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Title: SELECTIVE CONTROL OF VOLUNTEER WHEAT (*Triticum aestivum* (L.) em. Thell.) IN NEW SEEDINGS OF ALFALFA (*Medicago sativa* L.) WITH FLUAZIFOP-BUTYL AND SETHOXYDIM

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Volunteer winter wheat (*Triticum aestivum* 'Daws') severely suppressed growth of fall-planted alfalfa (*Medicago sativa* (L.) 'Vernal') seedlings. Wheat competition began soon after alfalfa emerged and continued until the first forage harvest the following May. Alfalfa yield at the first cutting was reduced by 1% for each day volunteer wheat was allowed to grow within the period of 20 to 41 days after planting. When the wheat remained until harvest, alfalfa yield was reduced by 85%.

Fluazifop-butyl (+) -butyl 2-[4-[[5-(trifluoromethyl)-2- pyridinyl] oxy] phenoxy] propanoate and sethoxydim 2-[1- (ethoxyimino)butyl] -5-[2-(ethylthio)propyl] -3-hydroxy-2-cyclohexen-1-one at rates as high as 3.2 kg/ha (plus

phytobland oil at 2.3 L/ha) did not injure the alfalfa or reduce the yield of alfalfa hay when applied at any stage of growth from the unifoliate to the fully developed stages.

Control of wheat was better when fluazifop-butyl and sethoxydim were applied in the fall than in the summer. Both herbicides controlled wheat slightly better when applied in the one- to five- tiller stages than at earlier or later stages of growth. In general, fluazifop-butyl was more effective than sethoxydim when applied at any given rate. Under favorable conditions, rates of fluazifop-butyl and sethoxydim as low as 0.12 and 0.18 kg/ha, respectively, killed wheat. Wheat growth was suppressed at even lower rates. However, higher rates (0.2 and 0.4 kg/ha of fluazifop-butyl and sethoxydim, respectively) were required to provide a long term effect under a broad range of conditions.

The activity of fluazifop-butyl applied at the two-tiller stage of wheat took place mainly through foliar rather than root exposure. Fluazifop-butyl at 0.2 kg/ha killed wheat regardless of the soil moisture content (8% vs 15%). The activity of fluazifop-butyl at 0.12, 0.18, and 0.24 kg/ha on wheat was severely reduced when combined with the dimethylamine salt of 2,4-DB [4-(2,4-dichlorophenoxy) butyric acid] at 1.8 kg/ha, but the antagonism was overcome by increasing the rate of the grass killer to 0.36 kg/ha.

SELECTIVE CONTROL OF VOLUNTEER WHEAT (*Triticum aestivum* (L.) em. Thell.) IN NEW SEEDINGS OF ALFALFA (*Medicago sativa* L.) WITH FLUAZIFOP-BUTYL AND SETHOXYDIM

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INTRODUCTION

Alfalfa for hay production commonly is seeded in August or September following harvest of winter wheat in the irrigated areas of the Pacific Northwest (26). Volunteer wheat is an important weed in such new seedings of alfalfa. Although it must be controlled to prevent severe suppression of the crop, wheat can be beneficial on light soils, because it helps to prevent wind erosion at the beginning of the growing season when the crop has not yet produced adequate cover.

Propham is currently used to control volunteer wheat in new seedings of alfalfa. Because propham is volatile, the application must be delayed until October to avoid high temperatures. Competition from the wheat may have already injured the alfalfa irreversibly before this time. Moreover, cereal treated with propham does not die completely until the next spring, and could continue to compete after herbicide application. Other herbicides are needed that will kill wheat rapidly when applied postemergence after the wheat has grown long enough to protect the soil from wind erosion, but before harmful competition has occurred.

Most of the alfalfa hay in Washington is grown under sprinkler or furrow irrigation. Moisture levels in the soil at the time of herbicide application, and the time and method of irrigation after application may affect the activity of the herbicides. It is important to know the influence of these factors because they might be manipulated to benefit the activity of the herbicide.

Fluazifop-butyl[1] and sethoxydim[2] are two experimental herbicides that control annual and perennial grasses when applied postemergence, and are selective on most broadleaf crops. Their time of application, related to the stage of growth of the grasses, is not as critical as that for many other herbicides, and they do not depend on low temperatures to be effective. This flexibility could allow their effective application during a prolonged period.

Several trials were conducted during the spring, summer, and fall of 1982 at the Irrigated Agriculture Research and Extension Center in Prosser, Washington, to obtain information on the control of volunteer wheat with fluazifop-butyl and sethoxydim. The objectives of these studies

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1. Fluazifop-butyl is the butyl ester formulation of fluazifop. Fluazifop is the proposed name of (+)-butyl 2-[4-[5-(trifluoromethyl)-2- pyridinyl] oxy] phenoxy] propanoate, formulated as FUSILADE ™ by ICI Americas Inc.; Agricultural Chemical Division, P.O. Box 208, Goldsboro, N.C. 27530. The formulation contains 46.6% active ingredient.
2. Sethoxydim is the proposed name of 2-[1-(ethoxyimino) butyl] -5-[2-(ethylthio)propyl] -3-hydroxy-2-cyclohexen-1-one, formulated as POAST ® by BASF Wyandotte Corporation, Agriculture Chemicals Division, 100 Cherry Hill Road, Parsippany, N.J. 07054. The formulation contains 20.0% active ingredient.

were to:

1. Determine how long volunteer wheat can grow with newly seeded alfalfa without adversely affecting the alfalfa.

2. Measure the tolerance level of alfalfa seedlings to fluazifop-butyl and sethoxydim.

3. Determine the susceptibility of wheat to fluazifop-butyl and sethoxydim.

4. Determine the influence of soil moisture levels at the time of postemergence application on the control of volunteer wheat by fluazifop-butyl.

5. Determine the relative importance of root and foliar uptake of fluazifop-butyl applied postemergence to volunteer wheat .

6. Obtain preliminary information on possible interactions of the tank mix combination of fluazifop-butyl and 2,4-DB.

LITERATURE REVIEW

Weeds competing with alfalfa seedlings may severely reduce forage and seed production by reducing the stand of the crop, its vigor, or both (21,46,57). Besides those detrimental effects, weeds reduce the protein content, the net energy, and the palatability of alfalfa forage (13,70).

Although alfalfa seedlings are more aggressive than other forage legumes (7), they grow more slowly than the seedlings of many weeds. They demand high light intensities for maximum growth rates (6), and are thus very susceptible to suppression from shading.

Recently, Fischer et al.[3] working under similar conditions of the present study, determined that alfalfa forage production was reduced by the competition from a mixture of weed species that compete for a period longer than 36 days after the emergence of the crop. They also determined that weeds emerging after that period did not affect forage yield at all. Under other conditions, delaying crabgrass (Digitaria sanguinalis (L.) Scop.) control reduced total forage production of newly seeded alfalfa (34).

Alfalfa is often planted with a cereal in the spring.

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3. Fischer, A.J., J.H. Dawson, and A.P. Appleby, 1982. Personal Communication.

The cereal does not benefit the alfalfa; it simply replaces the weeds with a valuable crop, and is no more competitive than the weeds would have been (20). Fall plantings of alfalfa with winter wheat as a companion crop could be suppressed by competition from excessive wheat growth particularly if planted early (55).

