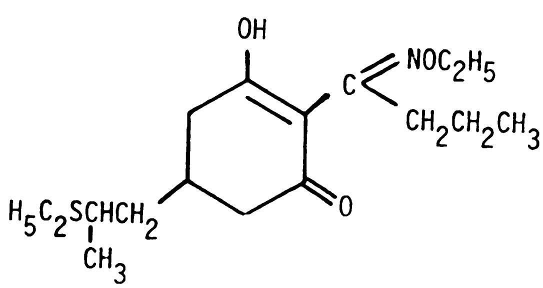
DPX-Y6202. 2-(4-((6-chloro-2-quinoxalinyl)oxy)-phenoxy)-propionic acid, ethyl ester. E.I. duPont de Nemours and Company. Proposed trade name - Assure.



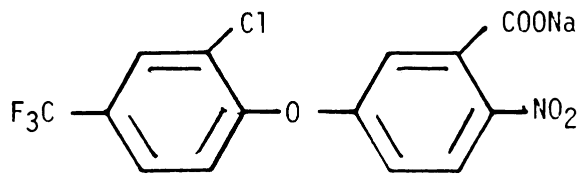
Fluazifop-butyl. ($\pm$)-butyl-2-(4-((5-trifluoromethyl)-2-pyridinyl)oxy phenoxy)propanoate. ICI Americas Inc. Registered trade name - Fusilade.



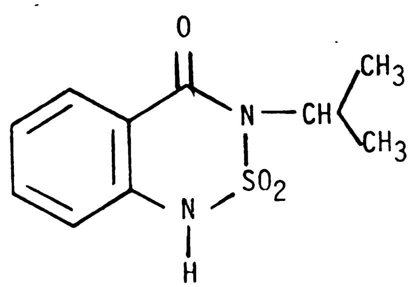
Haloxyfop-methyl. methyl-2-(4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl) oxy)phenoxy)propanoate. Dow Chemical Company. Proposed trade name - Verdict.



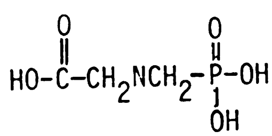
Sethoxydim. 2-(1-(ethoxyimino)butyl-5-(2-(ethylthio)propyl)-3-hydroxy-2-cyclohexen-1-one. BASF Wyandotte Corporation. Registered trade name - Poast.



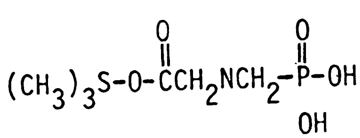
Acifluorfen. 5-(2-chloro-4-(trifluoromethyl)phenoxy)-2-nitrobenzoic acid. Rohm and Haas Company. Registered trade name - Blazer.



Bentazon. 3-isopropyl-1*H*-2,1,3-benzothiadiazin-4(3*H*) one-2,2-dioxide. BASF Wyandotte Corporation. Registered trade name - Basagran.



Glyphosate. *N*-(phosphonomethyl)glycine. Monsanto Agricultural Products Company. Registered trade name - Roundup.



SC-0224. trimethylsulfonium carboxymethylaminomethyl phosphonate. Stauffer Chemical Company.

CHAPTER I

REVIEW OF LITERATURE

Effective weed control is a critical aspect of soybean (*Glycine max* L.) production. Herbicides are tools widely used by soybean growers for the control of weeds. Various soil-applied herbicides have been available for years for the control of annual weeds as have several postemergence applied herbicides for the control of broadleaved weeds. For the control of difficult perennial weeds such as quackgrass (*Agropyron repens* (L.) Beauv.), soybean growers have used preplant and post-harvest applications of glyphosate (*N*-(phosphono-methyl)glycine) or have rotated to other crops such as corn where other herbicides such as atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine) are available. However, this may restrict future plantings of soybeans due to herbicide carryover. Recently, new herbicides have been developed which have demonstrated postemergence activity on grasses with no phytotoxic effect to broadleaved plants. The suspected mode of action of the grass herbicides is phytotoxicity by interruption of meristematic activity (9, 22, 49, 51, 76, 79, 121). Therefore, the possibility now exists for broad-spectrum weed control in soybeans by utilizing new postemergence grass herbicides and postemergence broadleaf herbicides such as acifluorfen (5-(2-chloro-4-

(trifluoromethyl) phenoxy)-2-nitrobenzoic acid) and bentazon (3-isopropyl-1*H*-2,1,3-benzothiadiazin-4(3*H*)-one 2,2-dioxide).

POSTEMERGENCE CONTROL OF ANNUAL WEEDS

Effects of Weed Interference. The utilization of postemergence weed control systems means that both crop and weeds would grow together until such time that the weeds are at the proper growth stages for herbicide application. The duration of this weed-crop interference can affect soybean yield. Dawson (41) described two distinct stages of weed-crop interference. Stage one lasts for 5 to 7 weeks after planting and is the most critical period of weed interference as the effects of this stage are shown much later in the season in terms of yield reduction. Stage two occurs from 7 weeks after planting until crop maturity. This stage is not as critical to crop yield as stage one since the larger crop plant can interfere more effectively with weed growth. Several other studies have examined soybean-weed interference. Knake and Slife (88) found that plots in which giant foxtail (*Setaria faberi* Herrm.) was seeded with soybeans resulted in bean yields which were significantly less than weed-free check plots whereas those seeded 3, 6, 9, and 12 weeks after planting were not significantly different from the control. Staniforth and Weber (145) found reduced soybean yields from yellow foxtail (*Setaria lutescens* (Weigel) Hubb.) seeded and grown with soybeans for 5 weeks before removal. Barrentine (8) found that early-season cocklebur (*Xanthium pensylvanicum* Wallr.) interference of 4 weeks significantly

reduced soybean yields while Coble and Ritter (30) reported that soybean-Pennsylvania smartweed (Polygonum pensylvanicum L.) interference should be limited to 6 weeks after emergence in order to not significantly affect yields. Coble et al. (31) found that common ragweed (Ambrosia artemisiifolia L.) needed to be removed within 6 weeks after planting in order to prevent yield loss. Wilhm et al. (167) found the critical period of pigweed (Amaranthus spp.) control to be the first 3 weeks after emergence. Wheatly and Cole (164) reported that 4 weeks of interference by a mixed grass-broadleaf weed population reduced soybean yields. Eaton et al. (53) in separate experiments planted prickly sida (Sida spinosa L.), venice mallow (Hibiscus trionum L.) and velvetleaf (Abutilon theophrasti Medic.) 0, 10, and 20 days after soybeans and found that the first two planting dates resulted in yields significantly lower than weed-free control plots while yields with the third planting date were not different from the control. Crop-weed interference is also affected by soil moisture levels (52, 166). Different species of the same genus interfere differently as Staniforth (144) found the giant foxtail caused greater soybean yield loss than either yellow or green (Setaria viridis (L.) Beauv.) foxtail. Therefore it is evident that in order for a postemergence annual weed system to be effective, the weeds must be controlled prior to the critical period of interference.

Postemergence Grass Herbicides for Annual Grass Control. Considerable recent research has demonstrated the effectiveness of postemergence grass herbicides on annual grasses (1, 7, 12, 13, 18, 19, 24, 33, 54, 60, 63, 64, 66, 69, 70, 93, 104, 122, 137, 146). However,

various factors must be considered regarding the positioning of a graminicide within a postemergence weed control system.

Adjuvants. Spray additives or adjuvants have been shown to affect activity of postemergence grass herbicides. Addition of several different petroleum based oils (crop oil concentrates) and surfactants at 0.5% v/v to applications of sethoxydim (2-(1-(ethoxyimino)-butyl)-5-(2-ethylthiopropyl)-3-hydroxy-2-cyclohexene) at 0.1 kg/ha resulted in significantly reduced wild oat (Avena fatua L.) fresh weights compared to applications without additives (29). Addition of crop oil concentrate or non-ionic surfactant to applications of DPX-Y6202 (2-(4-((6-chloro-2-quinoxalinyl)oxy) propionic acid) resulted in a two to four fold increase in phytotoxicity to treated grass (118). A 0.28 kg/ha application of sethoxydim plus crop oil concentrate at 2.3 L/ha gave control of green foxtail and barnyardgrass (Echinochloa crus-galli (L.) Beauv.) that was equivalent to a 0.56 kg/ha application without adjuvant (152). Similarly in another study, foxtail millet (Setaria italica (L.) Beauv.) control with low rates of sethoxydim (0.1 kg/ha), fluazifop-butyl (($\pm$) butyl 2-(4-((5-(trifluoromethyl)-2-pyridinyl)oxy)-phenoxy)propanoate) (0.07 kg/ha); CGA-82725 (2-propanyl 2-(4-(3,5-dichloro-2-pyridyloxy)phenoxy)propanoate) (0.05 kg/ha) and haloxyfop-methyl (methyl 2-(4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl)oxy)-phenoxy)propanoate) (0.035 kg/ha) was improved with the addition of crop oil concentrate and 2.3 L/ha was more effective than 1.2 L/ha (108). In this same study, crop oil concentrate was a more effective additive than either soybean oil or nonionic surfactant. In addition,

there was significantly more uptake and translocation of ^{14}C-CGA-82725 by oats (Avena sativa L.) when applied with the petroleum based oil than with soybean oil but no significant difference between additives in uptake and translocation of ^{14}C-sethoxydim. Other studies have shown little difference between petroleum based oils and soybean oils as spray additives (23, 26). Cranmer and Nalewaja (37) found that differences in wild oat control with sethoxydim due to temperature and humidity could be overcome with the addition of crop oil concentrate.

Growth Stage. The growth stage of the grass can influence control with postemergence herbicide applications. Generally, smaller grasses are more easily controlled than large. Diclofop (2,(4-(2,4-dichlorophenoxy)phenoxy)propanoic acid) is more effective on annual grasses in the two to four leaf stage than more advanced stages (56, 102, 159). Green and yellow foxtail retained more sprayed herbicides on a per unit basis in the two leaf stage than at the four leaf stage (159). Smeda and Putnam (140) working with four annual grasses, found the three leaf stage to be optimum for control with fluazifop-butyl as control decreased when treated at the five and seven leaf stages. Veenstra et al. (152) reported that seedling green foxtail and barnyardgrass were more easily controlled with 0.28 kg/ha of sethoxydim than when 20 to 45 cm tall. Applications of fluazifop-butyl (0.09 to 0.28 kg/ha), sethoxydim (0.11 to 0.28 kg/ha), haloxyfop-methyl (0.07 to 0.28 kg/ha) and CGA-82725 (0.11 to 0.45 kg/ha) were made to seven annual grass species at two growth stages: 5 to 12 cm and 22 to 40 cm tall (5). Generally, the lower rates of each herbicide were more

effective at the smaller grass stage and higher rates were necessary for effective control of the larger grass. Applications of fluazifop-butyl (0.42 and 0.56 kg/ha) and sethoxydim (0.22 kg/ha) were made to large crabgrass (*Digitaria sanginalis* (L.) Scop.) at heights of 5 to 10 cm, 10 to 15 cm and 16 to 30 cm; and results indicated that control declined with increasing grass size (151). In some cases, postemergence control of annual grasses is independent of grass size. Crabgrass at the spike, two to three leaf and four to five leaf stages were all equally controlled with 0.28 and 0.56 kg/ha of CGA-82725 (56). Sethoxydim at 0.2, 0.3 and 0.4 kg/ha plus crop oil concentrate (2.3 L/ha) controlled foxtail, barnyardgrass, fall panicum (*Panicum dicotomiflorum* Michx.), volunteer corn (*Zea mays* L.) and wheat (*Triticum aestivum* L.) with no significant difference between applications to 5 to 20 cm and 20 to 38 cm tall grass (85). Anderson observed no significant differences due to growth stage in control of two to three leaf and five leaf giant foxtail with haloxyfop-methyl, CGA-82725, fluazifop-butyl and sethoxydim at 0.05, 0.1, 0.2 kg/ha plus crop oil concentrate (1% v/v) except that 0.05 kg/ha of sethoxydim was more effective on the larger grass (3). Crane et al. (34) obtained excellent control of fall panicum and stinkgrass (*Eragrostis cilianensis* (All.) Lutati) from applications of 0.28 and 0.56 kg/ha of sethoxydim plus crop oil concentrate made from 22 to 50 days after planting soybeans.

Spray Volume. The spray volume delivering the herbicide solution may influence control. Smeda and Putnam (140) applied fluazifop-butyl

plus crop oil concentrate to four annual grasses in spray volumes ranging from 46.8 to 467.5 L/ha and observed better control with the lower volumes: 46.8 to 93.5 vs 187 to 374 L/ha, especially at low herbicide rates of 0.07 to 0.14 kg/ha. Buhler and Burnside (20) observed similar trends with fluazifop-butyl, sethoxydim and haloxyfop-methyl on forage sorghum (Sorghum bicolor (L.) Moench.). Cranmer and Duke (36) obtained significantly greater control of green and yellow foxtail and barnyardgrass with fluazifop-butyl and sethoxydim applied in low volumes with a controlled droplet applicator (CDA) compared to higher volumes applied with conventional flat fan nozzles. In contrast, Froseth and Arnold (61) observed no significant differences in yellow foxtail control with 0.134 kg/ha applied in spray volumes of 23 to 374 L/ha. Anderson (3) observed no significant differences between spray volumes of 93.5 or 187 L/ha for the control of giant foxtail, wild proso millet (Panicum miliaceum L.) and corn with haloxyfop methyl, CGA-82725, fluazifop-butyl and sethoxydim.

Soil Residual Activity. Control of annual grasses with postemergence applied herbicides may be enhanced due to soil activity of the herbicides. This would enable increased grass control due to root absorption plus residual control of grasses not emerged at the time of a spray application. Kells (81) demonstrated preemergence control of barnyardgrass with fluazifop-butyl at rates as low as 0.07 kg/ha. Postemergence applications of fluaxifop-butyl to barnyardgrass where the soil was covered by vermiculite during spraying were not as

effective as those to grass in uncovered soil (81). Handly et al. (65) obtained season-long control of barnyardgrass and giant foxtail from preemergence applications of haloxyfop-methyl at 0.28 and 0.56 kg/ha and near season-long control from 0.07 and 0.14 kg/ha. Rick et al. (126) obtained preemergence control of giant foxtail with CGA-82725 and fluazifop-butyl each applied at 0.28 and 0.56 kg/ha, and with haloxyfop-methyl at 0.07 and 0.14 kg/ha. They also observed that the higher rates in each case resulted in longer weed control. Buhler and Burnside (21) found preemergence applications of haloxyfop-methyl to forage sorghum demonstrated greater activity than either fluazifop-butyl or sethoxydim. In this study, a 0.5 kg/ha of haloxyfop-methyl resulted in 100% control 80 days after treatment while 1.0 kg/ha of fluazifop-butyl was needed to obtain 100% control. A 0.8 kg/ha application of sethoxydim resulted in only 43% control after 80 days. Rick and Slife (126) controlled 5 cm tall giant foxtail with 0.28 kg/ha of sethoxydim. However, severe reinfestation due to lack of soil residual activity occurred such that soybean yields were significantly lower than those of plots treated when the grass was either 10 or 15 cm tall, by which time most of the foxtail seeds had germinated and emerged. A tankmix of sethoxydim plus the soil applied grass herbicide alachlor (2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide) was beneficial only when applied to giant foxtail 5-cm tall. Ennis and Ashley (55) found very little preemergence activity on crabgrass with either sethoxydim (0.28 and 0.56 kg/ha) or diclofop (1.1 and 1.7 kg/ha) while CGA-82725 (0.28 and 0.56 kg/ha) significantly reduced grass

population and dry matter production. Although Mulder and Nalewaja (103) observed that increasing the soil concentration of diclofop between 0.5 and 5 ppmw resulted in decreased wild oat emergence and dry weight production, Nalewaja et al. (105) found that soil uptake makes only a minor contribution in the control of yellow foxtail.

Factors such as soil type, organic matter and clay content, cation exchange capacity, rainfall, seed depth also affect the soil activity of these herbicides in grass control (21, 65, 103, 118).

Dale (39) treated soybean seeds with fluazifop-butyl (2.2 and 4.4 g/kg-seed) and obtained 100% control of goosegrass (*Eleusine indica* (L.) Gaertn.) seeds with four soybean seeds per pot and 80 to 90% control with one seed per pot. Similar results were obtained with CGA-82725 although soybean injury occurred. Sethoxydim was less effective than the other two herbicides when applied in this manner.

Postemergence Weed Control Systems and Potential Interactions. A postemergence weed control system for annual weeds requires careful management of numerous factors, as exemplified by the preceding examples, particularly when attempting broad-spectrum weed control with tank-mix applications of grass and broadleaf herbicides. However, research has shown that postemergence control systems can be successful.

In an extensive cost/return study, total postemergence weed control programs utilizing the grass herbicide sethoxydim with acifluorfen and/or bentazon compared very favorably with normal farmer practices under no-till, reduced-tillage and conventional-tillage

soybeans (86). However, tank-mix applications of postemergence grass and broadleaf herbicides may result in antagonism in the form of reduced weed control. Reduced control of broadleaf weeds due to the presence of a grass herbicide in a tank-mix is rare, although Ritter and Harris (130) observed reduced morningglory (Ipomoea spp.) control with acifluorfen (0.42 kg/ha) when tank-mixed with 0.14 and 0.28 kg/ha of RO-13-8895 (acetone-o-(d 2-(p-(α,α,'-trifluoro-ptolyl)-oxy)phenoxy)-propinyl)oxime). Reduced control of several species of annual grasses has been reported from tankmix applications of diclofop and bentazon (2, 25, 130, 171), dinoseb (2-sec-butyl-4,6-dinitrophenol) (14), dicamba (114, 135), desmedipham (ethyl m-hydroxycarbanilate carbanilate (ester)) (113, 134), 2,4-D ((2,4-dichlorophenoxy)acetic acid) (114), MCPA (((4-chloro-o-tylyl)oxy)acetic acid) (114, 115, 135) and MCPA plus propanil (3',4'-dichloropropionanilide) (115). Similar reductions in annual grass control resulted from tank-mix applications of sethoxydim and bentazon (25, 46, 108, 125, 130, 133, 151, 168, 169), acifluorfen (46, 125, 133), MCPA (28, 46), desmedipham (46, 106) and 2,4-D (111). Additions of acifluorfen (46, 48, 125, 133) and bentazon (46, 48, 125, 133, 169) to both haloxyfop-methyl and fluazifop-butyl have resulted in reduced annual grass control. Additions of broadleaf herbicides to applications of DPX-Y6202 (45), CGA-82725 (45, 71, 106, 107, 125), RO-13-8895 (75, 82, 106, 107) and difenopenten (4-(4-(4-(trifluoromethyl)phenoxy)-2-pentenoic acid) (106, 130, 134) have also been antagonistic in the control of annual grasses. In some cases, this antagonism in annual grass control was overcome by increasing the grass herbicide rate, separating the application of tank-mix components, or by making the application before the grasses became too large (2, 14, 25, 28, 45, 46, 48, 71, 96, 113, 125, 130, 133, 151, 168, 169, 171).

It may be somewhat surprising to find this form of antagonism with tankmixes containing acifluorfen since it is phytotoxic to several species of annual grasses (124). Chen and Penner (27) found increased control of barnyardgrass with tank-mix applications of acifluorfen and sethoxydim compared to control with applications of sethoxydim alone. Therefore, tank-mixes can be synegistic in control of annual grasses.

However, the basis of antagonism may partly be explained by reduced absorption of the grass herbicide by the grass foliage. Woldetatios and Harvey (172) found reduced uptake of ^{14}C-diclofop by giant foxtail leaves which had been treated with a tank-mix application of diclofop-methyl and bentazon. Similarly, Williams and Wax (169) found reductions in the amounts of ^{14}C-haloxyfop-methyl and ^{14}C-fluazifop-butyl that penetrated the leaves of German millet (*Setaria italica* (L.) Beauv.) when applied in a mixture containing bentazon.

QUACKGRASS

Biology and Significance. Quackgrass (*Agropyron repens* (L.) Beauv.) is considered to be one of the world's worst weeds and is found in all of the world's major agricultural areas of the northern temperate zones (4, 72, 73, 94). It was introduced to North America from Europe during colonization for utilization as a forage (158). A complete morphological description is given by Palmer and Sager (117). The major characteristics of quackgrass contributing to its severity as a weed is the presence of long rhizomes which are sources of vegetative reproduction from rhizome nodes. Propagation by seeds is insignificant as many plants are self sterile (117, 123, 158). Vegetative reproduction by rhizomes can lead to large stands of "clones" which can have considerable genetic and morphological variability from other stands (109, 123, 158, 162, 170). Neuteboom (109) suggested that the type of land use affects genetic selection of quackgrass. Westra and Wyse (161) found ten phenotypically different biotypes of quackgrass growing within 8 km of each other. These biotypes were also differentially controlled by the non-selective herbicide glyphosate.

Vegetative growth of quackgrass rhizomes is extremely prolific. A single plant may give rise to as many as 150 rhizomes or rhizome branches in the first growing season each with an average length of 50 cm and with extremes of up to 1 meter (117). Raleigh et al. (123) describes a study where in one year a single-node rhizome section produced 140 m of rhizomes from which 206 shoots had arisen.

Many aspects of agriculture are favorable for quackgrass growth and development. It is a pioneer plant of disturbed areas and tends to form pure stands (117). Maximum growth occurs in the spring ahead of other weeds when daytime temperatures are between 20 and 27^{o}C (101, 131). Addition of fertilizer, particularly nitrogen, significantly increases growth of quackgrass (89, 112, 123, 131). Soil compaction

has been shown to increase quackgrass populations possibly because under these conditions rhizomes tend to grow more horizontally and become less distributed over the soil profile (112, 148).