The effect of wheat as a weed in alfalfa seedlings has not been established. However, it is generally accepted that grasses normally have a competitive advantage over legumes, especially under conditions of adequate nitrogen (33).

Herbicides represent an important tool in suppressing weeds selectively in alfalfa seedlings (8,16,20). Recently, several experimental herbicides that control grasses selectively in most broadleaf crops, have been studied in alfalfa. Two of those herbicides are fluazifop-butyl and sethoxydim.

The few reports concerning the use of fluazifop-butyl in alfalfa seedlings agree that there is excellent selectivity when rates as high as 1.0 kg/ha are applied postemergence, regardless of the stage of growth of the crop (5,25,27,39,41,42).

Similar selectivity was observed with sethoxydim applied postemergence to alfalfa seedlings (39,41,42,47,56). Norris et al. (46) reported satisfactory selectivity, even when sethoxydim was applied at the first true leaf stage of alfalfa. They observed only localized necrosis at rates of 2.2 kg/ha, but this effect was rapidly outgrown. Himmelstein and Peters (34) observed no injury at low rates, but detected forage yield reductions when sethoxydim was sprayed at 1.1 kg/ha at the two- to three- leaf stage. A similar reduction has been reported when sethoxydim (0.6 kg/ha plus adjuvant) was sprayed on a 3-year-old stand of alfalfa (38). However, other studies indicated good selectivity of this herbicide when applied to old stands of this legume (5,27,48,52).

None of these studies in which yield of alfalfa was reported involved weed-free alfalfa to avoid the effect of weeds on yields. Thus, possible yield reductions caused by the herbicides could have been masked by the beneficial effect of removing weed competition.

Wheat is very susceptible to both herbicides (4,24,66). Fluazifop-butyl at 0.25 kg/ha controlled volunteer wheat at the two-leaf stage (42). In a study including both herbicides, fluazifop-butyl at 0.125, 0.25, and 0.5 kg/ha (plus adjuvant) reduced the stand of volunteer wheat 28 cm tall by 30, 90, and 100%, respectively. Similarly, sethoxydim applied at 0.5 kg/ha controlled 95% of the wheat (39). Nalewaja et al. (44) controlled 100% of wheat at the five-to six-leaf stage with rates of sethoxydim as low as 0.14 kg/ha (plus adjuvant). A similar rate (0.1 kg/ha) controlled wheat at the two- leaf stage in another study

(42). It was reported that 0.6 kg/ha controlled wheat acceptably up to 15 cm tall but higher rates were required for complete control (47).

Although both chemicals control small weeds better than large ones (24,29,50), timing does not appear to be as critical as with some other herbicides (56,66).

The addition of adjuvants generally increases the activity of the two chemicals on most target species (4,12,14,15,25,31,54,65,71). However, Leroux and Harvey (38) suggested that the addition of phytobland oil could be the cause of the lack of selectivity observed in a study on established alfalfa. An oil concentrate was among the most active of several adjuvants in enhancing activity of sethoxydim against grasses (17). The oil concentrate enhanced the control of johnsongrass (Sorghum halepense (L.) Pers.) by fluazifop-butyl, and accelerated the action of the herbicide (30). Similarly, it reduced the rain-free period required for maximum effect after sethoxydim application (18).

An adequate soil moisture content at the time of spraying enhanced the activity of both fluazifop-butyl (4,59) and sethoxydim (4,29,64). However, Rushing and Murray (63) observed no differences in the effect of sethoxydim on Sorghum bicolor (L.) Moench when applied at most rates to plants under stress (water potential, -20 bars) compared to higher moisture conditions (water potential, -5 bars). At the lowest rate (0.028 kg/ha), they observed more injury to plants under higher stress.

Muzik (43) summarized the statements of several authors about the way that water stress may affect the activity of herbicides on plants. Among the most important factors that may affect the activity of foliar translocated herbicides, he mentioned a reduction in stomatal aperture, a reduction in photosynthesis, and a reduction in photosynthate translocation. He also mentioned that a prolonged water stress period may increase pubescence and thickness and density of cuticle, and that a brief severe water stress makes the cuticle less permeable and increases the contact angle of spray droplets, thus decreasing wettability.

Although both herbicides are being developed for postemergence treatments based on their foliar activity (4,35), the fact that they were active when sprayed through a sprinkler irrigation system (23) suggests some kind of soil activity.

Fluazifop-butyl is reported to have some residual soil activity (66). Although it has not been established if this herbicide can be absorbed by the roots, it is known to be absorbed by the foliage and translocated readily via phloem and xylem (35). Growth ceases almost immediately after application, but other symptoms may not appear before a week after application (35).

The fact that more ^{14}C-labeled fluazifop was translocated in sunflower (Helianthus annus L.), a tolerant species, than in johnsongrass, a susceptible one, would indicate that selectivity is not based on differential absorption or translocation of this chemical (62). After the ^{14}C compound was extracted from different parts of the plant and analyzed, it was concluded that the ^{14}C-labeled material was translocated throughout the plant but accumulated primarily in the meristematic regions of both species. In johnsongrass, only trace amounts of this translocated material was the butyl ester form of the compound and 35% corresponded to the free acid. No further studies have been reported related to the site of uptake, the fate of the chemical inside the plants, the basis for selectivity, or the mode of action of this herbicide.

Soil persistence of sethoxydim is very short (4). Cranmer and Nalewaja (18) reported some root uptake of this herbicide when applied to wild oats at early stages of growth (two leaves). However, the importance of root uptake decreased as the size of the grass increased. Also, as the rate of the herbicide increased, or when oil concentrate was added, the activity of the herbicide became less dependent on root uptake. Campbell and Penner (11), working with ^{14}C labeled sethoxydim, observed that 90 % of the ^{14}C label penetrated the foliage of both tolerant and susceptible species within 12 h, was readily translocated via phloem, and accumulated in the metabolic sinks. Swisher and Corbin (67) described a similar pattern indicating that the herbicide is translocated both acropetally and basipetally to meristematic tissues within 12 h.

There seem to be no differences in absorption or translocation of sethoxydim between susceptible and tolerant species that could explain differences in susceptibility (10). However, transformation to metabolites is known to be very rapid (11). In soybeans (Glycine max (L.) Merr.), a tolerant species, the parent molecule of sethoxydim is oxidized, structurally rearranged, and conjugated (4). Similarly, Swisher and Corbin (67) observed that, although the ^{14}C labeled compound was readily translocated in both susceptible and tolerant species, there was a higher proportion of undegraded sethoxydim in the susceptible plants. They observed the same phenomenon while working with callus-derived suspension cultures, and concluded that selectivity could be related to a reduced ability of the undifferentiated cells of the susceptible species to degrade the compound, rather than to differential uptake or translocation (68).

Based on the effect of sethoxydim on the metabolism of isolated leaf cells of soybeans, Hatzios [4] suggested that

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4. Hatzios, K.K., 1982. Personal Communication.

the phytotoxic action of this herbicide is due to the modification of the lipid composition of plant membranes.

It is important that a grasskiller applied postemergence can be tank mixed with a herbicide used for broadleaf weed control, so that a broad spectrum of weeds can be controlled in only one operation. The main herbicide applied postemergence for broadleaf control in alfalfa seedlings is 2,4-DB (20).

Several plant responses can be expected as a result of the joint action of two chemicals compared to an application of each one alone. These responses have been defined as: independent, additive, synergistic, or antagonistic. However, the classification of a certain response into one of these categories is often controversial because the terms are interpreted in different ways (2,45,69).

The problem arises if more than one of the components of the mixture are separately active for the test species, but there is no difficulty if only one component affects it (40). Thus, antagonism has been defined in two ways. According to Nash (45), there is antagonism when the response of an organism to a pesticide is less than the sum of its responses to the individual toxicants. According to Tammes (69), there is antagonism if the total effect of the two components is smaller than the effect of the most active component alone. Conversely, synergism has been defined as the cooperative action of two components of a mixture, such that the total effect is greater or more prolonged than the sum of the two taken independently (45,69). Finally, when the total response is the sum of the two independent components, there would be no interaction but an "additive action" (45), or an "addition effect" (69).

However, regardless of the definition, in a study of a mixture in which compound A is effective against the target species and compound B is not, there would be no question about the occurrence of antagonism if, at a constant rate of A, the effect on the species is diminished by the addition of compound B.

On the contrary, if the addition of B results in an increase of activity in any proportion compared to A alone, this would obviously be synergism because B itself has no effect. If the effect of A is not modified at all, the action of the two herbicides would be independent (69).

Diclofop-methyl kills grasses with activity similar to that of sethoxydim and fluazifop-butyl. Dortenzio and Norris (22) have summarized several studies concerning interactions resulting from tank mixing diclofop with herbicides applied postemergence for broadleaf weed control. These authors pointed out a few aspects about these interactions: a) although many combinations were antagonistic, some of the broadleaf herbicides were compatible with diclofop; b) the main effect of these mixtures was an antagonism expressed as a reduction in the activity against grass rather than a modification of the degree of broadleaf control. However, some increase in soybean injury as a result of mixing this grass killer with bentazon was also reported; c) the antagonism was species dependent; d) the antagonism could be reduced or overcome by separating in time the application of each compound; e) the antagonism appeared to be rate dependent, and increased with a decrease in the rate of the grass killer.

Very little is known about possible interactions resulting from combinations of fluazifop-butyl with other herbicides. Stonebridge (66) has reported that its activity against grasses can be reduced when combined with phenoxy type herbicides, including 2,4-DB, and that this combination also can result in an increased phytotoxicity on soybeans.

There is evidence that bentazon mixed with sethoxydim reduces grass control (17,32,38,42,52,61). However, Campbell and Penner (9) only observed this effect at low rates of sethoxydim (0.28 kg/ha), and it was overcome by increasing the rate to 0.56 kg/ha. In other studies, no antagonism was detected (19,36). The effect of that combination on broadleaf weed control was different in the different studies; it either was not modified (17,42) or was reduced (37).

In an attempt to explain the antagonism between these two chemicals, Rhodes and Coble (60) observed that the absorption of ^{14}C-sethoxydim was inhibited by the addition of bentazon, but translocation, once in the plant, was not affected. They concluded that the interaciton could be due to a reduction in the absorption of sethoxydim in this kind of mixture.

Some indication of antagonism when sethoxydim is tank mixed with acifluorfen has been reported (53), but this was not always evident (44,61), or was detected only at low rates of sethoxydim (17). Some antagonism resulted from mixing sethoxydim with desmedipham but not with bromoxynil nor MCPA (44).

When 2,4-DB at 0.21 kg/ha was mixed with sethoxydim at 0.21 kg/ha, control of wild oats (*Avena fatua* L.) and yellow foxtail (*Setaria glauca* (L.) Beauv.) was reduced compared to that from the same rate of sethoxydim applied alone. When the rate of sethoxydim was increased to 0.42 kg/ha, control with or without 2,4-DB was the same (17).

Control of several grass species, including volunteer wheat, by sethoxydim at 0.15 and 0.35 kg/ha was not reduced at all when combined with 1.1 kg/ha of 2,4-DB, and this combination did not modify the selectivity of either herbicide to alfalfa (42).

Differences in results among the studies mentioned might be due to the fact that they were conducted on different grass species which may respond differently.

Also, because antagonism is often overcome by high rates of the grass killer, some of the contradictions may be explained in that the rates used in some of those studies were not low enough to express the antagonism. A range of rates should be included in interaction studies (2) especially for the herbicide whose activity on the target species is apt to be modified in the mixture.

MATERIALS AND METHODS COMMON TO ALL EXPERIMENTS

Experiments were planted on a Warden very fine sandy loam with 0.7% organic matter located at the Irrigated Agriculture Research and Extension Center at Prosser, Washington.

Rainfall distribution and irrigation dates of every trial are described in Appendix Table 1. The source of nitrogen, when used, was ammonium nitrate and was incorporated with a rototiller 10 to 20 cm deep. 'Daws' winter wheat was the variety used in all the studies as volunteer wheat. 'Vernal' alfalfa, inoculated with <u>Rhizobium meliloti</u>, was planted 1.5 cm deep in rows 18 cm apart with a Tye drill with double disc openers at a rate of 20 kg/ha in all experiments. The sprayers were pressurized by CO_2 at 190 kPa and 8002 nozzles were used in every case. Treatments of fluazifop-butyl and sethoxydim included phytobland oil at 2.3 L/ha. The oil was formulated with 83% non phytotoxic paraffin base petroleum oil and 15% polyol fatty acid esters and polyeloxylated derivatives thereof[5]. The degree of chlorosis on wheat was rated with an arbitrary scale wherein 0 indicated no chlorosis and 10 indicated complete chlorosis or necrosis.

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5. "MOR-ACT,Adjuvants",Originally developed as ICI Americas ATPLUS[R] 411F.

TOLERANCE OF ALFALFA SEEDLINGS TO FLUAZIFOP-BUTYL AND SETHOXYDIM

The tolerance of alfalfa seedlings to high rates of fluazifop-butyl and sethoxydim applied at different growth stages, was studied in an experiment conducted twice in the field in 1982.

Materials and methods

Treatments were replicated four times in randomized complete block designs each time, in plots 2.2 by 3.3 m. The area of each experiment was fertilized with 40 kg/ha of nitrogen. Alfalfa was seeded on 15 June and 24 August, respectively. The trials were kept free of weeds by hand and sprinkler irrigated as needed to prevent any moisture stress.

Treatments were four rates each of fluazifop-butyl and sethoxydim, at three different times in a factorial arrangement. Both herbicides were applied at 0.4, 0.8, 1.6, and 3.2 kg ai/ha in water at 430 L/ha. In both experiments, the early application was when the alfalfa was in the unifoliate to first trifoliate leaf- stage (29 June and 8 September). The medium application was 13 days later. In the spring, alfalfa had five to ten leaves and was 12 cm tall (12 July); in the fall, it had three to four leaves and was 6 cm tall (21 September). The late application in the spring experiment was on 22 July when alfalfa was 28 cm tall and had several branches and numerous leaves; in the fall experiment, it was on 4 October when alfalfa had seven leaves and was 8 cm tall. Different rates of growth of the alfalfa in the two seasons made it impossible to match the applications in phenologic stages and periods of time.