Cultivation can increase the spread of rhizomes by dragging the rhizome segments over a field (147). Tillage operations which fragment rhizomes can increase quackgrass population by releasing apical dominance along a rhizome fragment (117, 154).

Quackgrass interference can be detrimental to soybeans. Interference by naturally occurring quackgrass stands for 4 and 6 weeks can significantly reduce soybean yield, particularly during water stressed conditions (175, 176). Sikkema and Dekker (138) using infrared thermometric monitoring of canopy temperature found that significant soybean stress leading to yield reductions had occurred at the four-leaf stage of quackgrass. By the five-leaf stage, interference resulting in greater than 50% reduction of soybean yield had occurred and no further yield reductions occurred due to interference from quackgrass beyond the five-leaf stage. The allelopathic characteristics of quackgrass are also well documented (62, 90, 91, 92, 97, 98, 99, 110, 119, 160, 165).

Adequate control of quackgrass is highly desirable by soybean growers. Wyse (174), realizing that one herbicide or tillage treatment is ineffective for control, has suggested quackgrass control systems be employed. That is, utilization of several chemical and non-chemical measures are necessary for effective quackgrass control.

Quackgrass Control with Tillage. Prior to the development of herbicides, tillage was the main quackgrass control practice. Fields of quackgrass were plowed at various times of the year to expose rhizomes to the environment where they could be desiccated or frozen (50, 95, 147). However, such practices often preclude the planting of a summer crop and are not totally effective since it would be impossible to expose all rhizomes. Fractioning and burial of rhizomes is another tillage practice. Percent shoot emergence with short rhizome segments decreases with depth of burial and no shoots emerged from depths of 25 cm or more as reported by Hongo (74). Vengris (154) suggested fractionation of rhizomes releasing apical dominance to cause greater shoot emergence and then burial by plowing whereby the carbohydrate reserves of the fragmented rhizomes would be depleted prior to emergence. However, this too would preclude a crop as well as be labor and energy intensive.

Quackgrass Control with Glyphosate. Of the soil applied herbicides available for use in soybeans, only vernolate (*s*-propyl dipropylthiocarbamate) has limited activity on quackgrass (173, 174). Glyphosate is a non-selective phloem-mobile herbicide which effectively controls quackgrass with four or more leaves (6, 17, 77, 128, 129). Since it is nonselective, glyphosate applications can only be made in the spring or fall in a soybean cropping situation. Control from fall applications has often been shown to be more effective than that from spring applications (10, 78, 128, 142). Possibly, quackgrass shoots in spring applications may not be at the proper growth stage for

effective control. Furthermore, Leaky and Chancellor (89) observed that rhizomes begin accumulating reserves (such as nitrogen) in the autumn. Therefore, fall applications of glyphosate may block accumulation of reserves as well as translocate more effectively to the rhizomes.

Several other factors may influence quackgrass control with glyphosate. One of these is tillage. Many growers begin land preparations following spring applications of glyphosate. Moldboard plowing the same day as a spring glyphosate application significantly reduced quackgrass control (17, 143). Brecke et al. (16) and Brockman et al. (17) observed no loss of control by plowing 1 day after a spring application of 1.56 kg/ha, although Sprankle et al. (143) found plowing 3 days after treatment to be optimal with this rate. Sprankle and Meggitt (142) found plowing several days after a fall application improved quackgrass control. However, spring applications following fall plowing are ineffective for quackgrass control because all shoots had not emerged at the time of application (11, 142, 143). Fall applications of glyphosate to quackgrass may be influenced by frost. Davis et al. (40) found significantly more glyphosate uptake and translocation the morning after the first fall frost than 5 days after. Devine and Bandeen (44) found that translocation of ^{14}C-glyphosate to quackgrass rhizomes is prevented only when cold treatment caused visible damage to foliage.

Spray volume can affect quackgrass control with glyphosate. Hanson and Crockett (67) found quackgrass treatments with glyphosate at

0.84 kg/ha applied in 47 to 94 L/ha to be as effective as 1.68 kg/ha applied in equal or higher volumes. Quackgrass control was more effective with glyphosate at 0.56 to 2.24 kg/ha applied with controlled droplet applicators in volumes of 9.34 to 149.39 L/ha than with flat fan nozzles in volumes of 18.67 to 233.4 L/ha (35, 36). Sandberg et al. (132) added sulfonine red dye to glyphosate spray solutions and observed that over half of the solution ran off treated foliage at volumes of 375 and 750 L/ha while nearly all of the solution was retained when applied at 130 L/ha. Addition of non-ionic surfactant to commercially formulated glyphosate (0.5% v/v) increases the effectiveness of low-rate, low-volume applications to quackgrass (57, 58, 67).

Additional factors such as hard water (120, 132), weevil feeding (163), and biotype (161) can reduce the effectiveness of glyphosate on quackgrass.

Another non-selective herbicide, SC-0224 (trimethylsulfonium carboxymethyl aminomethyl phosphonate) has shown equivalent activity on quackgrass as glyphosate (15, 87).

Quackgrass Control with Postemergence Applied Grass Herbicides. Considerably less research has been directed towards quackgrass control with selective postemergence applied grass herbicides than towards annual grass control.

Applications of sethoxydim, fluazifop-butyl, RO-13-8895, difenopenten, haloxyfop-methyl and DPX-Y6202 have been shown to more effectively control quackgrass in the three- to five-leaf stage than

when applied at later growth stages (42, 43, 83, 84, 116, 136, 149, 155, 156, 157). This would enable quackgrass control prior to the critical stages of interference as described by Sikkema and Dekker (138). In addition, application of postemergence grass herbicides should contain crop oil concentrate (2.3 L/ha) or non-ionic surfactant (0.1 to 0.5% v/v) to increase their effectiveness for quackgrass control (9, 49, 51, 76, 141, 150, 152).

Translocation. Kells et al. (84) found more extensive distribution of ^{14}C-fluazifop-butyl in two- to three-leaf quackgrass than in five- to six-leaf quackgrass. Evidently herbicide translocation at this growth stage parallels that of other plant metabolites as Fiveland et al. (59) found greater translocation of $^{14}CO_2$ assimilate to other shoots and rhizomes at the two- to three-leaf stage than at the five-leaf stage.

Patterns of translocation differ between herbicides. Harker and Dekker (68) found that ^{14}C-sethoxydim, fluazifop-butyl along with glyphosate tended to accumulate at the apical tips of rhizomes, whereas, ^{14}C-haloxyfop-methyl tended to be distributed more evenly along the rhizome. They concluded that haloxyfop-methyl would be more effective in preventing bud regrowth than the other herbicides. Dekker (43) found that node viability reduction to be greatest in nodes closest to the treated leaf with sethoxydim, haloxyfop-methyl and fluazifop-butyl, whereas, with DPX-Y6202, node viability reduction was greatest at the terminal nodes of the rhizome.

Field Application. Effective control of quackgrass in soybeans has been obtained with single applicationns of haloxyfop-methyl at 0.25 to 0.84 kg/ha (47, 139), sethoxydim at 0.84 to 1.12 kg/ha (83, 136, 156), fluazifop-butyl at 0.28 to 0.56 kg/ha (70, 139, 157) and difenopenten at 0.56 to 0.84 kg/ha (47, 156).

Frequently, split or sequential applications of postemergence applied grass herbicides have increased quackgrass control over that obtained by single applications. The sequential application is usually made 7 or more days following the first application. There are several reasons to justify split application. Dekker (42) has estimated that 33 to 67% of quackgrass rhizomes in the soil are not available for shoot uptake of the herbicides at the time of an early postemergence application. In addition, Johnson and Buchholtz (80) have described "late-spring dormancy" in quackgrass characterized by a reduction in bud activity after early-spring growth till June at which time buds are essentially inactive. This is followed by an increase in bud activity from July on through the growing season. Leaky and Chancellor (89) attribute this bud dormancy to nitrogen depletion in the rhizomes due to translocation to early developing shoots. Therefore, in either of these two situations, a sequential application could control these later emerging shoots.

Split applications of sethoxydim at 0.3 plus 0.3 kg/ha and 0.56 plus 0.56 kg/ha resulted in increased quackgrass control compared to single application (38, 47, 81, 100, 152, 153). Similary, split applications of fluazifop-butyl at 0.28 plus 0.28 kg/ha gave

significantly higher quackgrass control than a single application at 0.56 kg/ha (32, 81, 116, 150). Kells (81) obtained significantly higher quackgrass control with a split versus single application of 0.56 kg/ha of RO-13-8895 but not with DPX-Y6202 or or haloxyfop-methyl.

Soil Residual Activity. Waldecker and Wyse (157) found no preemergence activity on rhizome quackgrass in the field from 0.8 kg/ha applications of sethoxydim, RO-13-8895 and difenopenten. However, in a greenhouse study, Kells (81) found near complete inhibition of shoot emergence from rhizomes with fluazifop-butyl at 0.56 kg/ha.

Effect of Cultural Practices on Quackgrass Control with Postemergence Applied Grass Herbicides. A cultivation 1, 7 or 14 days after application of difenopenten, RO-13-8895 and sethoxydim at 0.84 kg/ha did not significantly affect quackgrass control or soybean yields (156, 157). A cultivation 5 days after an application of fluazifop-butyl at 0.56 kg/ha also did not affect quackgrass control (155). However, in another study, a cultivation 14 days after a 0.56 kg/ha application of sethoxydim resulted in 91% quackgrass control at the end of the season compared to 73% without cultivation (100). Rapid soybean canopy development and narrow soybean rows have also improved quackgrass control with sethoxydim (38, 100, 150).

Primary tillage may influence quackgrass control with postemergence herbicide applications. Colby et al. (32) found that through fragmentation of rhizomes is necessary for quackgrass control with fluazifop-butyl at rates of 0.28 to 0.56 kg/ha while higher rates are necessary for control of undisturbed rhizome quackgrass. With

spring applications of fluazifop-butyl at 0.56 kg/ha, Wagner (155) obtained 89% control of quackgrass which had been moldboard plowed the previous fall compared to 79% in a no-till situation.

Tankmix Application. Antagonism due to tankmix applications was discussed previously regarding annual grasses. This same effect has been observed with quackgrass. Kells et al. (81, 83) found that tankmixes containing either bentazon or acifluorfen with 0.56 kg/ha applications of DPX-Y6202, sethoxydim, RO-13-8895 or fluazifop-butyl had significantly reduced quackgrass control compared to that obtained by the grass herbicides applied alone. Increasing the rates of the grass herbicides from 0.56 to 1.12 kg/ha did not overcome the antagonistic response. Similar tankmixes with haloxyfop-methyl did not affect absorption and translocation of fluazifop-butyl (81).

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CHAPTER 2

POSTEMERGENCE SYSTEMS FOR THE CONTROL OF ANNUAL WEEDS IN SOYBEANS (*Glycine max* (L.) Merr.)

ABSTRACT

Soybean experiments were conducted in 1982 and 1983 to evaluate control of annual broadleaf and grass weeds with postemergence applied herbicides and a standard preemergence treatment of alachlor (2-chloro-2',6'-diethyl-*N*-(methoxymethyl)acetanilide) plus metribuzin (4-amino-6-*tert*-butyl-3-(methylthio)-*as*-triazin-5(4*H*)-one). This standard treatment gave near complete control of all weeds in both years. Postemergence applications consisted of four postemergence grass herbicides, each tank-mixed with acifluorfen (5-(2-chloro-4-(trifluoromethyl)phenoxy)-2-nitrobenzoic acid) and bentazon (3-isopropyl-1*H*-2,1,3-benzothiadiazin-4(3*H*)-one-2,2-dioxide). Nearly complete control of annual grasses was obtained from treatments containing sethoxydim (2-(1-(ethoxyimine)-butyl)-S-(2-ethylthiopropyl)-3-hydroxy-2-cyclohexene), fluazifop-butyl ((+)butyl 2-(4-((5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate), haloxyfop-methyl (methyl 2-(4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl) oxy) phenoxy)

propanoate) and in DPX-Y6202 (2-(4-((6-chloro-2-quinoxalinyl)oxy)-propionic acid) except in 1983 where poor control of yellow foxtail (Setaria lutescens (Wiegel) Hubb.) was obtained with treatments containing fluazifop-butyl. Treatments containing acifluorfen resulted in significantly higher control of redroot pigweed (Amaranthus retroflexus L.) and common ragweed (Ambrosia artemisiifolia L.) than those containing bentazon, although, in 1982 no postemergence teatment prevented the emergence and growth of common lambsquarters (Chenopodium album L.) which occurred after applications and prevented harvesting. In 1983, the standard preemergence treatment resulted in significantly higher soybean yields than treatments containing acifluorfen which were significantly higher than those containing bentazon. A cultivation 4 weeks after postemergence applications significantly increased late-season broadleaf control and soybean yields of treatments containing bentazon, but not of those containing acifluorfen. Metribuzin applied preemergence followed by postemergence applications of grass herbicides resulted in effective weed control but yields tended to be significantly lower than the standard preemergence treatment. A cultivation 3 days following applications of postemergence grass herbicides did not reduce grass control, but did not effectively control broadleaf weeds.

INTRODUCTION

Effective weed control is a critical aspect of soybean (*Glycine max* (L.) Merr.) production and for years growers have used various soil applied herbicides for the control of annual weeds. Acifluorfen (5-(2-chloro-4-(trifluoromethyl)phenoxy)-2-nitrobenzoic acid) and bentazon (3-isopropyl-1*H*-2,1,3-benzothiadiazin-4(3*H*)-one-2,2-dioxide) are herbicides which control certain broadleaf weeds when applied postemergence. Recently, new herbicides have been developed for the control of grasses through postemergence applications. Therefore, the potential now exists for broadspectrum weed control in soybeans with postemergence applications of tankmixed grass and broadleaf herbicides.

However, utilization of postemergence weed control systems means that both crop and weeds would emerge and grow together until the weeds are at the proper growth stages for herbicide application. The duration of this weed-crop interference can affect soybean yield (2, 3, 11).

In an extensive cost/return study, total postemergence weed control systems utilizing sethoxydim (2-(1-(ethoxyimino)-butyl)-5-(2-ethylthiopropyl)-3-hydroxy-2-cyclohexene) for grass control plus either acifluorfen or bentazon compared very favorably with normal farmer practices (7). However, antagonism in the form of reduced grass control often occurs when acifluorfen and/or bentazon are tankmixed with sethoxydim, fluazifop-butyl ((±)butyl 2-(4-((5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate), and haloxyfop-methyl (methyl 2-(4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate) (4, 8, 10, 12). While acifluorfen and bentazon have little soil activity for weed control, residual control of annual grasses has been obtained with haloxyfop-methyl (1, 5, 9) and fluazifop-butyl (1, 6, 9). However, soil residual control with sethoxydim is limited (1, 9). These factors may affect season-long control of weeds.

A 2 year field study was conducted to evaluate several postemergence weed control systems in soybeans with tankmix applications of acifluorfen and bentazon with sethoxydim, fluazifop-butyl, haloxyfop-methyl and DPX-Y6202 (2-(4-((6-chloro-2-quinoxalinyl)oxy)propionic acid). Weed control and soybean yields with these treatments were compared to standard preemergence applications of alachlor (2-chloro-2',6'-diethyl-*N*-(methoxymethyl)acetanilide) plus metribuzin (4-amino-6-*tert*-butyl-3-(methylthio)-*as*-triazin-5(4*H*)-one).

MATERIALS AND METHODS

Field experiments were conducted in 1982 and 1983 on adjacent areas of a Capac loam (pH 6.7) located at the Michigan State University Agricultural Experiment Station in East Lansing. Both areas were fallow the year prior to initiation of experiments and were moldboard plowed the preceding fall.

All postemergence herbicide applications were made with a compressed air tractor sprayer utilizing flat fan nozzles at a spray volume of 262 L/ha at 324 kPa. Preemergence applications were made in 215 L/ha at 208 kPa. The experimental design was a randomized complete block with four replications. Soybean row spacing was 76 cm and plot size was four rows by 10 meters. Visual ratings of weed control were made at several times following herbicide application. Ratings were based on a 0 to 10 scale where 0 indicated no weed control and 10 indicated complete control. Untreated control plots were used as the basis for no control. Rating data were converted to decimal form, subjected to the arcsin data transformation and then analyzed for mean separation using Duncan's multiple range test. Weed control data presented here have been converted to percent. No herbicide treatment caused any lasting visual crop injury and therefore such data are not presented.

The 1982 experimental area was planted with 'Hodgson 78' soybeans on May 20. Preemergence applications were made on May 26. Early postemergence applications of herbicides were made on June 14. Soybeans were in the first to second trifoliolate (V2 to V3). Weeds present, growth stages and approximate densities were: barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.) two to four leaves and 7.6 to 10.2 cm tall, 54 to 108 plants/m^2; common ragweed (*Ambrosia artemisiifolia* L.) two to four leaves and 4.0 cm tall, 11 to 32 plants/m^2; redroot pigweed (*Amaranthus retroflexus* L.) two to four leaves and 3 cm tall, 11 to 54 plants/m^2; and common lambsquarters (*Chenopodium album* L.) cotyledon stage, 1.0 to 1.5 cm tall and approximately 5 plants/m^2.

DPX-Y6202 was not available for the early postemergence application. Late postemergence applications of herbicides were made on June 27. Soybeans were in the three to four trifoliolate (V4 to V5) leaf stage. Weed growth stages at this time were: barnyardgrass, five to seven leaves and 10.2 to 20.3 cm tall; common ragweed, nine leaves and 7.6 to 12.7 cm tall; and common lambsquarters cotyledon to two leaves and 1.0 to 2.0 cm tall. Weed densities were similar to those at the time of the early postemergence applications. Weed control evaluations were made on July 17, 1982. In this experiment, the commercially formulated acifluorfen contained surfactant and thus no further additions of adjuvants were made. All other treatments contained added crop oil concentrate at a volume of 2.3 L/ha. This formulation of acifluorfen was discontinued following the 1982 season.

The 1983 experimental area was planted on May 17. The left two rows of each plot were planted with 'Harcor' and the right two with 'Corsoy' variety soybeans. Preemergence applications were made on May 21. Early postemergence applications of herbicides were made on June 20. Soybeans were in the second trifoliolate (V3) leaf stage. Weeds present, growth stages and approximate densities were: yellow foxtail (*Setaria lutescens* (Wiegel) Hubb.), three to four leaves, 5.0 to 10.2 cm tall and 54 plants/m^2; common ragweed, four to six leaves, 5.0 to 10.2 cm tall, 54 plants/m^2; and redroot pigweed, four leaves, 10.2 cm tall and 11 plants/m^2. Late postemergence applications of postemergence grass herbicides were made on July 9 to plots which received a preemergence application of metribuzin. The only weed present was yellow foxtail, three to five leaves and 10.2 to 15.2 cm tall, 10 to 15 plants/plot. Soybeans were in the fourth trifoliolate (V5) leaf stage. Cultivation treatments were made to the two center rows of the plots with a two-row tractor-mounted cultivator. Early cultivation treatments were made on June 23 and late cultivations on July 18. Weed control evaluations were made on July 5, July 18 and September 20. The two center rows of each plot were harvested for soybean yield on October 20 with a small-plot combine.

RESULTS AND DISCUSSION

All early postemergence tankmix applications of the four grass herbicides plus acifluorfen provided good to excellent control of barnyardgrass, common ragweed and redroot pigweed (Table 1). Bentazon was not effective in this system due to its low phytotoxicity to the broadleaf weeds present. No early postemergence treatment provided adequate control of common lambsquarters which evidently had not fully emerged at the time of the early postemergence applications. Reducing the rate of haloxyfop-methyl from 0.28 to 0.14 kg/ha did not result in reduced barnyardgrass control. The standard preemergence treatment of alachlor plus metribuzin controlled all weeds present.

Late postemergence application of treatments containing acifluorfen to larger weeds did not decrease the control of common ragweed and redroot pigweed (Table 2). Bentazon was ineffective as a

Table 1. Control of annual weeds in soybeans with herbicides applied early postemergence. East Lansing, MI; 1982[a].

Postemergence treatment[c]	Rate	Weed control[b]			
		Bygr[d]	Corw[d]	Rrpw[d]	Colq[d]
	(kg/ha)	--------%			--------
Sethoxydim + acifluorfen	0.28 + 0.56	99 e-f	95 f-g	94 c-d	25 a-e
Fluazifop-butyl + acifluorfen	0.28 + 0.56	100 f	98 f-g	95 c-e	33 a-g
Haloxyfop-methyl + acifluorfen	0.14 + 0.56	100 f	98 f-g	81 c	55 d-i
Haloxyfop-methyl + acifluorfen	0.28 + 0.56	100 f	98 f-g	88 c-d	38 b-g
Haloxyfop-methyl + bentazon	0.14 + 0.84	100 f	58 c-e	0 a	39 b-g
Haloxyfop-methyl + bentazon	0.28 + 0.84	100 f	48 c-e	18 a	18 a-c
Standard preemergence treatment					
Alachlor + metribuzin	2.24 + 0.42	96 e	99 f-g	100 e	99 j

[a]Means within an evaluation followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Weed control evaluated on 7/19/83.

[c]Treatments containing bentazon included crop oil concentrate at 2.3 L/ha.

[d]Bygr = barnyardgrass, Corw = common ragweed, Rrpw = redroot pigweed, and Colq = common lambsquarters.

Table 2. Control of annual weeds in soybeans with herbicides applied late postemergence. East Lansing, Mi; 1982[a].

Postemergence treatment[c]	Rate	Weed control[b] Bygr[d]	Corw[d]	Rrpw[d]	Colq[d]
	(kg/ha)	%			
Sethoxydim + acifluorfen	0.28 + 0.56	79 c-d	98 f-g	100 e	71 h-1
Fluazifop-butyl + acifluorfen	0.28 + 0.56	75 c	95 f-g	100 e	50 c-i
DPX-Y6202 + acifluorfen	0.28 + 0.56	88 d	100 g	100 e	38 b-g
DPX-Y6202 + bentazon	0.28 + 0.84	100 f	60 d-e	0 a	34 a-g
Haloxyfop-methyl + acifluorfen	0.14 + 0.56	86 c-d	100 g	100 e	54 d-i
Haloxyfop-methyl + acifluorfen	0.28 + 0.56	98 e-f	99 f-g	100 e	59 f-i
Haloxyfop-methyl + bentazon	0.14 + 0.84	100 f	10 a-b	0 a	0 a
Haloxyfop-methyl + bentazon	0.28 + 0.84	100 f	30 a-c	0 a	0 a
Standard preemergence treatment					
Alachlor + metribuzin	2.24 + 0.42	96 f	99 f-g	100 e	99 j

[a]Means within an evaluation followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Weed control evaluated on 7/19/83.

[c]Treatments containing bentazon included crop oil concentrate at 2.3 L/ha.

[d]Bygr = barnyardgrass, Corw = common ragweed, Rrpw = redroot pigweed, and Colq = common lambsquarters.

late postemergence treatment for the control of these weeds.

Barnyardgrass control from postemergence treatments containing sethoxydim and fluazifop-butyl was significantly lower when applied to grass in the five to seven leaf stage than to grass in the two to four leaf stage (Table 1). Barnyardgrass control from haloxyfop-methyl plus acifluorfen at 0.14-plus 0.56 kg/ha was significantly lower when applied late postemergence compared to early postemergence (86 v. 100%). Increasing the rate of haloxyfop-methyl to 0.28 kg/ha significantly increased barnyardgrass control and there was no significant difference in control between the two times of application with this rate. However, this was not observed from late postemergence applications of the lower rate of haloxyfop-methyl tankmixed with bentazon as this treatment resulted in 100% control (Table 2). Similarly, late postemergence applications of DPX-Y6202 plus acifluorfen resulted in significantly lower barnyardgrass control than DPX-Y6202 plus bentazon (88 v. 100%, Table 2). This shows that acifluorfen can cause an antagonistic response in annual grass control when applied in a tankmix with postemergence grass herbicides.

As with early postemergence applications, later postemergence applications of treatments were still ineffective in controlling common lambsquarters. Major emergence of this weed occurred after the late postemergence applications, thus, postemergence applications were ineffective since only sprayed weeds were controlled. Rapid growth of common lambsquarters occurred prior to full crop canopy development and was undoubtedly aided by lack of interference from other weeds that

were controlled from the herbicide applications. Common lambsquarters growth was so prolific that by the end of the season the plots could not be mechanically harvested. Even though common lambsquarters interference occurred after the critical soybean growth stages which most directly affect yield, ease of harvest is of major importance to a grower. Since by midseason it was evident that none of the postemergence treatments applied would be viable methods for soybean production, no further evaluations were made. In 1982, postemergence weed control systems did not compare favorably with the standard preemergence treatment of alachlor plus metribuzin.

The 1983 postemergence weed control systems were deisgned to deal with some of the problems encountered in 1982. These included mechanical cultivations, no late postemergence applications to weeds (particularly grasses) potentially too large to control, and utilization of soil applied broadleaf herbicides followed by postemergence grass herbicides. In addition, in 1983 the grass herbicide rates were reduced to 0.14 kg/ha based on the success in 1982 of early postemergence applications with 0.28 kg/ha. This would subsequently reduce costs to growers should all of these herbicides receive registration for use in soybeans.

In 1983, yellow foxtail was the predominant grass species present. Common ragweed and redroot pigweed were also present as in 1982. However, there was no common lambsquarters present as in 1982.

Good to excellent season-long control of yellow foxtail was obtained from postemergence applications of treatments containing

sethoxydim, DPX-Y6202 and haloxyfop-methyl (Table 3). Of these, only applications of haloxyfop-methyl resulted in reduced foxtail control when tankmixed with acifluorfen compared to bentazon, and this occurred a the late-season rating only. However, this reduction in control was not severe.

Applications of fluazifop-butyl with both acifluorfen and bentazon resulted in very poor and significantly reduced yellow foxtail control at the midseason rating compared to the other postemergence grass herbicides. Although growth was slowed, the grass had not become necrotic as with the other grass herbicides. By late season, the yellow foxtail treated with fluazifop-butyl plus acifluorfen was eventually controlled, but those treated with fluazifop-butyl plus bentazon were not. It is not clear why this occurred in 1983 but not in 1982, although, the species were different in the two years.

As in 1982, acifluorfen provided greater control of the broadleaf weeds present than acifluorfen. However, the standard preemergence treatment of alachlor plus metribuzin resulted in significantly greater broadleaf weed control than any postemergence treatment at the midseason rating and was still showing complete control of all weeds at the late season rating.

Because of the season-long weed control, the standard preemergence treatment had significantly higher soybean yields than any other treatment including the hand-hoed weed-free treatment. In spite of caution, hand-hoeing occasionally injured or removed some soybean plants plus caused considerable soil disturbance throughout the season,

Table 3. Control of annual weeds in soybeans with herbicides applied early postemergence.

East Lansing, Mi; 1983[a].

		Weed control[b]						
		Midseason			Late season			
Postemergence treatment[c]	Rate	Yeft[d]	Rrpw[d]	Corw[d]	Yeft[d]	Rrpw[d]	Corw[d]	Soybean Yield
	(kg/ha)	----------%----------			-----------%---------			(kg/ha)
Sethoxydim + acifluorfen	0.14 + 0.56	85 f-h	65 f-j	85 h-k	95 c-e	93 j-o	94 j-k	2602 g-i
Sethoxydim + bentazon	0.14 + 0.84	71 b-f	20 a-c	5 a	90 b-e	20 a-b	20 a-c	1893 c-d
Fluazifop-butyl + acifluorfen	0.14 + 0.56	33 a-b	60 e-i	85 i-l	95 c-e	88 h-o	93 h-k	2410 e-h
Fluazifop-butyl + bentazon	0.14 + 0.84	30 a	53 d-i	14 a-b	47 a	37 a-f	20 a-c	1785 b-d
DPX-Y6202 + acifluorfen	0.14 + 0.56	98 h-i	53 d-i	85 h-k	95 c-e	89 h-o	90 h-k	2496 f-h
DPX-Y6202 + bentazon	0.14 + 0.84	100 i	18 a-b	20 a-c	100 e	33 a-e	28 a-d	2049 c-f
Haloxyfop-methyl + acifluorfen	0.14 + 0.56	86 f-h	43 b-g	78 g-j	85 b-d	83 g-n	93 h-j	2593 g-i
Haloxyfop-methyl + bentazon	0.14 + 0.84	99 h-i	33 a-e	14 a-b	100 e	15 a	13 a-b	1906 c-d
Standard preemergence treatment								
Alachlor + metribuzin	2.24 + 0.42	100 i	100 n	100 m	100 e	100 o	100 l	3244 j
Hand-hoed weed free								2641 g-i
No treatment								1295 a-b

[a]Means within an evaluation followed by a common letter are not significant different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of weed control evaluations are: midseason - 7/18/83 and late season - 9/20/83

[c]Postemergence treatments contained crop oil concentrate at 2.3 L/ha except for those with bentazon and 1/2 L/ha with acifluorfen.

[d]Yeft = yellow foxtail, Rrpw = redroot pigweed, Corw = common ragweed.

whereas, the standard preemergence treatment was completely undisturbed. Reflective of weed-control ratings, treatments of grass herbicides containing acifluorfen yielded significantly more than those containing bentazon, except with DPX-Y6202. Although not significantly different statistically, the yield from a treatment of DPX-Y6202 plus bentazon was numerically less than that of DPX-Y6202 plus acifluorfen.

Table 4 shows the effects on weed control and yields of a cultivation approximately 4 weeks after postemergence applications of herbicides. Midseason ratings were taken immediately prior to the cultivation. Cultivations are particularly beneficial in increasing broadleaf control in plots treated with bentazon. Due to this increased broadleaf control, there was no significant difference in yield whether with acifluorfen or bentazon when a cultivation was performed. However, cultivations did not increase yields of treatments containing acifluorfen (Tables 3 and 4). Cultivation also provided significantly greater control of yellow foxtail with fluazifop-butyl plus bentazon (Tables 3 and 4).

Treatments of herbicide plus cultivation had significantly higher soybean yields than either no treatment or early cultivation plus late cultivation. There were no significant differences in yield between any of the postemergence herbicide plus cultivation treatments whereas without cultivations, the treatments containing acifluorfen yielded significantly more than those containing bentazon (Table 3). However, the standard preemergence treatment yielded significantly more than

most of the postemergence herbicide plus cultivation treatments (Table 4).

Although cultivations can increase broadleaf weed control with herbicide treated plots, a cultivation cannot substitute for broadleaf weed control with herbicides. Early postemergence applications of grass herbicides only followed 3 days later with a cultivation resulted in severe broadleaf pressure, particularly from common ragweed later in the season (Table 5). Yellow foxtail control remained excellent for the duration of the season despite a cultivation 3 days after application. However, yields from all herbicide treatments except haloxyfop-methyl, were not significantly higher than the control and there were no significant differences between yields from the herbicide treatments themselves. This is not a presentable option for broadspectrum weed control.

Since broadleaf weeds are seemingly more difficult to control season-long with postemergence herbicides, it may be practical to make a preemergence application of metribuzin for broadleaf weed control followed by a late postemergence application of grass herbicides (Table 6). Since metribuzin has some preemergence grass acitivity, the grass herbicide rate was reduced to 0.07 kg/ha. The early-season weed control evaluation showed very good broadspectrum weed control from metriuzin only. The significant contribution of alachlor to broadspectrum weed control with alachlor plus metribuzin was also seen. Addition of postemergence grass herbicides was able to maintain high levels of yellow foxtail control. However, such applications may be

Table 4. Control of annual weeds in soybeans with herbicides applied early postemergence followed by a late cultivation. East Lansing, Mi; 1983[a].

		Weed control[b]						
		Midseason			Late season			
Postemergence treatment[c]	Rate	Yeft[d]	Rrpw[d]	Corw[d]	Yeft[d]	Rrpw[d]	Corw[d]	Soybean Yield
	(kg/ha)	-----------%---------			-----------%---------			(kg/ha)
Sethoxydim + acifluorfen	0.14 + 0.56	97 g-i	60 3-i	86 i-l	97 c-e	93 j-o	97 k-l	2786 h-j
Sethoxydim + bentazon	0.14 + 0.84	46 a-d	25 a-d	25 a-d	84 a-d	85 h-n	78 g-h	2661 g-i
Fluazifop-butyl + acifluorfen	0.14 + 0.56	38 a-c	68 g-j	80 g-k	90 b-e	96 m-o	98 k-l	2766 h-j
Fluazifop-butyl + bentazon	0.14 + 0.84	30 a	18 a-b	15 a-b	85 b0d	93 j-o	70 f-g	2860 h-j
DPX-Y6202 + acifluorfen	0.14 + 0.56	93 f-i	58 e-i	85 h-k	96 c-e	94 k-o	96 j-l	2747 g-i
DPX-Y6202 + bentazon	0.14 + 0.84	98 g-i	10 a	20 a-c	100 e	68 d-l	66 e-g	2573 g-i
Haloxyfop-methyl + acifluorfen	0.14 + 0.56	48 a-e	68 g-j	88 j-l	80 a-d	96 m-o	98 k-l	2680 g-i
Haloxyfop-methyl + bentazon	0.14 + 0.84	85 f-h	25 a-d	10 a	98 d-e	76 f-n	64 e-g	2235 d-g
Standard preemergence treatment								
Alachlor + metribuzin	2.24 + 0.42	100 i	100 n	100 m	100 e	100 o	100 l	3244 j
Early cultivation; late cultivation								1630 b-c
Hand-hoed weed free								2641 q-i
No treatment								1295 a-b

[a]Means within evaluation followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of weed control evaluation are: midseason - 7/18/83 and late season - 9/20/83. Midseason rating taken prior to cultivation.

[c]Postemerqence treatments contained crop oil concentrate at 2.3 L/ha except for those with bentazon and 1.2 L/ha with acifluorfen.

[d]Yeft = yellow foxtail, Rrpw = redroot pigweed, Corw = common ragweed.

Table 5. Control of annual weeds in soybeans with postemergence applications of grass herbicides followed by an early cultivation. East Lansing, Mi; 1983[a].

Postemergence treatment[c]	Rate	Weed control[b] Midseason Yeft[d]	Rrpw[d]	Corw[d]	Late season Yeft[d]	Rrpw[d]	Corw[d]	Soybean Yield
	(kg/ha)	-----	%	-----	-----	%	-----	(kg/ha)
Sethoxydim	0.14	94 f-i	53 d-i	48 d-f	100 e	60 a-i	13 a-b	1669 b-c
Fluazifop-butyl	0.14	94 f-i	65 f-j	70 g-i	98 d-e	66 c-k	10 a-b	1626 b-c
DPX-Y6202	0.14	95 f-i	73 h-k	45 c-e	94 c-e	58 a-h	10 a-b	1604 b-c
Haloxyfop-methyl	0.14	08 g-i	68 g-j	68 f-h	100 e	80 g-n	10 a-b	1937 c-e
Standard preemergence treatment								
Alachlor + metribuzin	2.24 + 0.42	100 i	100 n	100 m	100 e	100 o	100 l	3244 j
Early cultivation; late cultivation								1630 b-c
Hand-hoed weed free								2641 g-i
No treatment								1295 a-b

[a]Means within an evaluation followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of weed control evaluations are: midseason - 7/18/83 and late season - 9/20/83.

[c]Postemergence treatments contained crop oil concentrate at 2.3 L/ha except for those with bentazon and 1.2 L/ha with acifluorfen.

[d]Yeft = yellow foxtail, Rrpw = redroot pigweed, Corw = common ragweed.

Table 6. Control of annual weeds in soybeans with a preemergence application of metribuzin followed by postemergence applications of grass herbicides. East Lansing, Mi; 1983[a].

	Weed control[b]									
	Early season			Midseason			Late season			Soybean
Treatment[c]	Yeft[d]	Rrpw[d]	Corw[d]	Yeft[d]	Rrpw[d]	Corw[d]	Yeft[d]	Rrpw[d]	Corw[d]	Yield
	--------	%	--------	--------	%	--------	--------	%	--------	(kg/ha)
Metribuzin + sethoxydim	83 c-i	97 g-h	93 j-n	85 f-h	92 l-m	93 k-l	93 c-e	94 l-o	84 j-k	3072 i-j
Metribuzin + fluazifop-butyl	90 f-j	97 g-h	97 l-n	75 c0g	90 k-m	83 h-k	90 b-e	93 j-o	88 h-k	2590 g-i
Metribuzin + DPX-Y6202	77 c-h	83 e-g	83 g-l	81 d-h	85 j-m	85 h-k	96 c-e	98 n-o	89 h-k	2557 g-i
Metribuzin + haloxyfop-methyl	90 f-j	76 e-f	89 i-m	81 d-h	91 l-m	91 j-l	91 b-e	100 o	93 h-k	2701 g-i
Standard preemergence treatment[e]										
Alachlor + metribuzin	100 j	100 h	100 n	100 i	100 n	100 m	100 e	100 o	100 l	3244 j
Hand-hoed weed free										2641 g-i
No treatment										1295 a-b

[a]Means within an evaluation followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of weed control evaluations are: early season - 7/5/83, midseason - 7/18/83 and late season - 9/20/83.

[c]Preemergence applications of metribuzin - 0.42 kg/ha; postemergence applications of grass herbicides at 0.07 kg/ha plus crop oil concentrate at 2.3 L/ha.

[d]Yeft = yellow foxtail, Rrpw = redroot pigweed, Corw = common ragweed.

[e]Standard preemergence treatment: Alachlor and metribuzin at 2.24 + 0.42 kg/ha, respectively.

unnecessary and give low cost/benefit returns due to the relatively high levels of grass control from metribuzin itself and the low grass densities at the time of application of postemergence grass herbicides. It would be considerably easier and more economical to make a single broadspectrum preemergence application rather than one application each for broadleaf and grass control.

SUMMARY

Postemergence tankmix applications of grass and broadleaf herbicides effectively controlled treated weeds if the proper broadleaf herbicide was matched to the weed problem. In these experiments, acifluorfen was more effective than bentazon in controlling the broadleaf weeds present. Poor weed control and low yields from treatments containing bentazon were increased with cultivations. However, lack of soil residual activity for late emerging weeds and for those not adequately covered with spray compounded with potential for reduced grass control (antagonism) with tankmixes were some of the shortcomings of a total postemergence weed control system in soybeans. The standard preemergence treatment of alachlor plus metribuzin was consistantly higher in both weed control and soybean yields than postemergence applications and were easier to apply requiring fewer trips across a field.

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CHAPTER 3

QUACKGRASS (*Agropyron repens* (L.) Beauv.) CONTROL IN SOYBEANS (*Glycine max* (L.) Merr.)

ABSTRACT

Experiments to evaluate quackgrass (*Agropyron repens* (L.) Beauv.) control in soybeans (*Glycine max* (L.) Merr.) were established at several locations under different tillage and crop rotation systems. Nonselective herbicides glyphosate (*N*-(phosphonomethyl)glycine) and SC-0224 (trimethylsulfonium carboxymethylaminomethyl phosphonate) provided poor control of quackgrass growing in tall wheat (*Triticum aestivum* L.) stubble due to poor coverage. Excellent control was obtained with both herbicides at other locations with spring and fall applications except with spring applications following fall moldboard plowing. Greater quackgrass control one year after spring application of glyphosate was obtained in a no-till soybean field which had been tilled and planted to soybeans the season prior to treatment than in one in which no crop had been planted the previous season and had developed a quackgrass sod. Significantly lower quackgrass control was obtained with 0.84, 1.68 and 2.52 L/ha of glyphosate applied in a spray volume of 37 L/ha

than in 65, 131 or 262 L/ha. Postemergence applications of the grass herbicide haloxyfop-methyl (methyl 2-(4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl)oxy)propanoate), DPX-Y6202 (2-(4-((6-chloro-2-quinoxalinyl)-oxy)propionic acid), and fluazifop-butyl (($\pm$butyl-2-(4-((5-trifluoromethyl)-2-pyridinyl)oxy)phonoxy)propanoate) were generally more effective than sethoxydim (2-(1-(ethoxyimino)butyl)-5-(2-(ethylthio)propyl)3-hydroxy-2-cyclohexen-1-one). Early postemergence applications following spring moldboard plowing to 10 to 15 cm tall quackgrass with two to three leaves were not as effective as later or split applications because spring plowing prohibited uniform shoot emergence. However, all applications were equally effective in a spring moldboard plowed, narrow-row soybeans situation as well as wide-row soybeans which had been fall moldboard plowed, fall chisel plowed or in no-till. Fall applications of postemergence grass herbicides did not provide season-long quackgrass control the following season. Cultivations were as effective as a second application of herbicide. Despite varying levels of quackgrass control from different herbicide treatments, nearly all treatments resulted in significantly increased yields over no-treatment when applied prior to the five-leaf stage of quackgrass. Higher subsequent season control was obtained with nonselective than selective-postemergence herbicides.

INTRODUCTION

Quackgrass is considered to be one of the world's worst weeds (7, 11). In corn, there are several effective soil applied herbicides available for quackgrass control, but none are available in soybeans. Glyphosate (N(phosphonomethyl)glycine) is a non-selective herbicide which effectively controls quackgrass with four or more leaves when applied in the spring before tillage or in the fall after harvest (1, 4, 8). Tillage and time of application have been shown to influence quakgrass control with glyphosate. For example, spring applications following fall plowing are ineffective because all shoots had not emerged at the time of application (3, 14, 15). Fall applications have been shown to be more effective than spring applications (2, 9, 142).

Selective postemergence applied grass herbicides are new herbicides which have demonstrated effective quackgrass control. Applications of sethoxydim (2-(1-(ethoxyimino)butyl)-5-(2-(ethylithio) propyl)3-hydroxy-2-cyclohexen-1-one), fluazifop-butyl ((±)-butyl-2 (4-((5-trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate), haloxyfop-methyl (methyl 2-(4-((3-chloro 5-(trifluoromethyl)-2-pyridinyl)oxy) propanoate) and DPX-Y6202 (2-(4-((6-chloro-2-quinoxalinyl)oxy)propionic pyridinyl)oxy)phonoxy)propanoate) have been shown to be more effective in controlling quackgrass in the three- to five-leaf stage than at

later stages (5, 6, 10, 13, 16). However, just as quackgrass control with glyphosate is influenced by various cultural factors, so may be the postemergence grass herbicides. Therefore, the objectives of this research were to 1) evaluate quackgrass control with postemergence applied grass herbicides under several tillage and cultural systems and compare control to that obtained from applications of the nonselective herbicides glyphosate and SC-0224 (trimethylsulfonium carboxymethyl aminomethyl phosphonate) and, 2) determine the effects of these control measures on soybean yield.