Twenty-four hours, 10 days, and 15 days after each application, symptoms of injury were described, and the alfalfa was rated on a scale wherein 0 indicated no symptoms and 10 indicated death. A 2.25-m^2 area was harvested in each plot on 19 August and 15 October for each respective experiment. In the spring experiment, the alfalfa was tall and upright, and was cut 1 cm high with an electricity powered clipper. The prostrate rosettes of alfalfa in the fall experiments, were cut underground 0.5 cm deep with a hoe. The harvested material was oven-dried and forage dry weights were recorded.

Results

Neither herbicide caused symptoms on the alfalfa at rates as high as 0.8 kg/ha. Small necrotic spots appeared on the alfalfa leaves within 24 h after the application of each herbicide at the five- leaf stage or earlier (early and medium application) at 3.2 kg/ha and occasionally at 1.6 kg/ha. This necrosis was more evident in the spring than in the fall and, at equivalent rates, sethoxydim was slightly more phytotoxic than fluazifop-butyl. No symptoms were observed in the late application in either trial. The symptoms were limited to the leaves present when treated and, did not enlarge with passing time. Symptoms were no longer visible 10 to 15 days after the application, and all treated alfalfa looked the same as the untreated. None of the treatments reduced the yield of alfalfa compared to the untreated check (Table 1).

Table 1. Response of weed-free alfalfa seedlings to fluazifop-butyl and sethoxydim applied postemergence at four rates and three times of application.

Treatments			Yield[c]		
Herbicide	Time of application[a]	Rate[b]	Experiment 1 Spring 1982	Experiment 2 Fall 1982	Avg
		(kg/ha)	(%)		
Fluazifop-butyl	Early	0.4	99 bc	97	98
		0.8	80 c	106	93
		1.6	96 bc	94	95
		3.2	125 abc	81	100
	Medium	0.4	94 bc	116	105
		0.8	111 bc	115	113
		1.6	90 bc	112	101
		3.2	78 c	108	93
	Late	0.4	84 c	106	95
		0.8	85 c	102	94
		1.6	79 c	101	90
		3.2	94 bc	94	94
Sethoxydim	Early	0.4	96 bc	116	106
		0.8	92 bc	127	110
		1.6	83 c	79	81
		3.2	86 c	112	99
	Medium	0.4	83 c	114	99
		0.8	92 bc	119	106
		1.6	89 bc	102	96
		3.2	86 c	108	97
	Late	0.4	154 a	112	133
		0.8	114 bc	106	110
		1.6	94 bc	110	97
		3.2	94 bc	109	101
Untreated		-	100 bc	100	100

[a]Early = alfalfa was in the unifoliate to 1 trifoliate leaf stage.
Medium = in spring: alfalfa had 5 to 10 leaves; in fall, 3 to 4 leaves.
Late = in spring: alfalfa was 28 cm tall and had several leaves and branches; in fall, was 8 cm tall and had 7 leaves.

[b]All herbicide treatments included phytobland oil at 2.3 l/ha.

[c]Yield is expressed as percentage of the untreated check. Yield in the untreated check in the spring experiment was 4,964 kg/ha and in the fall, experiment was 381.5 kg/ha. Means followed by the same letters do not differ at the 0.05 level according to Duncan's MRT. The F value was not significant at that level in the analysis of variance of Experiment 2.

SUSCEPTIBILITY OF WHEAT TO FLUAZIFOP-BUTYL AND SETHOXYDIM APPLIED POSTEMERGENCE

The susceptibility of volunteer wheat to fluazifop-butyl and sethoxydim was determined in an experiment conducted twice in the field in 1982. In this experiment, wheat was grown alone to determine the degree of control by the herbicides without the interference of alfalfa.

Materials and Methods

The plots consisted of three rows of wheat 10 m long, 18 cm apart, and separated by irrigation furrows. Wheat was planted at 80 kg/ha, 4 cm deep with a Tye drill on 23 June and 27 August for the spring and fall experiment, respectively. The experiments were furrow irrigated periodically.

Treatments were replicated six times in randomized complete block designs. Fluazifop-butyl and sethoxydim were applied at several rates at three stages of growth of the wheat (Table 2). The herbicides were applied in water at 200 L/ha with a knapsack sprayer. A boom with a single nozzle was operated 0.5 m high and directed to the central row of the plot. All data were collected from the center row of each plot. In the spring experiment, when wheat was in the four-leaf stage (13 June), bromoxynil was sprayed at 0.6 kg/ha to control redroot pigweed (*Amaranthus retroflexus* L.).

Table 2. Rates and dates of herbicide application in two experiments in which fluazifop-butyl and sethoxydim were applied to wheat at three stages of growth.

Stage of growth at the time of application	Exp. 1, Spring 1982		Exp. 2, Fall 1982	
	Date of application	Rate[a]	Date of application	Rate[a]
		(kg a.i./ha)		(kg a.i./ha)
2 to 3 leaves	8 July	0.06	13 Sept.	0.06
		0.12		0.12
		0.18		0.18
		0.24		0.24
		-		0.36
		-		0.48
1 to 2 tillers	16 July	0.06	21 Sept.	0.06
		0.12		0.12
		0.18		0.18
		0.24		0.24
		0.36		0.36
		-		0.48
5 tillers	23 July	0.18	1 Oct.	0.18
		0.24		0.24
		0.36		0.36
		0.48		0.48

[a]All treatments included phytobland oil at 2.3 l/ha.

Eight to 10 days after each application, the percentage growth reduction compared to the check was visually estimated. Fifteen days after each application, the degree of chlorosis was determined. Fifteen and 30 days after each application, plants were examined for new tillers that developed after treatment. The new tillers were counted in 10 representative plants and the average height of the new tillers was estimated, while the second time (30 days after the application), tillers were only counted. Also 30 days after each application, surviving plants were counted in a total of 100 consecutive plants in the central row.

The amount of green healthy wheat foliage as a percentage of the untreated check was estimated for all the treatments on 25 August and 2 November for each respective experiment. When the wheat was fully tillered but still in the vegetative stage, 8 (summer) and 4 (fall) meters of the central row of each plot, were cut with a hand clipper near the soil surface, and fresh and dry weights of the forage were determined.

Results

Summer Application:

Except at the lowest rate (0.06 kg/ha), both herbicides reduced wheat growth 50% or more within 10 days after each application (Appendix table 3). In every case, the treated foliage rapidly became chlorotic. In general, wheat was injured more at higher rate, and, at equivalent rates, fluazifop-butyl was more active than sethoxydim. However, with most of the rates, new tillers were evident within 15 days after application (Appendix table 4). The new tillers originated from unaffected buds, and were completely free of symptoms. Wheat recovered very rapidly, particularly after the early application (at the two- leaf stage), in which only the wheat treated with fluazifop-butyl at the highest rate (0.24 kg/ha) differed from the untreated check after a month (Appendix table 5).

The herbicides had a more lasting effect when applied at the one- to five- tiller stages. Although the number of surviving plants varied widely, more plants usually were killed in the late applications (one to five tillers) than at the earlier application (two- leaf stage). At a given rate, fluazifop-butyl killed more wheat plants than sethoxydim. For example, when applied at the five- tiller stage at 0.36 kg/ha, fluazifop-butyl killed 90% of the wheat plants, whereas sethoxydim at 0.48 kg/ha killed only 60% (Table 3).

Final wheat foliage production was less when the herbicides were applied at the two later dates because, the wheat had less time to recover from the time of the application until the experiment was ended (Figure 1).