MATERIALS AND METHODS

Field experiments were conducted in 1982 and 1983 at five locations in areas of dense quackgrass infestation. All herbicide applications were made with a compressed air tractor sprayer using flat fan nozzles. Visual ratings of quackgrass control were made at several times following herbicide application. Ratings were based on a 0 to 10 scale where 0 indicated no quackgrass control and 10 indicated complete control. Untreated control plots were used as a basis for no control. Rating data were converted to decimal form, subjected to the arcsin data transformation and then analyzed for mean separation using Duncan's multiple range test. Presented means are non-transformed and expressed as percent. Rates of glyphosate and SC-0224 are expressed on an acid equivalent basis. Postemergence grass herbicides were applied as early postemergence, late postemergence and split applications. A

split applicaion means that half of the total rate was applied early postemergence and half applied late postemergence. Two weeks separated early and late postemergence applications. No treatment resulted in soybean injury.

The first experiment was established in Clinton County in 1982 near Dewitt, Michigan on a Capac loam. The field had been planted to wheat in 1980 and harvested in 1981, and had not been tilled following harvest. The entire area contained 35 to 40 cm tall wheat stubble. All herbicide applications were made in a spray volume of 215 L/ha at a pressure of 208 kPa. Preplant applications of nonselective herbicides were made on May 16, 1982 when the quackgrass was 20 to 30 cm tall with four to six leaves. Half of the experimental area was moldboard plowed and disked on May 20, 1982, and the other half was left no-till. The experimental design was a randomized complete block with a split with four replications, the main factor being tillage. The field was not able to be planted at the same time. The conventional-till half was planted on May 25 and the no-till half was planted on June 2, following a burn-down application of paraquat at 1.12 kg/ha on May 25. The soybean variety planted was "Hodgson 78" with a 76 cm row spacing. A preemergence application of alachlor (2-chloro-2',6'-diethyl-*N*-(methoxymethyl)acetanilide) and metribuzin (4-amino-6-*tert*-butyl-3-(methylthio)-*as*-triazin-5(*H*)-one) at 2.24 and 0.42 kg/ha was made following planting to control annual weeds. Plot size was four rows by 12.2 m. Due to the different planting dates, postemergence applications of herbicides were made on different dates.

Early postemergence applications were made on June 10 in conventional-till and on June 26 in no-till. Quackgrass at this time was 10 to 15 cm tall with three leaves and soybeans were in the first trifoliolate stage (V2) in both experiments. Late postemergence applications were made on June 26 in conventional-till to 20 to 25 cm tall quackgrass with four to five leaves and to soybeans in the second to third trifoliolate leaf stage (V3 to V4). In no-till, late postemergence applications were made on July 9 to 20 to 30-cm quackgrass and to soybeans in the third trifoliolate leaf stage (V4). Visual control ratings were taken June 25, July 18, August 1, September 24 and the next spring on May 5, 1983. Due to the heavy thatch layer of wheat stubble and desiccated quackgrass in no-till, poor seed placement occurred during planting and non-uniform soybean stand was established. Therefore, yields were taken only in the conventional-till portion of the experiment. Yields were taken on October 14 by randomly harvesting 3 m of each of the two center rows of each plot and a mechanical thresher was used to separate the soybean seeds.

A second quackgrass control experiment was established in 1982 on the Michigan State University Agricultural Experiment Station in East Lansing on a Capac loam. The field was moldboard plowed, disked and field cultivated on June 7 and planted to 'Evans' soybeans with 24 cm row spacing on June 8. Early postemergence applications of herbicides were made on June 25 when the quackgrass was 10 to 18 cm tall with three to four leaves and the soybeans were in the unifoliolate leaf stage (V1). Late postemergence applications were made on July 9 when

the quackgrass was 20 to 35 cm tall and had three to five leaves. All herbicide applications were made at a spray volume of 262 L/ha at 324 kPa. The experimental design was a randomized complete block with four replications. Plot size was six rows by 10.7 m. Visual ratings were taken on July 23 and October 11. The four middle rows of each plot were harvested for yield on November 14 using a small plot combine.

In 1983, another experiment was established on the Michigan State University Agricultural Experiment Station in East Lansing on a Colwood-Brookston loam This field had not been cropped since 1981 and a dense quackgrass sod had developed in 1982. Fall applications of herbicides were made on October 4, 1982 when the quackgrass was 10 to 20 cm tall with three to four leaves. Fall treatments were applied in a spray volume of 215 L/ha at 208 kPa. One month prior to this application, the tall, mature quackgrass was knocked down with a tandem disk. This operation was necessary because the existing quackgrass was too tall for spraying. However, the disk was set so that the underlying soil was not disturbed and only the quackgrass stems were knocked down. Control evaluations were made the next spring on May 15. Half of the field was moldboard plowed on November 15 and the other half remained no-till. Experimental design was a randomized complete block with a split, the main factor being tillage. There were three replications. Spring preplant applications of non-selective herbicides were made on May 16, 1983 when the quackgrass was 20 cm tall with three to four leaves. Four spray volumes were compared. These were 262, 131, 65 and 37 L/ha, all made at 324 kPa. Applications of

postemergence grass herbicides were all made in a volume of 262 L/ha at 324 kPa.

Early postemergence applications were made on July 5 when the quackgrass was 15 to 25 cm tall with three to five leaves and soybeans were in the third trifoliolate leaf stage (V4). Late postemergence applications of split treatment were made on July 18 to quackgrass in various stages of chlorosis and soybeans in the six trifoliolate leaf stage (V7). Cultivation treatments were made on July 18 with a two-row tractor-mounted cultivator to designated plots in conventional-till. Weed-free plots were maintained throughout the season in conventional-till with the tractor-mounted cultivator. Control evaluations of all treatments were made on August 4 and October 10 and in no-till the next spring on May 12, 1984. The two center rows of each plot were harvested for yield on October 28 with a small-plot combine.

Another experiment was established in 1983 at the Kellogg Biological Station near Hickory Corners, Michigan in Kalamazoo County on a Kalamazoo loam. The area had been planted to soybeans in 1982 and had not been tilled following harvest. Preplant applications of glyphosate were made on May 14 to quackgrass that was 20 to 30 cm tall with four to five leaves. Four spray volumes were compared. These were 262, 131, 65, and 37 L/ha all made at 324 kPa. An application of paraquat at 0.56 kg/ha was made on May 25 and the field was planted to 'Corsoy' soybeans with 76 cm row spacing on June 2. Plot size was four rows by 12.2 m. The experimental design was a randomized complete block with three replications. A preemergence

application of metolachlor (2-chloro-N-(2-ethyl-6-methyl-phenyl)-N-(2-methoxy-1-methylethyl)acetamide) plus metribuzin at 2.24 and 0.42 kg/ha was made on June 2 to control annual weeds. Early postemergence applications were made on June 22 when the quackgrass was 15 to 20 cm tall with three to five leaves and the soybeans were in the first trifoliolate leaf stage (V2). Late postemergence applications were made on July 6 to 25 to 30.5 cm tall quackgrass with five leaves. Control evaluations were made on July 26, October 7 and the next spring on May 3. The two center rows of each plot were harvested for yield with a small plot combine on October 18 with a small plot combine.

An experiment was also established in 1983 in Clinton County near Fowler, Michigan, on a Metamora-Capac sandy loam. The field had been planted to soybeans in 1982 and was chisel plowed following harvest. A preplant incorporated application of trifluralin (α,α,α-trifluoro-2,6-dinitro-N,N,-dipropyl-p0toluidine) plus metribuzin at 0.84 and 0.28 kg/ha was made on June 15 for the control of annual weeds. The field was planted to 'Hardins' soybeans with 76 cm row spacing on June 17. Plot size was four rows by 12.2 m. The experimental design was a randomized complete block with three replications. Early postemergence applications of herbicides were made on July 7 when the quackgrass was 10 to 15 cm tall with three to four leaves and the soybeans were in the unifoliolate to second trifoliolate leaf stage (V1 to V3). Late postemergence applications were made on July 20 when the quackgrass was 20 to 30 cm tall with four to five leaves and soybeans were in the four to six trifoliolate leaf stage (V5 to V7). Control evaluations were made on August 8 and October 8.

RESULTS AND DISCUSSION

Quackgrass control at the Dewitt Location from spring preplant applications of the nonselective herbicides glyphosate and SC-0224 was considerably less than that expected (Table 1). The 20 to 30 cm tall quackgrass was growing in 35 to 40-cm tall wheat stubble which interfered with herbicide coverage thereby reducing effectiveness. The wheat stubble had been cut that high due to the heavy quackgrass infestation at the time of wheat harvest the previous year as the combine operator raised the header to reduce quackgrass foliage intake. SC-0224 resulted in significantly greater quackgrass control than an equal rate of glyphosate at the midseason rating in no-till and at the ealy season, late season and next spring rating in conventional-till. Moldboard plowing was beneficial only for SC-0224 as the amount of control the next spring was significantly higher in conventional till than in no-till, although control with all treatments at this time was poor.

At this location, the selective postemergence applied grass herbicides were more effective in controlling quackgrass than were the non-selective herbicides (Table 2). The no-till planter and tractor tires pushed down most of the wheat stubble during planting such that

Table 1. Quackgrass control in no-till and conventional-till (spring moldboard plowed) soybeans with glyphosate and SC-0224. Dewitt, Mi; 1982[a].

Treatment	Rate	Quackgrass control[b]			
		Early season	Midseason	Late season	Next spring
	(kg/ha)	--------------	--------------	% --------------	--------------
No-Till					
Glyphosate	1.68	75 c-f	43 b	25 b-g	18 a-e
Glyphosate	2.52	90 g-h	69 e	43 g-i	34 b-h
SC-0224	1.68	88 f-g	69 e	30 d-h	13 a-d
Conv.-till					
Glyphosate	1.68	64 b-d	45 b-e	18 a-f	22 a-f
Glyphosate	2.52	76 d-f	56 c-d	33 e-i	24 a-f
SC-0224	1.68	83 e-g	69 e	50 h-j	55 g-l

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Early season-6/25/83, 6 weeks after application; Midseason-7/18/82, 9 weeks after application; Late season-9/24/83, 19 weeks after application, Next spring-5/6/83, 51 weeks after application.

Table 2. Quackgrass control in no-till and conventional-till (spring moldboard plowed) soybeans with postemergence grass herbicides applied early postemergence, late postemergence, and split applications. Dewitt, Mi; 1982[a].

		Quackgrass control[b]								
		Midseason			Late season			Next spring		
Treatment[c]	Rate	EP[d]	LP[e]	Split	EP[d]	LP[e]	Split	EP[d]	LP[e]	Split
	(kg/ha)	%								
No till										
Haloxyfop-methyl	0.56	99 p-q	89 k-o	99 q-r	86 n-r	86 n-r	85 m-q	66 j-o	58 h-m	75 l-p
Haloxyfop-methyl	1.12	100 r	91 l-o	100 r	95 r	90 p-r	95 r	85 o-q	68 k-o	88 p-q
Fluazifop-butyl	0.56	98 p-q	-	98 p-q	64 j-k	-	73 k-m	44 d-k	-	63 i-n
Fluazifop-butyl	1.12	100 r	69 g-i	100 r	71 k-l	74 k-n	80 l-p	46 e-k	28 a-g	58 h-m
Sethoxydim	0.56	83 j-l	-	98 p-q	51 i-j	-	39 f-i	40 c-j	-	18 a-e
Sethoxydim	1.12	89 k-o	63 e-h	100 r	43 g-i	36 f-i	50 h-j	34 b-h	15 a-e	33 a-h
Conv. -till										
Haloxyfop-methyl	0.56	74 h-j	94 n-p	93 m-p	64 j-k	94 q-r	93 q-r	48 f-k	88 p-q	88 p-q
Haloxyfop-methyl	1.12	84 k-m	95 o-q	93 m-p	86 n-r	94 q-r	91 p-r	76 l-q	93 q	81 p-q
Fluazifop-butyl	0.56	65 f-h	-	86 k-n	50 h-j	-	88 o-r	28 a-g	-	80 m-q
Fluazifop-butyl	1.12	80 i-k	90 l-o	93 m-p	69 k-l	93 q-r	81 p-r	56 g-l	90 p-q	83 n-q
Sethoxydim	0.56	33 b	-	73 h-j	28 c-g	-	63 j-k	0 a	-	55 g-l
Sethoxydim	1.12	50 c-e	83 j-l	83 j-l	38 f-i	80 l-p	75 k-o	23 a-f	78 l-q	58 h-m

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-7/18/82 (conventional-till) and 8/1/82 (no-till), 5 weeks after early postemergence applications; Late season-9/24/82, 13 weeks after early postemergence application in no-till and 15 weeks after early postemergence applications in conventional-till; Next spring-5/6/83, approximately 9 1/2 months after application.

[c]Treatments contained crop oil concentrate at 2.3 L/ha, with each application.

[d]EP = Early postemergence application.

[e]LP = Late postemergence application.

interference with herbicide coverage was not a factor with postemergence applications. Midseason control evaluations indicate that early postemergence applications to 10 to 15 cm tall quackgrass was significantly higher for each herbicide in no-till than similar applications in the spring-plowed conventional-tilled soybeans. The split applications of each herbicide treatment in conventional-till resulted in significantly higher midseason quackgrass control than did the early postemergence applications. However, in no-till, except for sethoxydim, there were no significant differences in control between early postemergence and split applications. Therefore, at this location spring tillage influenced control. Spring plowing disrupted the rhizomes and dispersed fragments at different depths such that shoot emergence evidently was not uniform and a second or later application was necessary to control later emerging shoots. However, in no-till, the rhizomes were able to initiate shoot growth more uniformly such that most shoots were controolled with a single early postemergence application.

By late season, very good quackgrass control was maintained in no-till with all applications of haloxyfop-methyl. No significant differences in control were seen between 0.56 and 1.12 kg/ha except with the split application where the higher rate provided greater control. In conventional-till, the late postemergence and split application of 0.56 kg/ha of haloxyfop-methyl provided significantly greater quackgrass control than the early postemergence applications. A rate effect was observed with the early postemergence application

where 1.12 kg/ha of haloxyfop-methyl resulted in significantly greater control than 0.56 kg/ha.

Split and late-postemergence applications of fluazifop-butyl were also more effective in late season control in conventional-till than the early postemergence applications. However, in no-till there were no significant differences in control between time of application. No sinificant differences in control were observed between 0.56 and 1.12 kg/ha.

Sethoxydim was less effective than either fluazifop-butyl or haloxyfop-methyl, particularly in the later evaluations. As with the other herbicides, no significant differences in control were observed by late season between the different times of application in no-till, although the late and split applications were more effective in conventional-till. Particularly poor late-season control was obtained with early postemergence applications in conventional-till.

Several treatments resulted in moderately high levels of control the next spring approximately 9.5 months after application, particularly the late-postemergence and split applictions of haloxyfop-methyl and fluazifop-butyl in conventional-till.

Evidently the undisturbed no-till generated more new rhizomes and hence more regrowth the next spring than did the moldboard plowed system even though tillage did not greatly affect infestation levels the year in which tillage was performed.

Due to the heavy thatch layer of the wheat stubble and desiccated qackgrass at the time of planting, an uneven soybean stand was

established as the soybean seed was not able to consistantly drop into the seed furrow. Therefore, only the conventional-till portion was harvested and yield data are shown in Table 3 for all treatments. Despite rather poor season-long control obtained by the non-selective and sethoxydim treatments, all treatments resulted in yields significantly greater than the untreated plots. Evidently, the early season control was adequate. Highest yields tended to come from late postemergence and split applications which reflected extent of quackgrass control. Herbicide treatments enabled an approximate three-fold yield increase over no treatment.

The East Lansing 1982 location, also was moldboard plowed in the spring; however, this location was planted with soybeans in 24 cm row spacing compared to 76 cm row spacing at the Dewitt location. Unlike the Dewitt location, there was no significant difference between quackgrass control obtained by early postemergence and split applications for fluazifop-butyl and sethoxydim (Table 4). Although split application resulted in significantly greater control, split and early postemergence applications of haloxyfop-methyl did not differ in the magnitude of control at this location that they did at the Dewitt loaction. High levels of control were also obtained from early postemergence applications of DPX-Y6202. Evidently, the narrow row spacing enhanced control of the single early postemergence applications by interfering with the later emerging shoots. Late postemergence applications were lower in midseason quackgrass control than early postemergence and split application possibly due to interference in

Table 3. Soybean yields in conventional-till (spring moldboard plowed) soybeans with non-selective and selective postemergence grass herbicides. Dewitt, Mi; 1982[a].

Treatment	Rate	Soybean yield[b]			
		Preplant	EP[c]	LP[d]	Split
		(kg/ha)			
Glyphosate	1.68	1199 b-c	-	-	-
Glyphosate	2.52	1317 b-e	-	-	-
SC-0224	1.68	1734 c-j	-	-	-
Haloxyfop-methyl	0.56	-	1530 b-h	2223 j	1833 e-j
Haloxyfop-methyl	1.12	-	1760 d-j	1946 h-j	2174 i-j
Fluazifop-butyl	0.56	-	1392 b-g	1580 b-h	1789 d-j
Fluazifop-butyl	1.12	-	1790 b-j	1535 b-h	1696 c-j
Sethoxydim	0.56	-	1258 b-d	1798 d-j	1715 c-j
Sethoxydim	1.12	-	1360 b-f	1707 g-j	1505 b-h
No treatment	-	-	556 a		

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Selective postemergence grass herbicide treatments contained crop oil concentrate at 2.3 L/ha, with each application.

[c]EP = Early postemergence application.

[d]LP = Late postemergence application.

Table 4. Quackgrass control in conventional-till (spring moldboard plowed), narrow-row soybeans with postemergence grass herbicides applied as early postemergence, late postemergence, and split applications. East Lansing, Mi; 1982[a].

		Quackgrass control[b]					
		Midseason			Late season		
Treatment[c]	Rate	EP[d]	LP[e]	Split	EP[d]	LP[e]	Split
	(kg/ha)	%					
Haloxyfop-methyl	0.56	88 g-i	65 c-e	96 j-k	84 f-j	99 o	98 n-o
Haloxyfop-methyl	0.84	86 g-i	88 g-i	98 k	84 f-j	96 m-o	95 l-o
DPX-Y6202	0.56	84 f-h	-	94 i-k	84 f-j	-	89 i-l
DPX-Y6202	0.84	84 f-h	81 f-g	96 j-k	84 f-j	91 j-m	95 l-o
Fluazifop-butyl	0.56	79 e-g	-	88 g-i	78 d-h	-	88 h-k
Fluazifop-butyl	0.84	86 g-i	58 b-c	93 i-k	86 g-k	93 k-n	91 j-m
Sethoxydim	0.56	79 e-g	-	88 g-i	71 c-e	-	81 e-i
Sethoxydim	0.84	81 f-g	45 a-b	85 f-i	76 d-g	68 c-d	81 e-i

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-7/23/82, 4 weeks after early postemergence applications; Late season-10/11/83, 15 weeks after early postemergence applications.

[c]All treatments contained crop oil concentrate at 2.3 L/ha, with each application.

[d]EP = Early postemergence application.

[e]LP = Late postemergence application.

coverage due to the soybeans in narrow rows. However, sufficient phytotoxicity resulted to enable improved control by late-season evaluations.

All treatments resulted in significantly higher yields than the untreated control, although no significant differences were found between treatments (Table 5). Some soybeans were run over with the tractor during late postemergence applications due to the narrow rows and the size of the soybeans at that time. However, complete recovery was observed and this did not affect yield.

At the East Lansing 1983 location, postemergence grass herbicides were applied to quackgrass under no-till and conventional-till situations, however, the conventional tillage was fall moldboard plowed and the no-till was in a quackgrass sod. Very high levels of quackgrass control were obtained season-long with all rates of haloxyfop-methyl and DPX-Y6202, even with 0.28 kg/ha which was not applied in the 1982 experiments (Table 6). There were no significant differences in control due to tillage rate or time of applications with these two herbicides.

There were no significant effects on control with 0.42 and 0.56 kg/ha of fluazifop-butyl due to tillage or time of application. However, with 0.28 kg/ha, single early postemergence applications in no-till resulted in significantly lower quackgrass control than split applications or single applications of 0.42 and 0.56 kg/ha.

Applications of sethoxydim were generally uneffective in controlling quackgrass at this location. By late-season, particularly

Table 5. Soybean yields in conventional-till (spring moldboard plowed), narrow-row soybeans with postemergence grass herbicides applied as early postemergence, late postemergence, and split applications. East Lansing, Mi; 1982[a].

Treatment	Rate	Soybean yields		
		EP[c]	LP[d]	Split
	(kg/ha)			
Haloxyfop-methyl	0.56	2455 b-c	2950 b-c	2860 b-c
Haloxyfop-methyl	0.84	2836 b-c	2486 b-c	2321 b-c
DPX-Y6202	0.56	2705 b-c	-	2548 b-c
DPX-Y6202	0.84	2354 b-c	2252 b-c	2163 b
Fluazifop-butyl	0.56	2426 b-c	-	2543 b-c
Fluazifop-butyl	0.84	2791 b-c	2400 b-c	2724 b-c
Sethoxydim	0.56	2793 b-c	-	2745 b-c
Sethoxydim	0.84	2682 b-c	2105 b	2906 b-c
No treatment	-	774 a		

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]All treatments contained crop oil concentrate at 2.3 L/ha, with each application.

[c]EP = Early postemergence application.

[d]LP = Late postemergence application.

Table 6. Quackgrass control in no-till and conventional-till (fall moldboard plowed) soybeans with postemergence grass herbicides applied as single or split applications. East Lansing, Mi; 1983[a].

Treatment[c]	Rate	Quackgrass control[b]							
		Midseason				Late season			
		No-till		Conv.-till		No-till		Conv.-till	
		Single	Split	Single	Split	Single	Split	Single	Split
	(kg/ha)	%							
Haloxyfop-methyl	0.28	92 q-s	93 p-s	87 m-s	92 q-s	80 j-o	80 j-o	83 k-o	82 j-o
Haloxyfop-methyl	0.42	92 q-s	95 q-t	92 q-s	95 q-t	82 j-o	87 m-o	88 n-o	90 n-o
Haloxyfop-methyl	0.56	95 q-t	97 r-t	92 q-s	93 p-s	77 j-o	87 m-o	86 m-o	88 n-o
DPX-Y6202	0.28	93 p-s	95 q-t	88 n-s	98 s-t	88 n-o	90 n-o	85 l-o	87 m-o
DPX-Y6202	0.42	93 p-s	98 s-t	90 n-s	97 r-t	85 l-o	88 n-o	88 n-o	88 n-o
DPX-Y6202	0.56	95 q-t	98 s-t	93 p-s	100 t	83 k-o	83 k-o	92 o	88 n-o
Fluazifop-butyl	0.28	48 d-i	82 k-q	65 g-m	77 j-p	23 a-d	65 g-k	52 e-h	65 g-k
Fluazifop-butyl	0.42	78 j-p	87 m-s	75 j-o	85 l-r	75 i-n	75 i-n	62 f-j	68 h-m
Fluazifop-butyl	0.56	83 k-r	88 n-s	82 k-q	85 l-r	75 i-n	78 j-o	67 g-l	80 j-o
Sethoxydim	0.42	22 a-d	40 b-h	42 b-h	75 j-o	7 a-b	13 a-c	40 c-f	40 c-f
Sethoxydim	0.56	27 a-e	55 e-j	30 a-e	62 g-k	0 a	20 a-d	30 b-e	43 d-g
Sethoxydim	0.84	47 c-i	60 f-k	67 e-j	72 i-n	10 a-b	20 a-d	52 e-h	57 e-i

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level accroding to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-8/4/83, 4 weeks after each postemergence application; Late season-10/10/83, 14 weeks after early postemergence applications.

[c]All treatments contained crop oil concentrate at 2.3 L/ha, with each application.

in no-till, very little herbicidal effect was observed. Unlike spring moldboard plowing, fall moldboard plowing seemingly does not result in differences in quackgrass control between single early postemergence and split applications. Lack of major rhizome disruption in the spring during shoot initiation enables a relatively uniform growth stage for control with single applications of postemergence grass herbicides in both no-till and fall moldboard plowed situations. The only time an advantage to split applications was observed was with the 0.28 kg/ha rate of fluazifop-butyl in no-till and with 0.42 kg/ha of sethoxydim. Here the advantage of split applications is due to the fact that these rates are too low to be applied in one application and the multiple doses are more phytotoxic to quackgrass.

Despite varying levels of quackgrass control, there were generally no significant differences between treatment yields either in no-till or conventional-till (Table 7). Except for the single application of 0.56 kg/ha of sethoxydim in no-till and single and split applications of 0.42 kg/ha of fluazifop-butyl, all treatments had significantly higher yields than no treatment. It is felt that the aforementioned sethoxydim treatment did not differ in yield from no treatment as a result of lack of sufficient quackgrass control. However, other factors must be responsible for the fluazifop-butyl treatment not being significantly different in yield than no treatment since relatively high levels of quackgrass control were obtained season-long and no soybean injury was observed. Tillage did not affect quackgrass pressure in untreated plots as near identical yield means were obtained in no-till and conventional-till.

Table 7. Soybean yields in no-till and conventional-till (fall moldboard plowed) soybeans with postemergence grass herbicides applied as single or split applications. East Lansing, Mi; 1983[a].

		Soybean yield			
		No-till		Conv.-till	
Treatment[b]	Rate	Singel	Split	Single	Split
	(kg/ha)				
Haloxyfop-methyl	0.28	3314 g-k	3289 f-k	2595 b-g	2903 b-k
Haloxyfop-methyl	0.42	3109 c-k	2955 b-k	2595 b-g	2698 b-i
Haloxyfop-methyl	0.56	3006 b-k	2929 b-k	2569 b-f	2775 b-j
DPX-Y6202	0.28	3134 d-k	3443 i-k	2826 b-k	2800 b-k
DPX-Y6202	0.42	2829 b-k	3134 d-k	2980 b-k	2800 b-k
DPX-Y6202	0.56	3212 e-k	2903 b-k	2800 b-k	2800 b-k
Fluazifop-butyl	0.28	2852 b-k	2852 b-k	2826 b-k	2929 b-k
Fluazifop-butyl	0.42	3032 b-k	2749 b-i	2415 a-d	2338 a-b
Fluazifop-butyl	0.56	3366 h-k	3083 b-k	2775 b-j	2646 b-h
Sethoxydim	0.42	2646 b-h	2621 b-h	2723 b-i	3006 b-k
Sethoxydim	0.56	2441 a-d	2800 b-k	2852 b-k	3006 b-k
Sethoxydim	0.84	2595 b-h	2672 b-h	2980 b-k	2903 b-k
No treatment	-	1747 a		1773 a	

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]All treatments contained crop oil concentrate at 2.3 L/ha, with each application.

Despite high levels of season-long quackgrass control from several of the postemergence applied herbicide treatments, evaluations of regrowth the next spring in no-till indicate poor control with all treatments (Table 8). Since vegetative growth of quackgrass is so prolific it is unlikely that any treatment would provide satisfactory control through a second season and it is likely that retreatment is necessary.

A series of treatments was established in the conventional-till portion of this location where a mechanical cultivation was substituted for the second herbicide application of a split treatment. The control data in Table 9 indicate that a cultivation is as effective as a second application of herbicide. Late season evaluations showed that early postemergence plus cultivation treatments with sethoxydim were significantly better in quackgrass control than early postemergence or split applications. A cultivation also significantly increased the control of early postemergence applications of fluazifop-butyl. Soybean yields from cultivation treatments were not significantly different from early postemergence or split applications of treatments and there were no significant differences in yield between herbicides. All treatments resulted in significantly higher yield than no treatment (Table 10). Therefore, with all herbicides, cultivations enabled comparable control with half of the total rate of applied herbicide.

Fall applications of haloxyfop-methyl and DPX-Y6202 resulted in high levels of quackgrass control the following spring in no-till, but only fair control in conventional-till (Table 11). Perhaps moldboard

Table 8. Subsequent season quackgrass control in no-till soybeans with postemergence grass herbicides as single or split applications. East Lansing, Mi; 1983[a].

Treatment	Rate	Quackgrass control[b] Single	Split
	(kg/ha)	---------%---------	
Haloxyfop-methyl	0.28	43 a-k	37 a-j
Haloxyfop-methyl	0.42	47 b-m	50 c-m
Haloxyfop-methyl	0.56	47 b-m	30 a-i
DPX-Y6202	0.28	57 d-m	50 c-m
DPX-Y6202	0.42	37 a-j	33 a-i
DPX-Y6202	0.56	45 a-l	43 a-k
Fluazifop-butyl	0.28	7 a-c	27 a-g
Fluazifop-butyl	0.42	27 a-g	45 a-l
Fluazifop-butyl	0.56	40 a-g	50 c-m
Sethoxydim	0.42	10 a-c	10 a-c
Sethoxydim	0.56	7 a-c	13 a-d
Sethoxydim	0.84	3 a-b	3 a-b

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Quackgrass control evaluated on 5/12/84, 41 weeks after early postemergence applications.

Table 9. Quackgrass control in conventional-till (fall moldboard plowed) soybeans with postemergence grass herbicides applied as early postemergence, split and early postemergence plus cultivation treatments. East Lansing, Mi; 1983[a].

		Quackgrass control[b]					
		Midseason			Late season		
Treatment[c]	Rate	EP[d]	Split	EP + Cul.[e]	EP[d]	Split	EP + Cul.[e]
	(kg/ha)	%					
Haloxyfop-methyl	0.14	-	-	85 g-m	-	-	83 j-n
Haloxyfop-methyl	0.28	87 h-m	92 h-m	88 h-m	83 j-n	82 i-n	90 m-n
DPX-Y6202	0.14	-	-	88 h-m	-	-	78 h-n
DPX-Y6202	0.28	88 h-m	98 m-n	93 j-n	85 k-n	87 l-n	77 g-n
Fluazifop-butyl	0.14	-	-	87 h-m	-	-	78 h-n
Fluazifop-butyl	0.28	65 d-i	77 g-k	82 g-l	52 c-f	65 d-k	78 h-n
Sethoxydim	0.28	-	-	67 e-i	-	-	73 f-m
Sethoxydim	0.42	42 a-f	75 g-k	63 c-h	40 b-d	40 b-d	75 f-n

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-8/4/83, 4 weeks after early postemergence applications; Late season-10/10/83, 14 weeks after early postemergence applications.

[c]All treatments contained crop oil concentrate at 2.3 L/ha, with each application.

[d]EP = Early postemergence application.

[e]EP + Cul. = Early postemergence application plus cultivation.

Table 10. Soybean yields in conventional-till (fall moldboard plowed) soybeans with postemergence grass herbicides applied as early postemergence, split and early postemergence plus cultivation treatments. East Lansing, Mi; 1983[a].

Treatment[b]	Rate	Soybean yield		
		EP[c]	Split	EP + Cul.[d]
		(kg/ha)		
Haloxyfop-methyl	0.14	-	-	3006 b
Haloxyfop-methyl	0.28	2595 b	2903 b	2878 b
DPX-Y6202	0.14	-	-	2646 b
DPX-Y6202	0.28	2826 b	2800 b	2878 b
Fluazifop-butyl	0.14	-	-	2852 b
Fluazifop-butyl	0.28	2826 b	2929 b	2672 b
Sethoxydim	0.28	-	-	2852 b
Sethoxydim	0.42	2723 b	3006 b	2954 b
Cultivated weed-free	-	2749 b		
No treatment	-	1773 a		

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]All treatments contained crop oil concentrate at 2.3 L/ha, with each application.

[c]EP = Early postemergence application.

[d]EP + Cul. = Early postemergence application plus cultivation.

Table 11. Quackgrass control in no-till and conventional-till (fall moldboard plowed) soybeans with fall and early postemergence applications of postemergence grass herbicides. East Lansing, Mi; 1983[a].

Treatment[c]	Rate	Quackgrass control[b]					
		Spring		Midseason		Late season	
		No-till	Conv.-till	No-till	Conv.-till	No-till	Conv.-till
	(kg/ha)	--------------------	--------------------	--------------------	%	--------------------	--------------------
Fall applied							
Haloxyfop-methyl	0.56	88 f	63 e	3 a	17 a-c	0 a	17 a-d
DPX-Y6202	0.56	85 f	60 e	3 a	13 a-b	0 a	10 a-b
Fall; Early postemergence							
Haloxyfop-methyl	0.56; 0.28	90 f	60 e	93 p-s	90 n-s	83 k-o	90 n-o
DPX-Y6202	0.56; 0.28	87 f	50 d-e	88 n-s	87 m-s	87 m-o	87 m-o
Fluazifop-butyl	0.56; 0.28	60 d-e	20 b-c	60 f-k	63 g-l	33 b-e	55 e-i
Sethoxydim	0.56; 0.28	7 a-b	0 a	23 a-d	32 a-f	3 a	20 a-d

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass evaluations are: Spring-5/15/83; Midseason-8/4/83; Late season-10/10/83.

[c]All treatments contained crop oil concentrate at 2.3 L/ha, with each application.

plowing six weeks after a fall application reduced the phytotoxicity of herbicides by reducing translocation to rhizome fragments. However, despite high levels of spring control, very poor control was observed in both no-till and conventional-till at the midseason and late-season evluations. This was again due to the prolific growth of quackgrass that was not treated within the growing season. Early postemergence applications of haloxyfop-methyl and DPX-Y6202 following fall applications resulted in excellent, season-long quackgrass control. Therefore, fall applications of these herbicides was not advantageous to postemergence applications within a growing season. Poor quackgrass control in the spring was observed with fall applications of fluazifop-butyl and essentially no spring control occurred with fall applications of sethoxydim. Fall moldboard plowing also reduced effectiveness of fall applications of fluazifop-butyl. Early postemergence applications of fluazifop-butyl following fall treatment were not effective as were similar treatments of haloxyfop-methyl and DPX-Y6202 in season-long control of quackgrass. Very low levels of quackgrass control were obtained from sethoxydim applied in this manner.

However, despite varying levels of quackgrass control, all treatments resulted in yields that were significantly higher than no treatment except for the fall application of DPX-Y6202 in no-till (Table 12). Even though very poor control was obtained with sethoxydim, control was sufficient at the critical period of soybean growth so as to enable the observed increased yield. The highest yield was from fall plus spring applications of haloxyfop-methyl.

Table 12. Soybean yields in no-till and conventional-till (fall moldboard plowed) soybeans with fall and early postemergence applications of postemergence grass herbicides. East Lansing, Mi; 1983[a].

Treatment[b]	Rate	Soybean yield No-till	Soybean yield Conv.-till
	--------(kg/ha)--------		
Fall applied			
Haloxyfop-methyl	0.56	2492 b-e	2980 b-k
DPX-Y6202	0.56	2364 a-c	2698 b-i
Fall; Early postemergence			
Haloxyfop-methyl	0.56; 0.28	3520 j-k	2620 b-h
DPX-Y6202	0.56; 0.28	3314 f-k	2672 b-h
Fluazifop-butyl	0.56; 0.28	2829 b-k	2826 b-k
Sethoxydim	0.56; 0.28	2492 b-e	2878 b-k
No treatment	- -	1747 a	1773 a

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]All treatments contained crop oil concentrate at 2.3 L/ha, with each application.

Fall and spring applications of nonselective herbicides were also made to quackgrass at this location. Fall applications of both glyphosate and SC-0224 resulted in high levels of quackgrass control the following spring in both no-till and conventional-till (Table 13). Unlike the fall applications of postemergence grass herbicides, moldboard plowing after applications did not reduce control observed the following spring. Also, unlike the postemergence grass herbicides, fall applications of non-selective herbicides resulted in relatively high levels of quackgrass control the entire following season. High level season-long control with spring applications was obtained only in no-till. Evidently the fall moldboard plowing disrupted the rhizomes and dispersed fragments over several depths and not all shoots were emerged at the time of the spring preplant application. This is consistant with the findings of Sprankel et al. (14, 15) and Behrens and Elakkad (3). Therefore, under this cultural system it may be beneficial to utilize postemergence grass herbicides which are applied later in the season when the shoots from deeper rhizome fragments have emerged.

However, all non-selective herbicide treatments resulted in significantly increased yields over no treatment and were comparable to those obtained with postemergence grass herbicides (Table 14).

Spring applications of nonselective herbicides glyphosate and SC-0224 were applied in the no-till portion of this experiment at a rate of 1.68 kg/ha in four different spray volumes. Generally, spray volume did not influence control with this rate of these herbicides (Table

Table 13. Quackgrass control in no-till and conventional-till (fall moldboard plowed) soybeans with fall and spring applications of glyphosate and SC-0224. East Lansing, Mi; 1983[a].

		Quackgrass control[b]					
		Spring		Midseason		Late season	
Treatment	Rate	No-till	Conv.-till	No-till	Conv.-till	No-till	Conv.-till
	(kg/ha)	%					
Fall applied							
Glyphosate	1.68	85 f	80 f	77 j-p	82 k-q	82 j-o	88 n-o
Glyphosate	2.52	85 f	82 f	70 i-n	80 j-q	80 j-o	86 m-o
SC-0224	1.68	83 f	87 f	67 h-m	78 j-p	73 h-n	83 k-o
SC-0224	2.52	83 f	85 f	80 j-q	80 j-q	78 j-o	82 j-o
Spring applied							
Glyphosate	1.68	-	-	92 o-s	27 a-e	85 l-o	33 b-e
SC-0224	1.68	-	-	78 j-p	37 b-g	83 k-o	40 c-f

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Spring-5/15/83; Midseason-8/4/83; Late season-10/10/83.

Table 14. Soybean yields in no-till and conventional-till (fall moldboard plowed) soybeans with fall and spring applications of glyphosate and SC-0224. East Lansing, Mi; 1983[a].

Treatment	Rate	Soybean yield No-till	Soybean yield Conv.-till
	--------------------(kg/ha)--------------------		
Fall applied			
Glyphosate	1.68	3520 j-k	2800 b-k
Glyphosate	2.52	3520 j-k	2903 b-k
SC-0224	1.68	2852 b-k	2800 b-k
SC-9224	2.52	3109 c-k	2980 b-k
Spring applied			
Glyphosate	1.68	3494 j-k	2698 b-i
SC-0224	2.52	3417 j-k	2877 b-k
No treatment		1747 a	1773 a

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

15). Midseason control with SC-0224 from the 37 and 262 L/ha volumes was significantly lower than that from the 131 L/ha volume, although by later evaluations no significant differences were observed. Quackgrass control from both herbicides was comparable as were the soybean yields. Only fair control of quackgrass was observed the next spring or one year after application and retreatment may be necessary.

Several rates of glyphosate were applied in four spray volumes in a no-till situation at the Kellogg Biological Station in the spring of 1983. However, this no-till field had been in soybeans the previous season rather than in a quackgrass sod as in the East Lansing location.

Generally, the highest control was obtained with the three highest spray volumes of each rate (Table 16). Although high levels of control were obtained with 37 L/ha, this volume may have been too low for adequate coverate of the thick stand of quackgrass at this location. The 0.84 kg/ha plus surfactant rate was as effective as the two higher rates. Surfactant did not influence control with 1.68 kg/ha. All treatments resulted in yields which were significantly higher than no treatment and there were no significant differences between treatment yields (Table 17).

Complete or near-complete control of quackgrass was observed a year after application with all rates applied in the three highest spray volumes (Table 18). High levels of coontrol were obtained with the 37 L/ha volume. It is unlikely that retreatment of quackgrass with any herbicide would be necessary.

Table 15. Quackgrass control and soybean yields in no-till soybeans with glyphosate and SC-0224 applied in four spray volumes. East Lansing, Mi; 1983[a].

Treatment	Rate	Spray Vol.	Quackgrass control[b] Midseason	Late season	Next spring	Soybean Yield
	(kg/ha)	(L/ha)	-------------	%	-------------	(kg/ha)
Glyphosate	1.68	37	82 h-k	85 c-f	72 i-m	3443 j-m
Glyphosate	1.68	65	92 j-n	92 e-f	70 h-m	3186 e-m
Glyphosate	1.68	131	93 k-n	90 d-f	60 e-m	3263 e-m
Glyphosate	1.68	262	92 j-n	85 c-f	75 j-m	3494 k-m
SC-0224	1.68	37	80 h-j	78 c-f	60 e-m	3288 f-m
SC-0224	1.68	65	88 i-m	90 d-f	57 d-m	3545 m
SC-0224	1.68	131	93 k-n	93 f	75 j-m	3263 e-m
SC-0224	1.68	262	78 h-j	83 c-f	68 h-m	3363 i-m
No treatment						1747 a

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[c]Dates of quackgrass control evaluations are: Midseason-8/4/83, 11 weeks after application; Late season-10/10/83, 21 weeks after application; Next spring-5/12/84, 52 weeks after application.

Table 16. Quackgrass control in no-till soybeans with glyphosate applied in four spray volumes. Kellogg Biological Station, Mi; 1983[a].

		Quackgrass control[b]							
		Midseason				Late season			
Treatment	Rate	37-	65-	131-	262 L/ha	37-	65-	131-	262 L/ha
	(kg/ha)	%							
Glyphosate + X-77[c]	0.84 + 1/2% (v/v)	88 f-j	98 k-l	98 k-l	95 i-k	85 m-q	100 s	98 s-r	93 p-r
Glyphosate + X-77	1.68 + 1/2% (v/v)	88 f-g	100 l	98 k-l	98 k-l	90 o-r	100 s	95 q-r	100 s
Glyphosate	1.68	90 g-k	98 k-l	98 k-l	100 l	78 k-o	100 s	98 r-s	100 s
Glyphosate	2.52	88 f-j	100 l	98 k-l	100 l	78 k-o	100 s	100 s	100 s

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-7/26/83, 10 weeks after application; Late season-10/7/83, 21 weeks after application.

[c]X-77 = Chevron Chemical Company.

Table 17: Soybean yields in no-till soybeans with glyphosate applied in four spray volumes. Kellogg Biological Station, Mi; 1983[a].

Treatment	Rate	Soybean yield 37-	65-	131-	262 L/ha
		(kg/ha)			
Glyphosate + X-77[b]	0.84 + 1/2% (v/v)	1391 f-l	1464 g-l	1806 k-l	1464 g-l
Glyphosate + X-77	1.68 + 1/2% (v/v)	1660 i-l	1562 i-l	1684 i-l	1498 g-l
Glyphosate	1.68	1586 i-l	1611 i-l	1611 i-l	1538 g-l
Glyphosate	2.52	1513 g-l	1562 h-l	1562 h-l	1245 c-k
No treatment			635 a		

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]X-77 = Chevron Chemical Company.

Table 18. Subsequent season quackgrass control in no-till soybeans with glyphosate applied in four spray volumes. Kellogg Biological Station, Mi; 1983[a].

Treatment	Rate	Quackgrass control[b]			
		37-	65-	131-	262 L/ha
	(kg/ha)	----------	----------	% ----------	----------
Glyphosate + X-77[c]	0.84 + 1/2% (v/v)	85 h	95 i-j	95 i-j	95 i-j
Glyphosate + X-77	1.68 + 1/2% (v/v)	88 h-i	97 j	98 j-k	97 j
Glyphosate	1.68	85 h	98 j-k	100 k	98 j-k
Glyphosate	2.52	85 h	100 k	95 i-j	98 j-k

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Quackgrass control evaluated on 5/6/84, 51 weeks after application of treatment.

[c]X-77 = Chevron Chemical Company.