Table 3. Percentage of living plants of wheat 30 days after the application of fluazifop-butyl and sethoxydim at several rates and three stages of growth, in the summer of 1982.

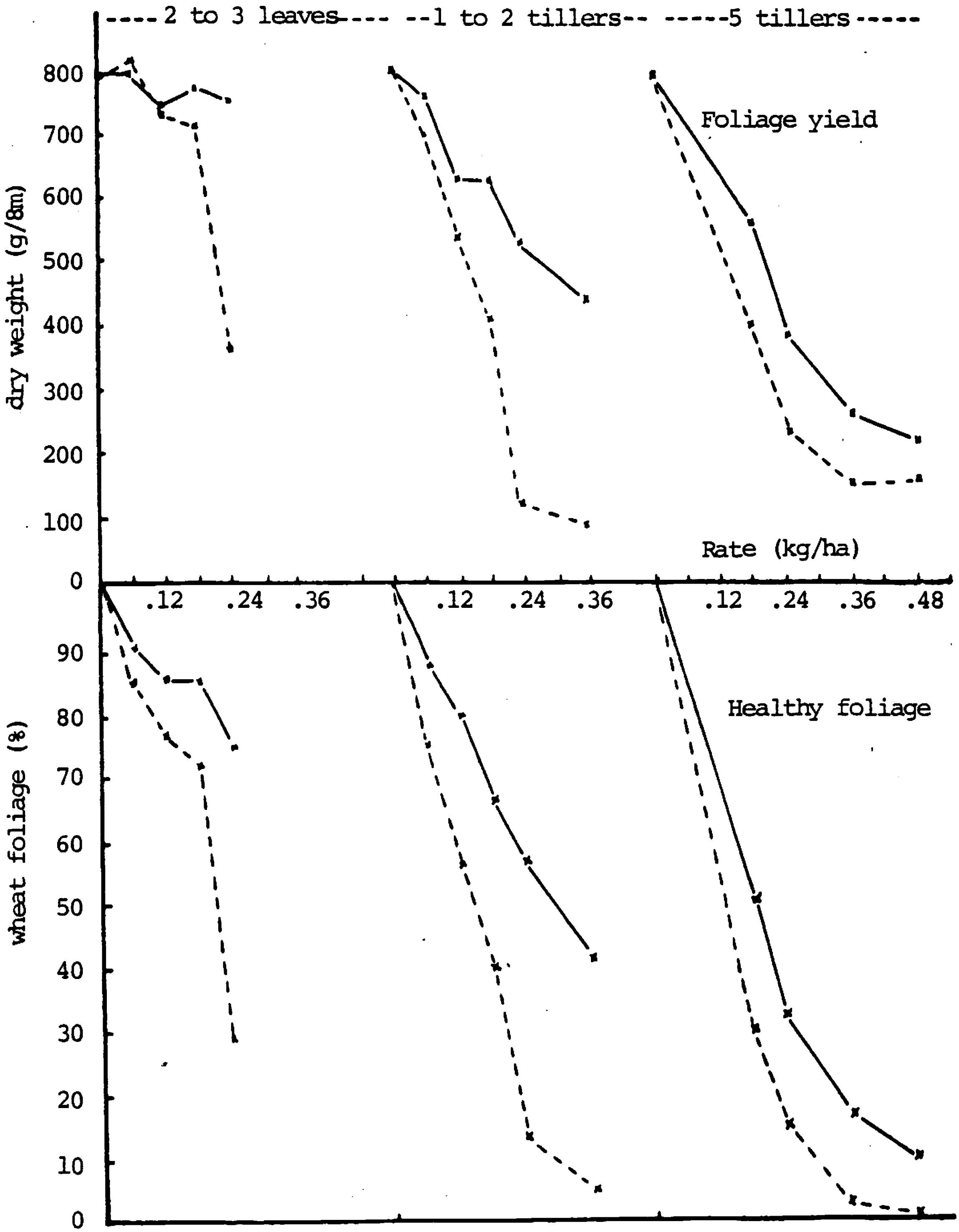
Treatments		Living plants[b]		
		Stage of growth when treated		
Herbicide	Rate[a]	(2 leaves)	(1 to 2 tillers)	(5 tillers)
	(kg/ha)		(%)	
Fluazifop-butyl	0.06	100	100	-
	0.12	100	98 ab	-
	0.18	99 a	77 ab	87 ab
	0.24	52 abc	46 c	56 ab
	0.36	-	11 d	10 d
	0.48	-	-	4 e
sethoxydim	0.06	100	100	-
	0.12	100	100	-
	0.18	100	100	100
	0.24	99 a	99 a	96 a
	0.36		87 ab	57 ab
	0.48		-	42 bc
Untreated	-	100	100	100

[a]All herbicide treatments included phytobland oil at 2.3 l/ha.

[b]Means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with values of 100 in all the replications were not included in the statistical analysis. Data were transformed to the Log (x + 1) before statistical analysis.

Fig. 1. Foliage yield of wheat and visual estimate of healthy foliage relative to that of the untreated check, in wheat plants treated with fluazifop-butyl and sethoxydim at three stages of growth in the summer of 1982.

Sethoxydim ———— Fluazifop-butyl - - - -



Fall Application:

All treatments reduced wheat growth within 10 days after each application (Appendix table 6). Most of the treatments affected all the tissue exposed at the time of spraying so that it stopped growing and eventually became chlorotic. When the herbicides were applied at the one- to two- tiller stage, however, the lowest rate of the two herbicides (0.06 kg/ha) and sethoxydim at 0.12 kg/ha, only burned the edges of the leaves. New growth appeared within 15 days of application of some treatments (Appendix table 7), while in others new growth first appeared later (Appendix table 8). Except in the three mentioned treatments, all leaves present when treated died. Any regrowth was from unaffected buds and consisted of new tillers, which were completely free of symptoms.

Fluazifop-butyl generally was more active than sethoxydim. Both herbicides killed more wheat plants at the one- to two- tiller and five- tiller stages than when applied at the two- leaf stage (Table 4). Fluazifop-butyl killed the wheat at 0.18 kg/ha at the later stages, whereas 46% of the plants survived this rate at the two- to three- leaf stage.

By the end of the experiment, the amount of wheat foliage was reduced more than 90% when either herbicide was applied at the two-leaf stage at 0.18 kg/ha. When

Table 4. Percentage of living wheat plants 30 days after the application of fluazifop-butyl and sethoxydim at several rates at three stages of growth, in the fall of 1982.