The type of no-till system evidently influenced the duration of control with the non-selective herbicide glyphosate. At the East Lansing location, only fair control was observed a year after spring applications to quackgrass growing in a dense sod which had not been cropped the previous year (Table 15). However, at the Kellogg location excellent quackgrass control was observed a year after applications to quackgrass growing in a field which had been tilled and planted to soybeans the previous year.

Postemergence grass herbicides were applied as early postemergence late postemergence, and split applications to quackgrass in no-till soybeans at the Kellogg location and control data are shown in Table 19. Generally, the early postemergence and split applications were more effective in quackgrass control than the late postemergence applications. Quackgrass was 20 to 30-cm tall at the time of late postemergence applications and was more difficult to control at this growth stage with the rates indicated. In addition, the larger soybean plants at this time reduced herbicide coverage of quackgrass.

Despite the relatively high levels of quackgrass control at the midseason evaluation with early postemergence and split applications, by the late season evaluation only fair control was obtained with applications of haloxyfop-methyl, DPX-Y6202 and fluazifop-butyl. Poor late-season control was obtained with obtained all applications of sethoxydim. There were no significant differences in control between the two different rates of each herbicide.

Table 19. Quackgrass control in no-till soybeans with postemergence grass herbicides applied as early postemergence, late postemergence and split applications. Kellogg Biological Station, Mi; 1983[a].

		Quackgrass control[b]					
		Midseason			Late season		
Treatment[c]	Rate	EP[d]	LP[e]	Split	EP[d]	LP[e]	Split
	(kg/ha)	%					
Haloxyfop-methyl	0.28	95 i-k	67 c-e	95 i-k	73 h-o	47 d-g	60 f-l
Haloxyfop-methyl	0.56	95 i-k	63 b-d	100 l	73 h-o	55 e-j	68 g-n
DPX-Y6202	0.28	87 f-j	63 b-d	98 k-l	60 f-l	33 b-e	68 g-n
DPX-Y6202	0.56	93 h-k	63 b-d	97 j-l	73 h-o	50 d-h	73 h-o
Fluazifop-butyl	0.28	78 d-g	40 a	92 g-k	47 d-g	17 a-c	53 e-i
Fluazifop-butyl	0.56	90 g-k	43 a-b	97 j-l	62 f-l	27 a-d	58 e-k
Sethoxydim	0.56	67 c-e	28 a	73 d-f	27 a-d	0 a	7 a-b
Sethoxydim	0.84	80 d-h	47 a-c	78 f-j	25 a-d	7 a-b	17 a-c

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-7/26/83, 5 weeks after early postemergence applications; Late season-10/7/83, 15 weeks after early postemergence applications.

[c]All treatments contained crop oil concentrate at 2.3 L/ha, with each application.

[d]EP = Early postemergence application.

[e]LP = Late postemergence applications.

All early postemergence and split applications of haloxyfop-methyl, DPX-Y6202 and fluazifop-butyl and those of the 0.84 kg/ha application of sethoxydim resulted in yields which were significantly higher than no treatment (Table 20). Late postemergence applications of 0.56 kg/ha of haloxyfop-methyl, 0.28 kg/ha of DPX-Y6202, 0.28 and 0.56 kg/ha of fluazifop-butyl, 0.56 and 0.84 kg/ha of sethoxydim and early postemergence and split applications of 0.56 kg/ha of sethoxydim did not result in yields which were significantly different than the untreated control plots. This occurred in spite of control evaluations, although poor, that were greater than those of other location in which significantly increased yields were obtained. However, it was generally the late postemergence treatments which had the reduced yields. Quackgrass was 20 to 30-cm tall and in the five-leaf stage at the time of application which has been shown to be the critical stage of interference (5, 12). Even though the duration of interference did not differ between here and other locations, the quackgrass at this location had obtained a larger size in a relatively short period of time. In addition, the postemergence grass herbicides are relatively slow acting which enables quackgrass interference following application. Therefore, it is critical to control the quackgrass prior to the five-leaf stage regardless of the duration of interference. In this case then, the early postemergence and split applications were more beneficial.

Table 20. Soybean yields in no-till soybeans with postemergence grass herbicides applied as early postemergence, late postemergence, and split applications. Kellogg Biological Station, Mi; 1983[a].

Treatment[b]	Rate	Soybean yield EP[c]	Soybean yield LP[d]	Soybean yield Split
		(kg/ha)		
Haloxyfop-methyl	0.28	1513 g-l	1123 b-j	1611 i-l
Haloxyfop-methyl	0.56	1611 i-l	804 a-f	1513 g-l
DPX-Y6202	0.28	1587 i-l	903 a-g	1342 e-l
DPX-Y6202	0.56	1879 l	1074 b-i	1586 i-l
Fluazifop-butyl	0.78	1562 h-l	927 a-h	1611 i-l
Fluazifop-butyl	0.56	1562 h-l	708 a-d	1416 f-l
Sethoxydim	0.56	757 a-e	391 a	732 a-e
Sethoxydim	0.84	1220 b-k	659 a-c	1196 b-k
No treatment	-		635 a-b	

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]All treatments contained crop oil concentrate at 2.3 L/ha, with each application.

[c]EP = Early postemergence application.

[d]LP = Late postemergence application.

Quackgrass control evaluations the next spring, 46 weeks after application, showed very poor control with all selective herbicide treatments which indicates that the postemergence grass herbicides were ineffective in controlling quackgrass for more than a single season, whereas the non-selective glyphosate can control quackgrass for more than one season (Table 21).

The final cultural system in which quackgrass control was examined was a continuous soybean, fall chisel plowed situation. Fall chisel plowing is less disruptive to soil, and therefore, quackgrass rhizoimes, than is moldboard plowing and is often referred to as conservation tillage.

Quackgrass control evaluations showed no significant differences between time of application or between rates of haloxyfop-methyl and DPX-Y6202 (Table 22). However, late postemergence applications of fluazifop-butyl were less effective than early postemergence applications and increased rate did not result in increased control. This indicates that fluazifop-butyl is less effective on the larger quackgrass than either haloxyfop-methyl or DPX-Y6202. Split applications of sethoxydim were more effective than either early postemergence or late postemergence applications. But by the late-season evaluation, control with all applications of sethoxydim are poor except for a split application of 0.84 kg/ha.

Quackgrass control data from fall chisel plowing were not unlike those from fall moldboard plowing where the single early postemergence application is as effective as the split application. This is because

Table 21. Subsequent season quackgrass control in no-till soybeans with postemergence grass herbicides applied as early postemergence, late postemergence and split applications. Kellogg Biological Station, Mi; 1983[a].

Treatment[c]	Rate	Quackgrass control[b]		
		EP[d]	LP[e]	Split
	(kg/ha)	------------%------------		
Haloxyfop-methyl	0.28	37 b-g	23 a-e	33 a-g
Haloxyfop-methyl	0.56	38 c-g	20 a-d	33 a-g
DPX-Y6202	0.28	27 a-e	28 a-e	33 a-g
DPX-Y6202	0.56	37 b-g	30 a-f	40 c-g
Fluazifop-butyl	0.28	28 a-e	17 a-c	33 a-g
Fluazifop-butyl	0.56	38 c-g	13 a-b	37 b-g
Sethoxydim	0.56	20 a-d	13 a-b	10 a
Sethoxydim	0.84	27 a-e	13 a-b	17 a-c

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Quackgrass control evaluated on 5/6/84, 46 weeks after early postemergence applications.

[c]All treatments contained crop oil concentrate at 2.3 L/ha, with each application.

[d]EP = Early postemergence application.

[e]LP = Late postemergence application.

Table 22. Quackgrass control in conservation-till (fall chisel plow) soybeans with postemergence grass herbicides applied as early postemergence, late postemergence and split applications. Fowler, Mi; 1983[a].

		Quackgrass control[b]					
		Midseason			Late season		
Treatment[c]	Rate	EP[d]	LP[e]	Split	EP[d]	LP[e]	Split
	(kg/ha)	%					
Haloxyfop-methyl	0.28	73 i-q	63 f-o	80 m-r	72 i-o	70 h-o	73 j-o
Haloxyfop-methyl	0.42	82 n-r	77 k-r	-	77 k-o	82 m-o	-
Haloxyfop-methyl	0.56	80 m-r	83 o-r	97 s	62 e-o	82 m-o	85 o
DPX-Y6202	0.28	82 n-r	83 o-r	90 q-s	73 j-o	72 i-o	78 l-o
DPX-Y6202	0.42	77 k-r	80 m-r	-	72 i-o	73 j-o	-
DPX-Y6202	0.56	85 p-r	80 m-r	92 r-s	77 k-o	83 m-o	62 e-o
Fluazifop-butyl	0.28	78 l-r	45 b-h	70 i-p	57 c-n	43 a-j	68 h-o
Fluazifop-butyl	0.42	82 n-r	53 c-j	-	65 g-o	55 c-m	-
Fluazifop-butyl	0.56	80 m-r	50 c-i	85 p-r	77 k-o	55 c-m	68 h-o
Sethoxydim	0.42	17 a	37 a-e	68 h-p	20 a-c	30 a-f	43 a-j
Sethoxydim	0.56	17 a	43 a-g	-	7 a	40 a-i	-
Sethoxydim	0.84	38 a-f	58 d-l	78 l-r	23 a-d	23 a-d	72 i-o

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-8/8/83, 4 weeks after early postemergence applications; Late season-10/5/83, 12 weeks after early postemergence applications.

[c]EP = Early postemergence application.

[d]LP = Late postemergence application.

quackgrass shoots are at a uniform growth stage at the time of the early postemergence applications due to lack of soil disturbance in the spring.

Although nonselective herbicides were not included in this location, the grower made spring applications of 1.68 kg/ha of glyphosate to quackgrass growing outside the experimental area and made an early-season cultivation. This resulted in near complete control of quackgrass season-long despite the fact the field was fall chisel plowed.

Previously, effective quackgrass control was shown with glyphosate and SC-0224 applied in several spray volumes. At the conservation-till location, 0.56 kg/ha of fluazifop-butyl and sethoxydim were applied in four spray volumes. At the midseason evaluation, significantly higher quackgrass control was observed with fluazifop-butyl applied in 37, 65 and 131 L/ha than in 252 L/ha (Table 23). However, by late season this effect was no longer prevalent. Changing spray volumes did not influence control with sethoxydim.

SUMMARY

Cultural systems such as rotation and tillage practice can influence chemical control of quackgrass. Nonselective herbicides such as glyphosate and SC-0224 provided quackgrass control for more than one season when applied in the fall or spring. However, reduced control can result when herbicide coverage is reduced, as from tall wheat

Table 23. Quackgrass control in conservation-till (fall chisel plow) soybeans with fluazifop-butyl and sethoxydim applied in four spray volumes. Fowler, Mi; 1983[a].

		Quackgrass control[b]							
		Midseason				Late season			
Treatment[c]	Rate	37-	65-	131-	262 L/ha	37-	65-	131-	262 L/ha
	(kg/ha)	----------	----------	----------	----------	%	----------	----------	----------
Fluazifop-butyl	0.56	78 l-r	77 k-r	77 k-r	50 c-i	62 e-o	63 f-o	60 e-o	55 c-m
Sethoxydim	0.56	62 e-n	60 d-m	45 b-h	43 a-g	37 a-h	60 e-o	33 a-g	40 a-i

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-8/8/83, 5 weeks after application; Late season-10/8/83, 13 weeks after application.

[c]Treatments tank-mixed with crop oil concentrate at 1% v/v.

stubble, or when applied in the spring following moldboard plowing since shoot emergence is not uniform. Late postemergence and split applications of postemergence grass herbicides more effectively controlled quackgrass in a spring moldboard plowed system than early postemergence applications. The spring disruption of rhizomes caused uneven shoot emergence such that shoots emerged after the early postemergence application. In no-till and fall-plowed systems, early postemergence applications were usually as effective as late and split applications. A cultivation substituted for the second half of a split application. Despite varying levels of season-long quackgrass control, significantly increased yields are obtained when quackgrass was treated prior to becoming 25 to 30 cm tall with five leaves. However, poor quackgrass control in late season may present harvesting difficulties. Effective quackgrass control with postemergence grass herbicides was usually limited to one season.

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CHAPTER 4

POTENTIAL REDUCTION IN QUACKGRASS (*Agropyron repens* (L.) Beauv.) CONTROL FROM ADDITIONS OF BROADLEAF HERBICIDES TO GRASS HERBICIDE APPLICATIONS

ABSTRACT

Postemergence tank-mix applications of two broadleaf and four grass herbicides were made to three- to five-leaved quackgrass to examine for antagonism in the form of significantly reduced control compared to that of grass herbicides only. Antagonism varied with location and herbicide. Addition of acifluorfen (sodium 5-(2-chloro-4 (trifluoro-methyl)phenoxy)-2-nitrobenzoate) to applications of haloxyfop-methyl (methyl 2-(4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl)-oxy) propanoate), DPX-Y6202 (2-(4-((6-chloro-2-quinoxalinyl)oxy)-phenoxy)propionic acid, ethyl ester) and fluazifop-butyl ((±)-butyl-2-(4-((5-trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate) resulted in reduced quackgrass control 15 weeks after application, but not 4 weeks after. Both acifluorfen and bentazon (3-siopropyl-1*H*-2,1,3,-benzothiadiazin 4(3*H*)-one 2,2,-dioxide) reduced control with sethoxydim (2-(1-(ethoxyimino)-butyl)-5-(2-(ethylthio)propyl) 3-hydroxy-2-cyclohexen-1-one) 4 and 15 weeks after application. Increased rates of

haloxyfop-methyl, DPX-Y6202 and fluazifop-butyl often circumvented antagonism. An application of either acifluorfen or bentazon followed the next day by haloxyfop-methyl resulted in antagonism 15 weeks later whereas the reverse did not. Antagonism manifested in late season but not early after application suggests that acifluorfen and bentazon do not interfere with the initial phytotoxic effects of the grass herbicides, but may reduce translocation of the grass herbicide to quackgrass rhizomes thereby enabling increased generation of shoots from the rhizomes. Antagonism did not significantly affect soybean (*Glycine max* L.) yields.

INTRODUCTION

Quackgrass is a rhizomatous perennial grass that has been referred to as one of the world's worst weeds and is a serious weed problem in soybeans (*Glycine max* (L.) Merr.) in the Northern temperate areas of the United States (1, 7, 9). The recent development of selective postemergence applied grass herbicides has given soybean growers a new option for quackgrass control. Consequently, a grower may wish to tankmix a broadleaf herbicide with a grass herbicide to increase the spectrum of a postemergence application. However, this may result in antagonism in the form of reduced quackgrass control. Reduced control of various annual grasses has been observed from additions of acifluorfen (5-(2-chloro-4-(trifluoromethyl)phenoxy)-2-nitrobenzoic acid) and bentazon (3-isopropyl-1*H*-2,1,3-benzothiadiazin-4(3*H*)-one-2,2-dioxide) to applications of sethoxydim (2-(1-(ethoxyimino)-butyl)-5-(2-ethylthio-propyl)-3-hydroxy 2-cyclohexene-1-one), haloxyfop-methyl (methyl-2-(4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy) propanoate), DPX-Y6202 (2-(4-((6-chloro-2-quinoxalinyl)oxy)-phenoxy)-propionic aicd, ethyl ester), and fluazifop-butyl (($\pm$)-butyl-2-(4((5-(triluomethyl)-2-pyridinyl)-oxy)phenoxy)propanoate) (4, 5, 6, 10, 13). In some cases, antagonism in annual grasses was overcome by increasing the herbicide rate, separating the application of the tank-mix

components, or by making application before the grass became too large (2, 3, 6, 10, 11).

Angatonism may also be a factor in quackgrass control. Kells et al. (8) obtained reduced quackgrass control from additions of acifluorfen and bentazon to applications of fluazifop-butyl, haloxyfop-mehyl and sethoxydim. This antagonism presents a potential problem with postemergence applied herbicides for broad-spectrum weed control. The objectives of this research were to (1) examine the potential antagonism in quackgrass from tank-mix applications of the postemergence broadleaf herbicide acifluorfen and bentazon with several rates of postemergence grass herbicides haloxyfop-methyl, DPX-Y6202, fluazifop-butyl and sethoxydim; (2) examine the effects of separation of application of broadleaf and grass herbicides on antagonism, and (3) determine the effects of antagonism on soybean yields.

MATERIALS AND METHODS

Field experiments were conducted at three locations in areas of dense quackgrass infestations. All herbicide applications were made with a compressed air tractor sprayer using flat fan nozzles at a spray volume of 262 L/ha at 324 kPa. The experimental design was a randomized complete block. Visual evaluations of quackgrass control were made at several times following herbicide application. Evaluations were based on a 0 to 10 scale where 0 indicated no quackgrass control and 10 indicated complete control. Untreated plots were used as the basis for no control. Control data were converted to decimal form, subjected to the arcsin data transformation and then analyzed for mean separation using Duncan's miltiple range test. Quackgrass control data presented here are non-transformed and have been converted to percent. Soybean yields were taken at two locations using a small plot combine.

The first experiment was established on the Michigan State University Agricultural Experiment Station on a Capac loam in 1982. The field was moldboard plowed, disked and field cultivated on June 7 and planted to 'Evans' soybeans with 24-cm row spacing on June 8. Postemergence applications of herbicides were made on June 25 when the quackgrass was 10 to 18-cm tall with three to four leaves and soybeans were in the unifoliolate leaf stage (V1). Crop oil concentrate was applied at 2.3 L/ha with all treatments except those containing acifluorfen. In this experiment, the commercially formulated acifluorfen contained surfactant. This formulation was discontinued following 1982. Plot size was six rows by 10.7 m, and there were four replications. Control evaluations were made 4 and 15 weeks after herbicide applications. The four middle rows of each plot were harvested for yield on November 14.

In 1983, an experiment was established in Clinton County near Fowler, Michigan on a Metamora-Capac sandy loam. The field was chisel plowed in the fall of 1982. A preplant incorporated application of trifluralin (α,α,α-trifluoro-2,6-dinitro-<u>N</u>-<u>N</u>-dipropyl-<u>p</u>-toluidine) plus metribuzin (4-amino-6-<u>tert</u>-butyl-3-(methylthio)-<u>as</u>-triazin-5(4H)-

one) at 0.84 and 0.28 kg/ha, respectively, was made on June 15 for the control of annual weeds. The field was planted to 'Hardins' soybeans with 76-cm row spacing on June 17. Plot size was four rows by 12.2 m with three replications. Postemergence applications of herbicides were made on July 7 when the quackgrass was 10 to 15-cm tall with three to four leaves and the soybeans were in the unifoliolate to second trifoliolate leaf stage (V1 to V3). Crop oil concentrate was applied at 2.3 L/ha with all treatments except those containing acifluorfen where 1.2 L/ha was used. Visual ratings were taken 5 and 13 weeks after application.

An experiment was established in 1983 in Kalamazoo County at the Kellogg Biological Station near Hickory Corners, Michigan on a Kalamazoo loam. The field was planted to soybeans in 1982 and was not tilled following harvest. An application of paraquat at 0.56 kg/ha was made on May 25. The field was planted to 'Corsoy' soybeans with 76-cm row spacing on June 2. Plot size was four rows by 12.2 m with three replications. A preemergence application of metolachlor (2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide) plus metribuzin at 2.24 and 0.42 kg/ha respectively, was made on June 2 to control annual weeds. Early postemergence applications of herbicides were made on June 22 when the quackgrass was 15 to 20 cm tall with three to four leaves and the soybeans were in the first trifoliolate (V2). Late postemergence applications were made on July 6 when the quackgrass was 20 to 30.5-cm tall with five leaves and the soybeans were in the fourth trifoliolate leaf stage (V5). A series

of teatments involving a one-day separation of applications of haloxyfop-methyl and either acifluorfen or bentazon was initiated where the first application was made on June 22 and the second on June 23. Crop oil concentrate was applied at 2.3 L/ha with all treatments except those containing acifluorfen where 1.2 L/ha was used. Control evaluations were made 5 and 15 weeks after herbicide applications. The two center rows of each plot were harvested for yield on October 18.

RESULTS AND DISCUSSION

Antagonism was considered to have occurred if the resultant quackgrass control from a tank-mix application was significantly less than that obtained with a grass herbicide applied alone. Data indicated that the antagonism level varied with herbicide and location.

At the East Lansing location, there was no antagonism observed four weeks after application with any tankmix applications containing haloxyfop-methyl, DPX-Y6202 or fluazifop-butyl (Table 1). However, fifteen weeks after application antagonism was observed in plots treated with each of these three herbicides plus acifluorfen, but not bentazon. Tank-mix applications of acifluorfen plus sethoxydim resulted in antagonism expressed at both the early and later evaluations, whereas antagonism with bentazon plus sethoxydim was observed only at the later evaluation. Soybean yields from treatments which resulted in antagonism were not significantly different from those which did

Table 1. Quackgrass control in soybeans with postemergence grass herbicide applied alone or in tank-mix with acifluorfen on bentazon. East Lansing, Mi; 1982[a].

Treatment	Rate	Quackgrass control[b]					
		Midseason			Late season		
		COC[c]	ACI[d]	BEN[e]	COC	ACI	BEN
	(kg/ha)	---	---	---	%	---	---
Haloxyfop-methyl	0.56	88 g-i	75 d-g	83 f-h	84 f-j	68 c-d	88 h-k
DPX-Y6202	0.56	84 f-h	79 e-g	83 f-h	84 f-j	68 c-d	78 d-h
Fluazifop-butyl	0.56	79 e-g	71 c-f	76 e-g	78 d-h	61 b-c	76 d-g
Sethoxydim	0.56	79 e-g	30 a	61 b-d	71 c-e	43 a	54 a-b

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level accirding to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-7/23/82, 4 weeks after application; Late season-10/11/83, 15 weeks after application.

[c]Treatment tank-mixed with crop oil concentrate at 2.3 L/ha.

[d]Treatment tank-mixed with acifluorfen plus crop oil concentrate at 0.56 kg/ha and 1.2 L/ha, respectively.

[e]Treatment tank-mixed with bentazon plus crop oil concentrate at 0.84 kg/ha and 2.3 L/ha, respectively.

not, and all treatments resulted in soybean yields significantly higher than no treatment (Table 2).

At the Fowler location, two rates of each of the postemergence grass herbicides were applied alone and in tank-mix with acifluorfen and bentazon. At this location, quackgrass control with sethoxydim plus crop oil concentrate was poor at both rates and any potential antagonism was therefore, inconsequential (Table 3). A tankmix application of 0.28 kg/ha of fluazifop-butyl plus acifluorfen was the only treatment to result in antagonism 5 weeks after application. By increasing the rate of fluazifop-butyl to 0.56 kg/ha, antagonism due to addition of acifluorfen was avoided. Thirteen weeks after application, quackgrass control from 0.28 kg/ha of fluazifop-butyl plus crop oil concentrate had decreased considerably and consequently, there was no significant effect due to tankmix. Tankmix applications of 0.28 kg/ha of haloxyfop-methyl with acifluorfen and bentazon resulted in antagonism 13 weeks after application as did an application of DPX-Y6202 at 0.28 kg/ha plus acifluorfen. However, antagonism was avoided in both cases by increasing the rate of the grass herbicide in the tankmix to 0.56 kg/ha.

At the Kellogg Biological Station location, early postemergence tank-mix and same day, separated applications of haloxyfop-methyl and acifluorfen did not result in antagonism (Table 4). Similarly, addition of acifluorfen and bentazon to either the early postemergence or late postemergence applications of a split application of haloxyfop-methyl did not result in antagonism (Table 5). An application of

Table 2. Soybean yield in soybeans treated with postemergence grass herbicides applied alone or in tank-mix with acifluorfen or bentazon. East Lansing, Mi; 1982[a].

Treatment	Rate	Soybean yield COC[b]	ACI[c]	BEN[d]
	(kg/ha)	----------%----------		
Haloxyfop-methyl	0.56	2455 b-c	3212 c	2257 b-c
DPX-Y6202	0.56	2705 b-c	2568 b-c	2905 b-c
Fluazifop-butyl	0.56	2426 b-c	2779 b-c	2249 b-c
Seethoxydim	0.56	2793 b-c	2860 b-c	2555 b-c
No treatment	-	----------774 a----------		

[a]Means followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Treatment tank-mixed with crop oil concentrate at 2.3 L/ha.

[c]Treatment tank-mixed with acifluorfen plus crop oil concentrate at 0.56 kg/ha and 1.2 L/ha, respectively.

[d]Treatment tank-mixed with bentazon plus crop oil concentrate at 0.84 kg/ha and 2.3 L/ha, respectively.

Table 3. Quackgrass control in soybeans with postemergence grass herbicides applied alone or in tank-mix with acifluorfen and bentazon. Fowler, Mi; 1983[a].

		Quackgrass control[b]					
		Midseason			Late season		
Treatment	Rate	COC[c]	ACI[d]	BEN[e]	COC	ACI	BEN
	(kg/ha)	%					
Haloxyfop-methyl	0.28	73 i-q	60 d-m	60 d-m	72 i-o	33 a-g	37 a-h
Haloxyfop-methyl	0.56	80 m-r	78 l-r	73 i-q	62 e-o	50 b-l	57 c-n
DPX-Y6202	0.28	82 n-r	63 f-o	72 i-p	73 j-o	45 a-i	65 g-o
DPX-Y6202	0.56	85 p-r	75 j-q	82 n-r	77 k-o	62 e-o	63 f-o
Fluazifop-butyl	0.28	78 l-r	55 c-k	67 g-p	57 c-n	37 a-h	55 c-m
Fluazifop-butyl	0.56	80 m-r	70 i-o	82 n-r	77 k-o	57 c-n	57 c-n
Sethoxydim	0.56	17 a	37 a-e	30 a-c	7 a	7 a	13 a-b
Sethoxydim	0.84	38 a-f	35 a-d	30 a-c	23 a-d	20 a-c	13 a-b

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-8/8/84, 5 weeks after application and Late season-10/5/83, 13 week after application.

[c]Treatment tank-mixed with crop oil concentrate 2.6 L/ha.

[d]Treatment tank-mixed with acifluorfen plus crop oil concentrate at 0.56 kg/ha and 1.3 L/ha, respectively.

[e]Treatment tank-mixed with bentazon plus crop oil concentrate at 0.84 kg/ha and 2.6 L/ha, respectively.

Table 4. Quackgrass control in soybeans with haloxyfop-methyl plus acifluorfen and bentazon applied in tank-mix or separate applications. Kellogg Biological Station, Mi; 1983[a].

Treatment	Rate	Quackgrass control[b] Midseason	Quackgrass control[b] Late season	Soybean Yield
	(kg/ha)	-----------%----------		(kg/ha)
Haloxyfop-methyl + COC[c]	0.28 + 2.3 L/ha	95 i-k	73 h-o	1660 i-l
Haloxyfop-methyl + COC	0.56 + 2.3 L/ha	95 i-k	73 h-o	1513 g-l
Tank-mix application				
Haloxyfop-methyl + acifluorfen + COC	0.28 + 0.56 + 1.2 L/ha	87 f-g	70 g-n	1318 d-l
Haloxyfop-methyl + acifluorfen + COC	0.56 + 0.56 + 1.2 L/ha	97 j-l	78 k-o	1318 d-l
Haloxyfop-methyl + bentazon + COC	0.28 + 0.84 + 2.3 L/ha	93 h-k	75 i-o	1318 d-l
Haloxyfop-methyl + bentazon + COC	0.56 + 0.84 + 2.3 L/ha	97 j-l	75 i-o	1220 b-k
Separate application, same day				
Haloxyfop-methyl + COC; acifluorfen + COC	0.28 + 1.2 L/ha; 0.56 + 1.2 L/ha	92 g-k	67 g-m	1660 i-l
Haloxyfop-methyl + COC; acifluorfen + COC	0.56 + 1.2 L/ha; 0.56 + 1.2 L/ha	97 j-l	78 k-o	1611 j-l
Haloxyfop-methyl + COC; Bentazon + COC	0.28 + 1.2 L/ha; 0.84 + 1.2 L/ha	97 j-l	87 n-q	1757 i-l
Haloxyfop-methyl + COC; bentazon + COC	0.56 + 1.2 L/ha; 0.84 + 1.2 L/ha	100 l	83 m-q	1708 g-l
No treatment				635 a-b

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-7/26/83, 5 weeks after postemergence applications; Late season-10/7/83, 15 weeks after postemergence applications.

[c]COC = Crop oil concentrate.

Table 5. Quackgrass control in soybeans with split applications of haloxyfop-methyl plus acifluorfen and bentazon. Kellogg Biological Station, Mi; 1983[a].

Treatment[c]	Rate	Quackgrass control[b] Midseason	Quackgrass control[b] Late season	Soybean Yield
	(kg/ha)	--------%--------	--------%--------	(kg/ha)
Haloxyfop-methyl; haloxyfop-methyl	0.14; 0.14	95 i-k	60 f-l	1611 i-l
Haloxyfop-methyl; haloxyfop-methyl	0.28; 0.28	100 l	68 g-n	1513 g-l
Haloxyfop-methyl + acifluorfen; Haloxyfop-methyl	0.14 + 0.56; 0.14	95 i-k	55 e-j	1562 h-l
Haloxyfop-methyl + acifluorfen; Haloxyfop-methyl	0.28 + 0.56; 0.28	100 l	75 i-o	1806 k-l
Haloxyfop-methyl; haloxyfop-methyl + acifluorfen	0.14; 0.14 + 0.56	97 j-l	85 m-q	1440 g-l
Haloxyfop-methyl; haloxyfop-methyl + acifluorfen	0.28; 0.28 + 0.56	98 k-l	85 m-q	1342 e-l
Haloxyfop-methyl + bentazon; haloxyfop-methyl	0.14 + 0.84; 0.14	98 k-l	70 g-n	1513 g-l
Haloxyfop-methyl + bentazon; haloxyfop-methyl	0.28 + 0.84; 0.28	100 l	77 j-o	1611 i-l
Haloxyfop-methyl; haloxyfop-methyl + bentazon	0.14; 0.14 + 0.84	100 l	80 l-p	1538 g-l
No treatment	-		-	635 a-b

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-7/26/83, 5 weeks after early postemergence application; Late season-10/7/83, 15 weeks after early postemergence application.

[c]Treatments of haloxyfop-methyl and haloxyfop-methyl plus bentazon contained crop oil concentrate at 2.3 L/ha; treatments of haloxyfop-methyl plus acifluorfen contained crop oil concentrate at 1.2 L/ha.

haloxyfop-methyl followed the next day by an application of either acifluorfen or bentazon also did not result in antagonism (Table 6). However, an application of either acifluorfen or bentazon followed the next day by an application of haloxyfop-methyl resulted in antagonism expessed fifteen weeks after application. However, this antagonism did not significantly affect yields.

SUMMARY

Antagonism varied with location and herbicide. Variations may be due to differential response to herbicides by the different quackgrass biotypes. Quackgrass biotypes have been shown to respond differently to glyphosate (12). There was generally no antagonism observed at the early control evaluations. In most instances where antagonism occurred, it was not expressed until the later rating period in the form of increased shoot regrowth. This would suggest that the broadleaf herbicides are not interferring with initial action of the grass herbicides because phytotoxicity is observed at the midseason evaluation. Increased regrowth observed later in the season with tank-mix applications suggests reduced translocation of the grass herbicide from the treated foliage to the rhizomes. A reduction in grass herbicide concentration in the rhizomes would enable increased generation of shoots from rhizomes. The broadleaf herbicides acifluorfen and bentazon, while not phytotoxic to quackgrass, could predispose the quackgrass for reduced translocation. Evidence for this

Table 6. Quackgrass control in soybeans with haloxyfop-methyl plus acifluorfen and bentazon with a one-day separation of applications. Kellogg Biological Station, Mi; 1983[a].

Treatment[c]		Rate	Quackgrass control[b]		Soybean
			Midseason	Late season	Yield
		(kg/ha)	-----------	%----------	(kg/ha)
First day	; Second day				
Haloxyfop-methyl	; --	0.28; --	95 i-k	73 h-o	1660 i-l
Haloxyfop-methyl	; --	0.56; --	95 i-k	73 h-o	1513 g-l
Haloxyfop-methyl	; acifluorfen	0.28; 0.56	93 h-k	70 g-n	1464 g-l
Haloxyfop-methyl	; acifluorfen	0.56; 0.56	100 l	85 m-q	1903 l
Haloxyfop-methyl	; bentazon	0.78; 0.84	90 g-k	67 g-m	1587 i-l
Haloxyfop-methyl	; bentazon	0.56; 0.84	97 j-l	72 h-n	1660 i-l
Acifluorfen	; haloxyfop-methyl	0.56; 0.28	83 e-i	33 b-e	1464 g-l
Acifluorfen	; haloxyfop-methyl	0.56; 0.56	90 g-k	55 e-j	1513 g-l
Bentazon	; haloxyfop-methyl	0.84; 0.28	87 f-j	47 e-i	1635 i-l
Bentazon	; haloxyfop-methyl	0.84; 0.56	85 f-i	37 c-f	1660 i-l
No treatment		-	-	-	635 a-b

[a]Means within an evaluation period followed by a common letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

[b]Dates of quackgrass control evaluations are: Midseason-7/26/83, 5 weeks after postemergence application; Late season-10.7/83, 15 weeks after postemergence application.

[c]Treatments of haloxyfop-methyl and bentazon contained crop oil concentrate at 2.3 L/ha; treatments of acifluorfen contained crop oil concentrate at 1.2 L/ha.

was observed at the Kellogg Biological Station where the broadleaf herbicides applied a day before the grass herbicides resulted in antagonism whereas the reverse did not. Antagonism did not reduce yields since it was not manifested until late in the season which is well after the early growth stages of soybeans which are the most susceptible to weed interference. Although antagonism did not adversely affect yields, higher quackgrass populations may occur the following spring in areas where antagonism had previously occurred. Further research is needed to investigate the physiological processes affected which result in antagonism.

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CHAPTER 5

EFFECT OF ACIFLUORFEN AND BENTAZON ON ABSORPTION AND TRANSLOCATION OF HALOXYFOP-METHYL AND DPX-Y6202 IN QUACKGRASS (*Agropyron repens* (L.) Beauv.)

ABSTRACT

Translocation of ^{14}C-haloxyfop-methyl (methyl 2-(4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate) in quackgrass (*Agropyron repens* (L.) Beauv.) out of the treated area (the middle 2.5-cm of the second of three leaves) was significantly reduced in plants in which 0.56 kg/ha of acifluorfen (5-(2-chloro-4-(trifluoromethyl) phenoxy)-2-nitrobenzoic acid) and 0.84 kg/ha of bentazon (3-isopropy-1*H*-2,1,3-benzothiadiazin-4(3*H*)-one 2,2-dioxide) were added in tankmix to a 0.07 kg/ha application of haloxyfop-methyl. Translocation of ^{14}C was also reduced to the lower leaves. This reduction was not seen at higher rates of applied haloxyfop-methyl. Bentazon reduced quackgrass absorption of ^{14}C-DPX-Y6202 (2-(4-((6-chloro-2-qunioxalinyl)oxy)-phenoxy)-propionic acid, ethyl ester) while acifluorfen reduced translocation to the tip of the treated leaf. Absorption and translocation of ^{14}C-haloxyfop-methyl and ^{14}C-DPX-Y6202 in quackgrass was not affected by a 24 h pretreatment with acifluorfen and bentazon. Considerably more ^{14}C-haloxyfop-methyl than ^{14}C-DPX-Y6202 was absorbed

by quackgrass, although amounts translocated to rhizomes and small shoots were comparable.

INTRODUCTION

Attempts for broad spectrum weed control with postemergence applications of tankmixes of broadleaf and grass herbicides may result in control levels that are lower than expected due to herbicide interaction (4). Woldentatios and Harvey (7) found that tank-mix applications of diclofop-methyl (2,(4-(2,4-dichlorophenoxy)phenoxy) propanoic acid) and bentazon (3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one-2,2-dioxide) reduced uptake of ^{14}C-diclofop by giant foxtail (Setaria faberi Herrm.) leaves. Similarly, Williams and Wax (6) found reduced penetration of ^{14}C-haloxyfop-methyl (methyl 2-(4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate) and ^{14}C-fluazifop-butyl ((±)-butyl -2-(4-((5-(trifluoromethyl) -2-pyridinyl) oxy) phenoxy)propanoate) penetrated into German millet (Setaria italica (L.) Beauv.) leaves when applied in a mixture containing bentazon. Rhodes and Coble (5) found that bentazon reduced absorption but not translocation of ^{14}C-sethoxydim (2-(1-(ethoxyimino)butyl)-5-(2-(ethylthio) propyl)-3-hydroxy-2-cyclohexene-1-one) in goosegrass (Eleusine indica (L.) Gaertn.).

Quackgrass (Agropyron repens (L.) Beauv.) is a rhizomatous, perennial weed of world-wide significance (1). Kells et. al. (2, 3) found that tank-mix applications containing either bentazon or acifluorfen (5-(2-chloro-4-(trifluoromethyl)phenoxy) -2-nitrobenzoic

acid) with 0.56 kg/ha applications of fluazifop-butyl, sethoxydim or DPX-Y6202 (2-(4-((6-chloro-2-quinoxalinyl)oxy)-phenoxy)-propionic acid, ethyl ester) resulted in significantly reduced quackgrass control compared to that of the grass herbicides applied alone. However, acifluorfen and bentazon did not affect absorption and translocation of ^{14}C-fluazifop-butyl in quackgrass (2).

In field trials by the author, the addition of acifluorfen and bentazon to applications of several grass herbicides did not cause reductions in quackgrass control 4 weeks after treatment. However, significantly increased quackgrass regrowth occurred 13 to 15 weeks after application in plots treated with tank-mix applications which suggests that acifluorfen and bentazon may be reducing translocation of the grass herbicide throughout the quackgrass plant including rhizomes which would enable regrowth.

Therefore, the objectives of this research were to examine absorption and translocation of ^{14}C-haloxyfop-methyl and ^{14}-C-DPX-Y6202 in quackgrass plants treated with several rates of the respective grass herbicide both alone and in tankmix with acifluorfen and bentazon. In addition, the effects of a 24 h quackgrass pretreatment with acifluorfen and bentazon on absorption and translocation of these two grass herbicides were examined.

MATERIALS AND METHODS

General Procedures. Six to eight node quackgrass rhizome sections were planted in 473 ml plastic containers filled with number 2 grade vermiculite and soaked with tap water after which they were watered on alternate days with 50 ml of Hoagland's solution. The containers were placed in a glasshouse with full sunlight supplemented by sodium halide lights with an intensity of 280 $\mu E/m^2/s$ with a 16 h photoperiod. Temperature was 27 $\pm$ 3^{o}C. After shoot emergence, rhizomes were trimmed to four-node sections in which two adjacent shoots were on the end two nodes and the other two nodes lacked shoots. When shoots had reached the three-leaf stage, the shoot next to the end was cut with a razor blade to 2-cm from the rhizome. Preliminary tests showed complete shoot regrowth following cutting with no adverse effects. Treatments were initiated approximately 5 h following cutting. The cutting operation was performed so as to simulate a shoot which had not yet emerged and was dependent on the larger shoot for translocation of assimilates. Treatments of non-^{14}C labelled herbicides were applied in a spray chamber with a stationary nozzle with plants on a moving belt. Spray volume was 355 L/ha at a pressure of 220 kPa. The vermiculite was covered with a paper towel during application to prevent root uptake of the herbicide.

<u>Effect of Tankmix and Rate</u>. A factorial arrangement of treatments was applied where plants were treated with three rates of either haloxyfop-methyl or DPX-Y6202 alone or in tankmix with 0.56 kg/ha of acifluorfen or 0.84 kg/ha of bentazon. Grass herbicide rates were selected so as to have a normal field-use rate (0.28 kg/ha), a low rate (1/4x or 0.07 kg/ha) and a high rate (4x or 1.12 kg/ha). Broadleaf herbicide rates are the labeled rates for field use. Crop oil concentrate was applied with each treatment at 2.3 L/ha except those containing acifluorfen where 1.2 L/ha was used. The middle leaf of the three-leaved quackgrass was supported on an inverted 946-ml, 14-cm tall plastic cup to insure full coverage of the adaxial surface. Immediately following passage under the spray nozzle, the center 2.5 cm of the middle leaf was treated with a 2 µl solution containing either 0.2 µCi of ^{14}C-haloxyfop-methyl (phenyl ring label, 11.2 mCi/mM) or ^{14}C-DPX-Y6202 (phenyl ring label, 10.7 mCi/mM). Applications were made with 5 µl syringe. Treatment solution of ^{14}C was allowed to mix with the sprayed herbicide solution on the leaf. Each treatment was replicated five times. Three replications were assayed for absorption and translocation and two replications were used for autoradiography. After treatment with the ^{14}C-labeled herbicide, plants were returned to the greenhouse for 4 days at which time they were harvested in the procedure described below. All experiments were conducted separately. The experiment with ^{14}C-haloxyfop-methyl was repeated twice and data from all three experiments were combined. The experiment with ^{14}C-DPX-Y6202 was repeated once and data from both experiments were combined.

Effect of Pre-Treatment with Acifluorfen and Bentazon. Quackgrass plants were treated in the spray chamber with either acifluorfen plus crop oil concentrate at 0.56 kg/ha and 1.2 L/ha, respectively; bentazon plus crop oil concentrate at 0.84 kg/ha plus 2.4 L/ha, respectively; or no treatment. Plants were returned to the greenhouse for 24 h at which time the center 2.5 cm of the middle leaf was treated with a 2 µl solution containing 0.2 µCi of either ^{14}C-haloxyfop-methyl or ^{14}C-DPX-Y6202. Four days after treatment with ^{14}C, plants were harvested in the procedure described below. Each treatment was replicated five times in the manner of the previous section. Experiments were conducted separately and each experiment was repeated once and data from both times were combined.

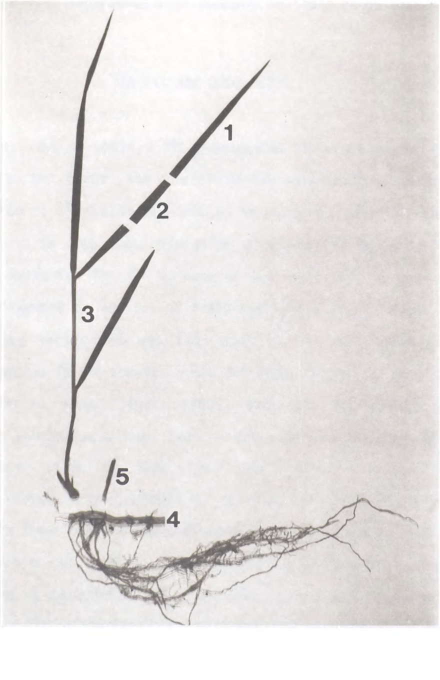
Preparation of ^{14}C-Solutions. Treatment solutions of ^{14}C labeled herbicides were prepared as follows. The ^{14}C-haloxyfop-methyl was received dissolved in benzene. The desired amount of activity for an experiment was removed and placed in a reaction vial and the benzene was evaporated under nitrogen. A treatment solution of 0.1 µCi/µl was prepared by re-dissolving the ^{14}C-haloxyfop-methyl in a solution of 89.0% distilled water, 1.0% crop oil concentrate and 10.0% blank technical carrier XRM-4570[1]. The mixture was kept suspended with a test tube shaker between applications. A new treatment solution was prepared prior to each experiment. The ^{14}C-DPX-Y6202 was received as a solid. This was dissolved in toluene from which desired amount of

[1]Dow Chemical Company.

activity was withdrawn for each preparation. The desired amount of activity was withdrawn and placed in a reaction vial and the toluene was evaporated under nitrogen. The treatment solution preparation and application with ^{14}C-DPX-Y6202 was identical to that with ^{14}C-haloxyfop-metnhyl.