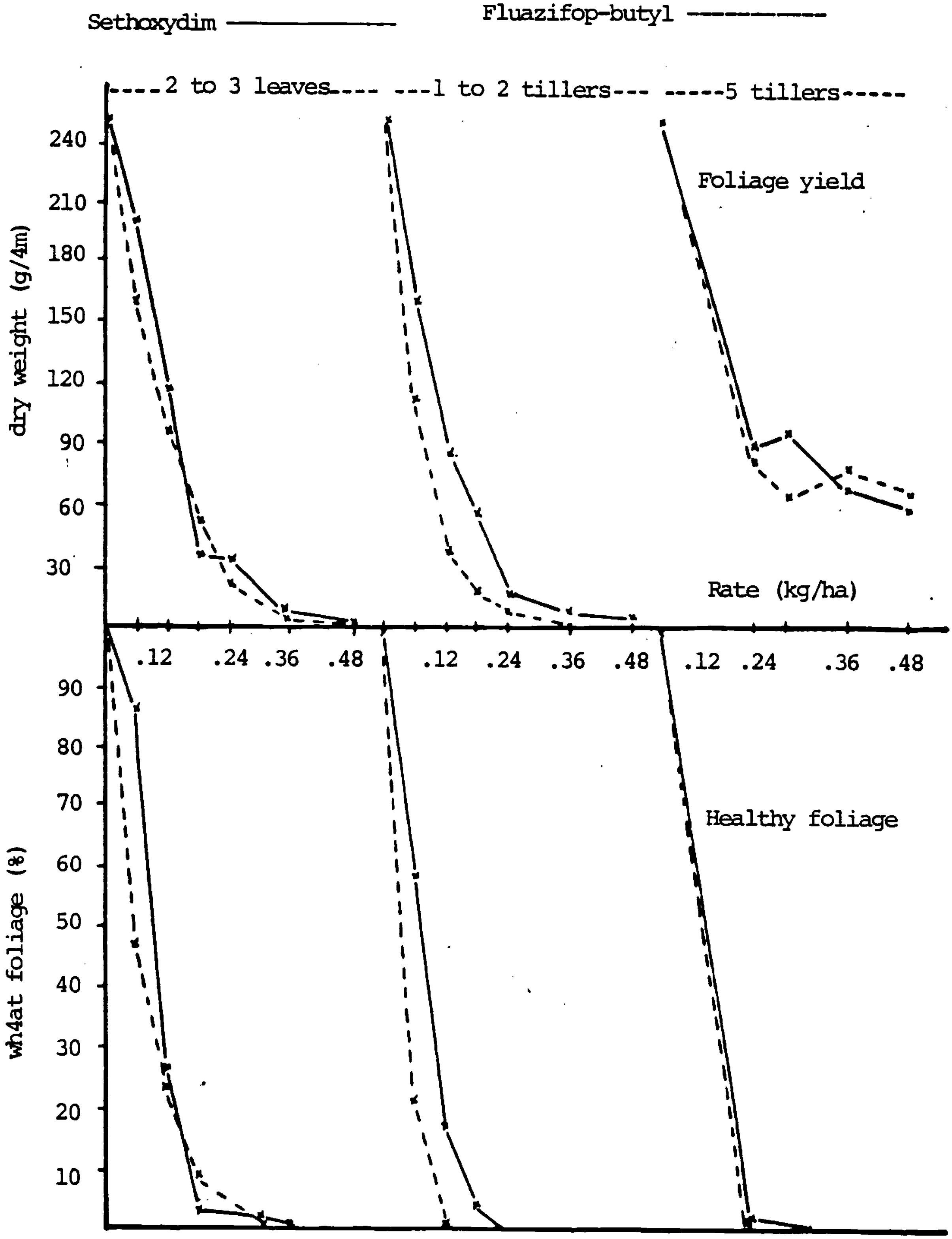
Treatments		Living plants[b]		
		Stage of growth when treated		
Herbicide	Rate[a]	(2 leaves)	(1 to 2 tillers)	(5 tillers)
	(kg/ha)		(%)	
Fluazifop-butyl	0.06	100	99 a	-
	0.12	72 ab	11 def	-
	0.18	46 abcd	1 h	0
	0.24	31 efg	0	0
	0.36	4 fgh	0	0
	0.48	0	0	0
Sethoxydim	0.06	100	100	-
	0.12	85 a	84 a	-
	0.18	40 abc	58 ab	65 ab
	0.24	53 ab	14 cde	21 bcd
	0.36	10 efg	0	0
	0.48	4 gh	0	0
Untreated	-	100	100	100

[a]All herbicide treatments included phytobland oil at 2.3 l/ha.

[b]Means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with values of 0 or 100 in all replications were not included in the statistical analysis. Data were transformed to the Log (x + 1) before statistical analysis.

applied at the one- to two- tiller stage, fluazifop-butyl at 0.06 reduced wheat foliage by 80% and fluazifop-butyl at 0.12 and sethoxydim at 0.18 reduced wheat foliage more than 90% (Figure 2). Although some plants survived the low rates of sethoxydim (0.18 and 0.24 kg/ha) at the last application, cool weather retarded their regrowth. By the time of harvest, their dry weight was similar to that of the treatments that killed all the wheat at that time of application (Figure 2).

Fig. 2. Foliage yield of wheat and visual estimate of healthy foliage relative to that of the untreated check, in wheat plants treated with fluazifop-butyl and sethoxydim at three stages of growth in the fall of 1982.



PRELIMINARY EVALUATION OF THE RESPONSE OF ALFALFA SEEDLINGS AND VOLUNTEER WHEAT TO DIFFERENT RATES AND TIMES OF APPLICATION OF FLUAZIFOP-BUTYL AND SETHOXYDIM

Although volunteer wheat is principally a problem in alfalfa seeded in late summer or fall, this study was established during spring under somewhat artificial conditions to gain preliminary information.

The objective was to determine the response of alfalfa and wheat to fluazifop-butyl and sethoxydim applied at different rates and times.

Materials and Methods

The experiment was conducted during spring and summer of 1982. Treatments were replicated four times in a split plot design in which the main plots were herbicide treatments and the subplots were either alfalfa alone or alfalfa plus wheat. The main plots were 2.2 m by 11 m while the subplots were 2.2 m by 5.5 m.

The area of the trial was fertilized with nitrogen at 115 kg/ha on 6 April. On 13 April, wheat was broadcast by hand in prescribed subplots at a rate of 90 kg/ha and incorporated immediately with the rollers of a Brillion Seeder. The resulting wheat population was 168 plants/m^2. Alfalfa was seeded on 14 April. The plots were sprinkler irrigated as needed to favor emergence of alfalfa and wheat and to keep both species free of moisture stress.

The herbicides were applied in water at 250 L/ha with a sprayer mounted on a tractor with wheels spaced 2.3 m apart. In all tractor operations, the wheels were kept on the edges of the plot so that they never affected plants within the plot. The boom was 2.1 m long with seven nozzles spaced 30 cm apart and was operated 0.56 m high to provide double coverage.

The herbicide treatments consisted of a factorial arrangement of the two herbicides each applied at three rate (0.2, 0.4, or 0.8 kg ai/ha) at each of three times. The three dates of application were: 11 May (early), when alfalfa was at the unifoliate stage and wheat had three leaves in the first tiller and a second tiller was being formed; 25 May (medium), when alfalfa was 10 cm tall and the wheat had five tillers and was 25 cm tall; 8 June (late), when alfalfa was 25 cm tall and wheat had an average of 17 tillers and was 31 cm tall.

The whole experiment was treated with the dimethylamine salt of 2,4-DB at 1.0 kg ae/ha for the control of broadleaf species on 18 May. Because this treatment was delayed to avoid possible interaction of the chemical with the grasskiller herbicides, many redroot pigweed and common lambsquarters (Chenopodium album L.) plants were large enough to escape control.

Because competition from broadleaf weeds and damping off reduced the stand of the crop in some plots, yields of alfalfa were not recorded. Fifteen days after each application, the percentage of green, healthy wheat foliage was estimated and the degree of chlorosis was rated. The wheat and the alfalfa were observed frequently and the development of symptoms of injury from the herbicides were described. Thirty days after the application, living wheat plants were counted in two 0.25-m^2 squares per plot; tillers on five representative plants per plot were counted and the average heights of the new tillers were measured. On 8 July, 30 days after the application, the volume of uninjured wheat foliage that grew after the application was visually estimated in the entire experiment. The same day, wheat foliage was collected from a 0.25-m^2 square per plot, and fresh and dry weight were determined.

Results

Both herbicides affected wheat similarly. Roots and leaves stopped growing almost immediately after the applications. Five days later, the younger leaves were chlorotic, while the older, fully grown leaves, remained green but had become hard and stiff. Seven days after the treatment, the older leaves also had become chlorotic, while the young leaves were becoming necrotic. They finally disintegrated.

At equivalent rates, fluazifop-butyl was more active than sethoxydim and symptoms were more intense as rates of both herbicides increased. All rates of fluazifop-butyl controlled wheat that had five tillers or less at the time of application (early and medium applications). However, 0.4 kg/ha was required in the late application to kill the larger plants (Table 5).

Although the lowest rate (0.2 kg/ha) of sethoxydim reduced growth of wheat at any time of application, higher rates were required to kill the plants (Table 5). In the surviving plants, new tillers, which were completely free of symptoms, originated from unaffected buds. Sethoxydim killed more plants when applied at the five- tiller stage (medium) than at any other stage. Moreover, the plants that survived treatment at that stage grew so little that their weight at time of harvest was inconsequential (Table 6). At that time, most treatments applied on the first two dates had eliminated the wheat. However, wheat plants killed by the treatments applied on the last date had not disintegrated yet.

Table 5. Visual estimates of the portion of wheat foliage remaining green, and the survival of wheat plants after the application of fluazifop-butyl and sethoxydim at three rates and three different times, in the summer of 1982.

Treatments				
Herbicide	Time of application[a]	Rate[b]	Green tissue[c,d]	Surviving plants[c,e]
		(kg/ha)	(%)	
Fluazifop-butyl	Early	0.2	0	0
		0.4	0	0
		0.8	0	0
	Medium	0.2	7 bc	0
		0.4	0	0
		0.8	0	0
	Late	0.2	0	40 ab
		0.4	0	0
		0.8	0	0
Sethoxydim	Early	0.2	7 bc	63 a
		0.4	2 c	10 c
		0.8	0	1 c
	Medium	0.2	8 b	20 bc
		0.4	2 c	2 c
		0.8	0	0
	Late	0.2	16 a	100
		0.4	4 bc	100
		0.8	0	3 c
Untreated		-	100	100

[a]Early = May 11; alfalfa unifoliate stage; wheat 1 to 2 tillers.
Medium = May 25; alfalfa 10 cm tall; wheat 5 tillers and 25 cm tall.
Late = June 8; alfalfa 25 cm tall; wheat 17 tillers and 31 cm tall.

[b]All herbicide treatments included phytobland oil at 2.3 l/ha.

[c]Within columns, means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with means of 0 ot 100 were not included in the statistical analysis. Data were transformed to the Log (x + 1) before statistical analysis.

[d]Rated 15 days after each respective application.

[e]Counted 30 days after each respective application.

Table 6. Dry weight of wheat and visual estimate of the volume of uninjured wheat foliage that grew after herbicide applications in plots where fluazifop-butyl and sethoxydim were applied at three rates at three different times, in the summer of 1982.

Treatments				
Herbicide	Time of application[a]	Rate[b]	New tissue[c,d]	Dry weight[c]
		(kg/ha)	(%)	(kg/ha)
Fluazifop-butyl	Early	0.2	0	0
		0.4	0	0
		0.8	0	0
	Medium	0.2	0	0
		0.4	0	0
		0.8	0	0
	Late	0.2	3 b	1,800 d
		0.4	0	1,955 cd
		0.8	0	1,865 cd
Sethoxydim	Early	0.2	6 b	440 e
		0.4	0	0
		0.8	0	0
	Medium	0.2	0	0
		0.4	0	0
		0.8	0	0
	Late	0.2	38 a	2,265 b
		0.4	27 a	2,495 bc
		0.8	3 b	1,717 d
Untreated		-	100	4,065 a

[a]Early = May 11; alfalfa u nifoliate stage; wheat 1 to 2 tillers. Medium = May 25; alfalfa 10 cm tall; wheat 5 tillers and 25 cm tall. Late = June 8; alfalfa 25 cm tall; wheat 17 tillers and 31 cm tall.

[b]All herbicide treatments included phytobland oil at 2.3 l/ha.

[c]Data was collected on July 8, 30 days after the last application. Within columns, means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with mean 0 or 100% values were not included in the statistical analysis.

[d]Data were transformed to the Log (x + 1) before statistical analysis.

SELECTIVE CONTROL OF VOLUNTEER WHEAT IN NEW SEEDINGS OF ALFALFA

This study was done during the fall season, which is the time of the year when the problem of volunteer wheat occurs under normal conditions. The objectives of this experiment were to determine: a) the period when volunteer wheat can grow with newly seeded alfalfa without affecting the alfalfa adversely; b) the effect on volunteer wheat and alfalfa of fluazifop-butyl and sethoxydim applied at different times and rates; and c) the response of alfalfa to physical removal of volunteer wheat at different stages, compared to treatments with fluazifop-butyl and sethoxydim at the same times.

Materials and Methods

The experiment was established in the fall of 1982. Treatments were replicated four times in a randomized complete block design. Plots were 9 by 2.2 m. The area of the trial was fertilized with nitrogen at 80 kg/ha on 18 August. On 19 August, wheat was planted broadcast on the whole area except on the four weed-free check plots. Wheat was planted 0 to 2 cm deep with a Brillion seeder. A seeding rate of 80 kg/ha was desired, but, a higher rate (120 kg/ha) was planted to compensate for the anticipated failure of some seeds to germinate on and near the soil surface. The resulting stand of wheat was 139 plants/m^2.

Alfalfa was seeded within 4 h after the wheat was seeded. Both species emerged together on 23 August, 4 days after planting. The herbicides were applied in the same way at the same rates as in the previous experiment. However, in this experiment, the herbicides were applied at four times: early, on 8 September when alfalfa had two leaves and wheat had one to two tillers and was 14 cm tall; medium, on 17 September when alfalfa had four leaves and wheat had five tillers and was 16 cm tall; late, on 30 September when alfalfa had several leaves and branches and was 15 cm tall, and wheat had 17 tillers and was 26 cm tall; and finally the last application was done in the spring on 15 March 1983 when wheat and alfalfa were 30 and 18 cm tall, respectively.

Two checks without herbicide treatment were included: one always free of wheat and the other always infested with wheat. Also, at each date of application, a corresponding treatment without herbicide was handweeded and kept free of volunteer wheat. For handweeding the wheat, plants were cut with a sharp knife near the soil surface, but underneath the growing point, and then were removed with minimun soil disturbance or alfalfa injury.

The whole experiment was sprayed three times (13 August and 12 October, 1982, and 9 March, 1983) with with 2,4-DB, dimethylamine salt, at 1.0 kg ae/ha for the control of hairy nightshade (Solanum sarrachoides Sendt.) and shepherdspurse (Capsella bursa-pastoris (L.) Medic.). The plots were sprinkler irrigated as needed to keep both the wheat and the alfalfa free of moisture stress.