Harvesting and Determination of Translocation. Four days after treatment, plants from three replications were sectioned into five parts for translocation assay. They are: (1) leaf tip, (2) treated area, (3) lower leaves, (4) rhizome, and (5) small shoot (Figure 1). A leaf wash to remove non-absorbed ^{14}C was done by holding the end of the treated area with forceps and rinsing the adaxial surface with a 10 ml stream of acetone from a pipette. Both herbicides are highly soluble in acetone and preliminary tests found that this procedure removed over 99% of applied ^{14}C which had been blown dry and rinsed several minutes after application to quackgrass leaves. Ten ml did not result in any significant cuticle removal as the rinse remained clear whereas higher volumes were tinted green. The rinse was collected in a scintillation vial and was allowed to evaporate. After evaporation, 0.5 ml of acetone was added to the vial and swirled around the internal surfaces to redissolve the ^{14}C-herbicide followed by 10 ml of scintillation cocktail. Activity in the leaf wash was determined by liquid scintillation counting. After the acetone rinse, the treated area and other plant parts were put in test tubes and placed in a freezer for 24 h and then lypholized. The amount of activity per plant part was determined with biological oxidation and liquid scintillation counting. For each plant, the percent of the total recovered ^{14}C by plant part

Figure 1. Quackgrass plant sectioned into parts for determination of translocation.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(including leaf wash) was determined. Analysis of variance to determine treatment effects was conducted within the different plant parts. Data were subjected to the arcsin data transformation and analyzed for mean separation with Duncan's multiple range test.

RESULTS AND DISCUSSION

The recovery of applied ^{14}C averaged 81.7% for haloxyfop-methyl and 84.8% for DPX-Y6202 with no differences between treatments. The distribution of ^{14}C-haloxyfop-methyl is shown in Table 1. Based on leaf wash, it is seen that absorption of haloxyfop-methyl with all treatments accounted for 97% or more of the recovered ^{14}C and was not greatly influenced by additon of broadleaf herbicide. A major effect of combining herbicides was seen only at the 0.07 kg/ha rate of haloxyfop-methyl in the treated area and lower leaves of quackgrass. In the treated area, significantly more ^{14}C was retained when acifluorfen and bentazon were present than when haloxyfop-methyl was applied alone. It follows that significantly more ^{14}C translocated to the lower leaves in the absence of acifluorfen and bentazon. This reduction in translocation may influence phytotoxicity and could result in a reduction of control of quackgrass. Although only minor differences in amounts of ^{14}C were seen in the lower plant parts, retention of ^{14}C in the treated area over time may result in reduced translocation to the rhizome and non-emerged shoots such that they would survive a herbicide application where acifluorfen or bentazon was

Table 1. Absorption and translocation of ^{14}C-haloxyfop-methyl in quackgrass 144 h after application to treated plants[a].

Treatment[b]	Rate	^{14}C Recovery by plant part					
		Leaf Tip	Trt. Area	Lower Leaves	Rhizome	Small Shoot	Leaf Wash
	(kg/ha)	%					
Haloxyfop-methyl	0.07	10.6 a	54.3 a-b	31.0 b	1.9 b	0.9 a	1.3 a
Haloxyfop-methyl + acifluorfen	0.07 + 0.56	8.8 a	66.4 c	19.5 a	1.5 a-b	1.7 b	2.4 a-b
Haloxyfop-methyl + bentazon	0.07 + 0.84	10.4 a	65.0 c	18.8 a	1.5 a-b	1.2 a	2.5 a-b
Haloxyfop-methyl	0.28	12.3 a	64.1 c	18.5 a	1.6 a-b	1.3 a-b	2.7 a-b
Haloxyfop-methyl + acifluorfen	0.28 + 0.56	10.1 a	58.1 a-c	26.8 a-b	1.4 a	1.2 a	2.4 a-b
Haloxyfop-methyl + bentazon	0.28 + 0.84	11.9 a	59.5 a-c	23.1 a-b	1.4 a	1.0 a	3.2 b
Haloxyfop-methyl	1.12	14.8 a	50.7 a	28.2 a-b	1.5 a-b	1.1 a	2.9 b
Haloxyfop-methyl + acifluorfen	1.12 + 0.56	10.9 a	58.9 a-c	24.9 a-b	1.1 a	1.0 a	3.0 b
Haloxyfop-methyl + bentazon	1.12 + 0.84	12.1 a	61.5 b-c	21.1 a-b	1.4 a	0.8 a	3.1 b

[a]Means within a plant part are not significantly different at the 5% level according to Duncan's multiple range test.

[c]Treatments of haloxyfop-methyl and haloxyfop-methyl + bentazon were tankmixed with crop oil concentrate at 2.3 L/ha and treatments of haloxyfop-methyl + acifluorfen were tankmixed with crop oil concentrate 1.2 L/ha.

present.

At the higher rates of haloxyfop-methyl application, herbicide combination treatment effects were not as prevalent in the treated area and lower leaves, although at the highest rate bentazon caused retention of ^{14}C in the treated areas. These results are consistant with those seen by the author in the field where reduced control of quackgrass due to tank-mixing broadleaf and grass herbicides were overcome by increasing the application rate of the grass herbicide. In addition, the data expressed are percent of the amount of ^{14}C recovered and this percentage is relatively constant with the three rates of applied haloxyfop-methyl. Therefore, the total amount of haloxyfop-methyl within a quackgrass plant would be greater at the higher rates since more total haloxyfop-methyl was available for abosrption and translocation.

Autoradiographs show darker images in the treated areas on plants in which acifluorfen and bentazon were applied with the 0.07 kg/ha rate of haloxyfop-methyl than when haloxyfop-methyl was applied alone (Figures 2, 3 and 4). This indicated reduced translocation out of the teated area as depicted in Table 1. However, the autoradiography was not sensitive enough to show the reduced translocation to the lower leaves when acifluorfen and bentazon were present in combination with haloxyfop-methyl. All autoradiographs show that the ^{14}C translocated throughout the entire plant. It is interesting to note darker labeling at the tip of the small shoot which is a region of high meristematic activity. This is seen in all three autoradiographs.

Figure 2. Distribution of ^{14}C-haloxyfop-methyl 144 h after treatment of plant receiving an application of haloxyfop-methyl plus crop oil concentrate at 0.07 kg/ha plus 2.3 L/ha, respectively. Top - plant; Bottom - autoradiographs. Arrow denotes treated area.

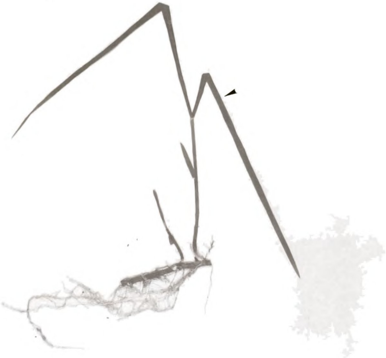


Figure 3. Distribution of ^{14}C-haloxyfop-methyl 144 h after treatment of plant receiving an application of haloxyfop-methyl plus acifluorfen plus crop oil concentrate at 0.07- plus 0.56 kg/ha plus 1.2 L/ha, respectively. Top - plant; Bottom - autoradiograph. Arrow denotes treted area.

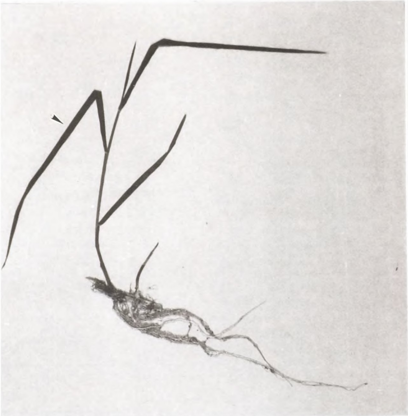
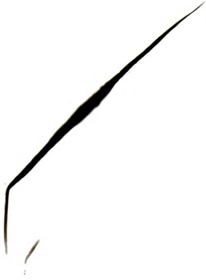


Figure 4. Distribution of ^{14}C haloxyfop-methyl 144 h after treatment of plant receiving an application of haloxyfop-methyl plus bentazon plus crop oil concentrate at 0.07- plus 0.84 kg/ha plus 2.3 L/ha, respectively. Top - plant; Bottom - autoradiograph. Arrow denotes treated area.



Pretreatment with acifluorfen and bentazon did not influence translocation of ^{14}C-haloxyfop-methyl applied 24 h later (Table 2). However, plants were not sprayed with haloxyfop-methyl prior to treatment with ^{14}C as in the previous experiment. Although separate experiments, it appeared that translocation of ^{14}C from the treated area was less than when plants were sprayed with haloxyfop-methyl immediately prior ^{14}C application. This suggests that haloxyfop-methyl may enhance its own translocation.

The distribution of ^{14}C-DPX-Y6202 is shown in Table 3. Leaf wash data shows considerably less absorption of DPX-Y6202 by quackgrass than haloxyfop-methyl. The effects of herbicide combination show further differences between the two grass herbicides. Within the low rate (0.07 kg/ha) treatments of DPX-Y6202, acifluorfen significantly reduced translocation of ^{14}C to the leaf tip suggesting that acifluorfen reduced transpiration. Both acifluorfen and bentazon significantly reduced translocation of ^{14}C to the rhizome although these differences were small and contribution to reduced control in the field is uncertain. At the middle and highest (0.28 and 1.12 kg/ha) rates of sprayed DPX-Y6202, the presence of bentazon in the application significantly reduced the absorption of ^{14}C-DPX-Y6202 as shown by the higher activity in the leaf wash of that treatment.

The basis for herbicide combination effects are evidenced when the means of the different tankmixes were averaged over the three rates of DPX-Y6202 (Table 4). Data indicated that acifluorfen reduced translocation of ^{14}C to the leaf tip and bentazon reduced its

Table 2. Translocation of ^{14}C-haloxyfop-methyl in quackgrass 144 h after application to plants which received a 24 h pretreatment of acifluorfen or bentazon.

Treatment[a]	Rate	^{14}C Recovery by plant part					
		Leaf Tip	Trt. Area	Lower Leaves	Rhizome	Small Shoot	Leaf Wash
	(kg/ha)	%					
None	--	8.9	72.8	13.6	1.9	1.3	2.0
Acifluorfen	0.56	11.5	72.1	12.0	0.7	1.2	2.1
Bentazon	0.84	12.6	74.9	11.5	1.4	1.4	1.3
		nsd[b]	nsd	nsd	nsd	nsd	nsd

[a]Aciflurofen and bentazon tankmixed with crop oil concentrate at 2.3 and 1.2 L/ha, respectively.

[b]There were no significant differences observed between treatments within plant parts at the 5% level of probability.

Table 3. Absorption and translocation of ^{14}C-DPX-Y6202 in quackgrass 144 h after application to treated plants[a].

		^{14}C Recovery by plant part					
Treatment[b]	Rate	Leaf Tip	Trt. Area	Lower Leaves	Rhizome	Small Shoot	Leaf Wash
	(kg/ha)	%					
DPX-Y6202	0.07	11.8 b-c	28.0 c	13.8 a-b	2.4 b	0.6 c	43.4 a-c
DPX-Y6202 + acifluorfen	0.07 + 0.56	2.6 a	22.8 b-c	33.1 b	1.0 a	0.3 a-c	43.2 a-c
DPX-Y6202 + bentazon	0.07 + 0.84	5.0 a-b	23.2 b-c	22.3 a-b	1.1 a	0.3 a-c	48.1 a-c
DPX-Y6202	0.28	10.0 a-c	16.8 a-b	28.3 a-b	1.8 a-b	0.5 c	32.8 a
DPX-Y6202 + acifluorfen	0.28 + 0.56	4.3 a-b	19.4 a-c	26.6 a-b	1.0 a	0.3 a-c	40.8 a-b
DPX-Y6202 + bentazon	0.28 + 0.84	9.5 a-c	12.8 a	24.4 a-b	1.1 a	0.4 a-c	51.8 b-c
DPX-Y6202	1.12	13.9 a-c	21.0 a-b	21.0 a-b	1.2 a	0.5 c	40.9 a-b
DPX-Y6202 + acifluorfen	1.12 + 0.56	6.7 a-c	25.4 a-b	25.4 a-b	1.4 a-b	0.2 a-b	46.4 a-c
DPX-Y6202 + bentazon	1.12 + 0.84	13.3 c	12.7 a	12.7 a	0.9 a	0.2 a-b	58.1 c

[a]Means within a plant part are not significantly different at the 5% level accroding to Duncan's multiple range test.

[b]Treatments of DPX-Y6202 and DPX-Y6202 + bentazon were tankmixed with crop oil concentrate at 2.3 L/ha and treatments of DPX-Y6202 + acifluorfen were tankmixed with crop oil concentrate at 1.2 L/ha.

Table 4. Absorption and translocation of ^{14}C-DPX-Y6202 averaged over three rates of DPX-Y6202 plus three tankmixes, 144 h after application to treated plants[a].

Tankmix	Rate	^{14}C Recovery by plant part					
		Leaf Tip	Trt. Area	Lower Leaves	Rhizome	Small Shoot	Leaf Wash
	(kg/ha)	%					
Crop oil concentrate	2.3 L/ha	11.9 b	22.1 a	21.0 a	1.8 b	0.6 b	39.1 a
Acifluorfen + COC[b]	0.56 + 1.2 L/ha	4.5 a	21.0 a	28.3 a	1.1 a	0.3 a	43.5 a
Bentazon + COC	0.84 + 2.3 L/ha	11.3 b	16.9 a	19.8 a	1.0 a	0.3 a	52.7 b

[a]Means within a plant part are not significantly different at the 5% level according to Duncan's multiple range test.

[b]COC = Crop oil concentrate.

absorption. Both broadleaf herbicides resulted in reduced translocation of ^{14}C to the rhizome and small shoot, although these differences are very small.

Autoradiography does not clearly depict these differences (Figures 5, 6, 7). However, less ^{14}C-DPX-Y6202 translocated throughout the quackgrass than did ^{14}C-haloxyfop-methyl since whole-plant images of the former are lighter than with the latter (Figures 5, 6 and 7 vs. 2, 3 and 4). This is undoubtedly due to the lower levels of absorption of ^{14}C-DPX-Y6202 compared to ^{14}C-haloxyfop-methyl. However, previous field results obtained by the author indicate very similar quackgrass activity with both compounds. This suggests that DPX-Y6202 is a more phytotoxic molecule than haloxyfop-methyl since it is just as active on quackgrass although less was absorbed.

As with ^{14}C-haloxyfop-methyl, pretreatment with acifluorfen and bentazon also did not influence translocation of ^{14}C-DPX-Y6202 which was applied 24 h later (Table 5). However, 24 h treatment with acifluorfen and bentazon reduced quackgrass control with both DPX-Y6202 and haloxyfop-methyl in field trials by the author.

SUMMARY

Patterns of absorption and translocation of ^{14}C-haloxyfop-methyl and ^{14}C-DPX-Y6202 were determined in quackgrass plants treated with several rates of the respective grass herbicides applied with and without the broadleaf herbicide acifluorfen and bentazon.

Figure 5. Distribution of ^{14}C-DPX-Y6202 144 h after treatment of plant receiving an application of DPX-Y6202 plus crop oil concentrate at 0.07 kg/ha plus 2.3 L/ha, respectively. Top - plant; Bottom - autoradiograph. Arrow denotes treated area.

Figure 6. Distribution of ^{14}C-DPX-Y6202 144 h after treatment of plant receiving an application of DPX-Y6202 plus acifluorfen plus crop oil concentrate at 0.07 - plus 0.56 kg/ha plus 1.2 L/ha, respectively. Top - plant; Bottom autoradiograph. Arrow denotes treated area.

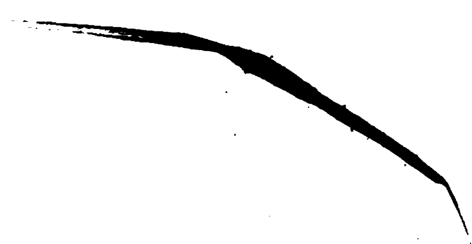


Figure 7. Distribution of ^{14}C-DPX-Y6202 144 h after treatment of plant receiving an application of DPX-Y6202 plus bentazon plus crop oil concentrate at 0.07 - plus 0.84 kg/ha plus 2.3 L/ha, respectively. Top - plant; Bottom - autoradiograph. Arrow denotes treated area.

Table 5. Translocation of ^{14}C-DPX-Y6202 in quackgrass 144 h after application to plants which received a 24 h pretreatment of acifluorfen or bentazon.

Pretreatment[a]	Rate	^{14}C Recovery by plant part					
		Leaf Tip	Trt. Area	Lower Leaves	Rhizome	Small Shoot	Leaf Wash
	(kg/ha)	%					
None	--	2.0	28.0	12.8	1.1	0.4	55.7
Acifluorfen	0.56	2.7	31.1	10.0	0.8	0.2	55.1
Bentazon	0.84	1.5	27.0	7.0	0.9	0.2	63.4
		nsd[b]	nsd	nsd	nsd	nsd	nsd

[a]Acifluorfen and bentazon tankmixed with crop oil concentrate at 2.3 and 1.2 L/ha, respectively.

[b]There were no significant differences observed between treatments within plant parts at the 5% level of probability.

A major difference between the two labeled herbicides was observed in the amount of ^{14}C absorbed as considerably more ^{14}C-haloxyfop-methyl was absorbed by the treated quackgrass leaves than ^{14}C-DPX-Y6202. Reduced translocation of ^{14}C-haloxyfop-methyl out of the treated area and into the lower leaves was observed in plants treated with haloxyfop-methyl and acifluorfen at 0.07 plus 0.56 kg/ha plus crop oil concentrate at 1.3 L/ha. However, this effect was not seen in plants treated with higher rates of haloxyfop-methyl.

When averaged over rates of DPX-Y6202 application, acifluorfen reduced translocation of ^{14}C-DPX-Y6202 from the treated area to the tip of the treated leaf and bentazon reduced its absorption into treated quackgrass plants. However, with both herbicides, acifluorfen and bentazon did not have a large effect on translocation of ^{14}C to the rhizome and small shoot on the rhizome.

These reductions in translocation may partially explain the reduction in quackgrass control observed in the field when acifluorfen and bentazon are added to certain applications of postemergence grass herbicides.

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CHAPTER 6

SUMMARY AND CONCLUSIONS

Field trials were conducted in 1982 and 1983 for the evaluation of total postemergence weed control systems compared to conventional systems.

In the control of annual weeds, postemergence systems were generally not as effective as standard preemergence applications. Numerous factors influenced control obtained with a total postemergence approach. One of these was the ability to make herbicide applications at the proper plant growth stage. Weeds must be treated before they become too large to be controlled or before interference causes yield reduction. Weather and other farm priorities may influence proper timing. It may also be that while one particular group of weeds are in the proper growth stage for application, others may be too small or not yet emerged as in the case of common lambsquarters in the 1982 study. Knowledge of weeds present, particularly broadleaves, is important since different herbicides controlled different weeds.

However, postemergence applications can fit into a system in several ways. Often inadequate rainfall occurs for the activation of preemergence applied herbicides such that weeds escape control. In addition, in large acreages of soybeans, many times the grower is

unable to complete preemergence applications prior to weed emergence. In these instances, postemergence weed control can be very useful. In addition, there are various species of broadleaved and grass weeds not easily controlled with soil applied herbicides that are controlled with a particular postemergence herbicide. Thus, that postemergence weed control can fit into a program where needed rather than be relied upon as the only means of weed control.

It is shown with quackgrass, that tillage, crop rotation, and tank-mixes can influence control with both non-selective and the selective postemergence herbicides. Generally, longer and more effective quackgrass control was obtained with non-selective herbicide applications. However, again the postemergence herbicides offer the grower other options for his system. It is often impractical to make non-selective applications in the temperate North due to weather slowing quackgrass growth in the spring, early frosts in the fall, or time constraints. In other cases, a grower may not realize the severity of a quackgrass infestation until after the soybeans have emerged. The postemergence grass herbicides offer solutions in these and other situations.

In most instances with postemergence grass herbicides it was demonstrated that despite poor control of quackgrass regrowth in the late season, adequate control was obtained in the early season so that maximum yields were obtained. However, grower satisfaction may be affected by the potentially large fall weed infestation in a field that received expensive herbicide applications. Growers may not be convinced that yields are not greatly affected by late season growth.

Tankmixes of acifluorfen and bentazon with postemergence grass herbicides often reduced control of quackgrass, particularly in the late season. These two herbicides were shown to differentially affect absorption and translocation of ^{14}C-haloxyfop-methyl and DPX-Y6202 which may partially explain this antagonism. However, these tankmixes did not significantly affect soybean yields since the reduced control was not manifested until late season.

In conclusion, it is important to realize that weed control is subject to numerous influences. Therefore, weed control measures should be matched to growers total agronomic system while considering the economics of such applications.