Fifteen days after each application, wheat was assessed visually in all treated plots to determine the degree of chlorosis; the portion of green, healthy wheat foliage; the percentage of the total area occupied by the wheat foliage; and, after the third date of application, height of the wheat plants.

Thirty days after each application, living wheat plants in two 0.25-m^2 squares and number of tillers on five representative wheat plants per plot were counted, and average height of the new tillers was measured.

The occurrence of symptoms of injury on alfalfa was recorded 15 days after each application. On 9 October and 10 November, height of alfalfa was estimated in every plot. On 29 October, the percentage of healthy wheat foliage related to the check was estimated in all plots, and on 30 October, a 1-m^2 area per plot was harvested. Wheat and alfalfa foliage were separated and fresh and dry weights were determined.

On 2 November, 10 representative alfalfa plants were dug out of each plot. Roots and shoots were separated at the crown level and the roots were trimmed to a uniform length of 10 cm. Dried roots and shoots were weighed separately. On 10 November, alfalfa in 2 meters of row was cut at the root level (1 cm deep) and the plants were counted. Stems per plant were counted in ten representative plants.

At the time of the spring application, the percentage of the total area occupied by the wheat and the vigor of alfalfa as a percentage of the clean check were visually estimated in every plot. On 18 May 1983, wheat and alfalfa foliage was harvested from 5.8 m^2 per plot and total fresh weight determined. The proportion of dry weight for each species was determined from a subsample of the whole plot.

Results

All the treatments applied at the one- to two- tiller stage of the wheat stopped growth of the wheat plants rapidly. Thus, 15 days after the application, the area covered by wheat in the treated plots was 5% of the plot area compared to 80% in the untreated checks. The leaves were all stiff to the touch and almost completely chlorotic (Table 7). Symptoms were the same when the herbicides were applied at the five- tiller stage, except that they developed less rapidly. Twenty to 30% of the wheat foliage was still green 15 days after the application of the lower rates of both herbicides (Table 7). For this reason, in the plots treated with the lower rates, the wheat covered 20% more of the area than in the plots sprayed with higher rates (50% vs 30%) 15 days after this application. At this

Table 7. Visual estimate of the portion of wheat foliage remaining green, and the survival of wheat plants after the application of fluazifop-butyl and sethoxydim at three rates and three different times, in the fall of 1982.

Herbicide	Time of application[a]	Rate[b]	Green tissue[c]	Surviving plants[d]
		(kg/ha)	---------- (%) ----------	
Fluazifop-butyl	Early	0.2	9 f	0
		0.4	0	0
		0.8	0	0
	Medium	0.2	28 cd	0
		0.4	0	0
		0.8	0	0
	Late	0.2	55 ab	0
		0.4	43 abc	0
		0.8	35 bcd	0
Sethoxydim	Early	0.2	13 ef	35
		0.4	5 g	0
		0.8	0	0
	Medium	0.2	23 de	15
		0.4	0	0
		0.8	0	0
	Late	0.2	70 a	100
		0.4	55 ab	0
		0.8	35 bcd	0
Untreated		-	100	100

[a]Early = September 8; alfalfa 2 true leaves; wheat 1 to tillers and 14 cm tall.
Medium = September 17; alfalfa 4 leaves; wheat 5 tillers and 16 cm tall.
Late = September 30; alfalfa 15 cm tall; wheat 17 tillers and 26 cm tall.

[b]All herbicide treatments included phytobland oil at 2.3 l/ha.

[c]Rates 15 days after each respective application. Means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with means of 0 or 100 were not included in the statistical analysis. Data were transformed to the Log (x + 1) before statistical analysis.

[d]Counted 30 days after each application.

time the wheat covered 100% of the soil surface in the untreated plots.

Plenty of green tissue still remained after the application of all treatments at the 17- tiller stage of the wheat (Table 7). At the time of this application, the wheat plants had already covered 100% of the soil surface. Although all treatments stopped wheat growth within 15 days after the application, the percentage of the area covered was only reduced approximately 10% because the plants did not disintegrate within that period.

In spite of those differences, all the fall treatments, except the lowest rate of sethoxydim, killed all the wheat plants. Sethoxydim at 0.2 kg/ha, killed 65, 85, and 0% of wheat plants in the early, medium, and late date of application, respectively. Ultimately, the few plants that survived after the medium application had died by the time of the fall harvest (Table 8), suggesting that sethoxydim is more effective at the five- tiller stage than at the other times of application.

Treated wheat leaves were usually destroyed but the wheat recovered by forming new tillers from unaffected buds. Most of the new tillers were evident within 15 days after the two first dates of application, but a month passed before new growth became evident after the late application in the fall. For this reason, even though all the plants recovered from sethoxydim applied late at 0.2

Table 8. Dry weight of alfalfa and wheat foliage, and visual estimate of the volume of uninjured wheat foliage that grew after herbicide applications in plots where fluazifop-butyl and sethoxydim were applied at three different rates and times, in the fall of 1982.

Treatments			Wheat[c]		Alfalfa[c]
Herbicide	Time of application[a]	Rate[b]	New tissue	Dry weight[d]	Dry weight[e]
		(kg/ha)	(%)	(kg/ha)	(kg/ha)
Fluazifop-butyl	Early	0.2	0	0	1,043
		0.4	0	0	1,073
		0.8	0	0	1,493
	Medium	0.2	0	0	805
		0.4	0	0	795
		0.8	0	0	745
	Late	0.2	0	1,818 b	293
		0.4	0	1,820 b	362
		0.8	0	1,818 b	310
Sethoxydim	Early	0.2	3	215 c	1,168
		0.4	0	0	1,508
		0.8	0	0	1,148
	Medium	0.2	0	61 c	680
		0.4	0	0	643
		0.8	0	0	785
	Late	0.2	1	1,940 b	318
		0.4	0	1,873 b	333
		0.8	0	1,627 b	340
Untreated		-	100	2,820 a	223

[a]Early = September 8; alfalfa 2 true leaves; wheat 1 to 2 tillers and 14 cm tall.
Medium = September 17; alfalfa 4 leaves; wheat 5 tillers and 16 cm tall.
Late = September 30; alfalfa 15 cm tall; wheat 17 tillers and 26 cm tall.

[b]All herbicide treatments included phytobland oil at 2.3 l/ha.

[c]Data was collected on November 2, 33 days after the last application.

[d]Means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with mean 0 were not included in the statistical analysis.

[e]Dry weight data were analyzed as a factorial arrangement. There were no significant ($p < 0.05$) differences due to herbicide or rate, but the effect of time of application was significant ($p < 0.01$). Average yields of each time of application for both herbicides at all rates are compared to the hand-weeded treatments in Figure .

kg/ha, new tillers were hardly visible at the time the plots were cut in the fall and dry weight of wheat was similar to those of the other treatments which did kill the wheat (Table 8).

About 5% of the wheat plants that were considered dead 30 days after the first date of application recovered and had new healthy tillers at the time of the fall cut. Also, after the first and second dates of application of the two lower rates of sethoxydim (0.2 and 0.4 kg/ha), and the lowest rate of fluazifop-butyl (0.2 kg/ha), some seeds on the soil surface germinated and grew on the treated soil. Perhaps at the high rate of sethoxydim, and the two higher rates of fluazifop-butyl, residual herbicide killed the seedlings.

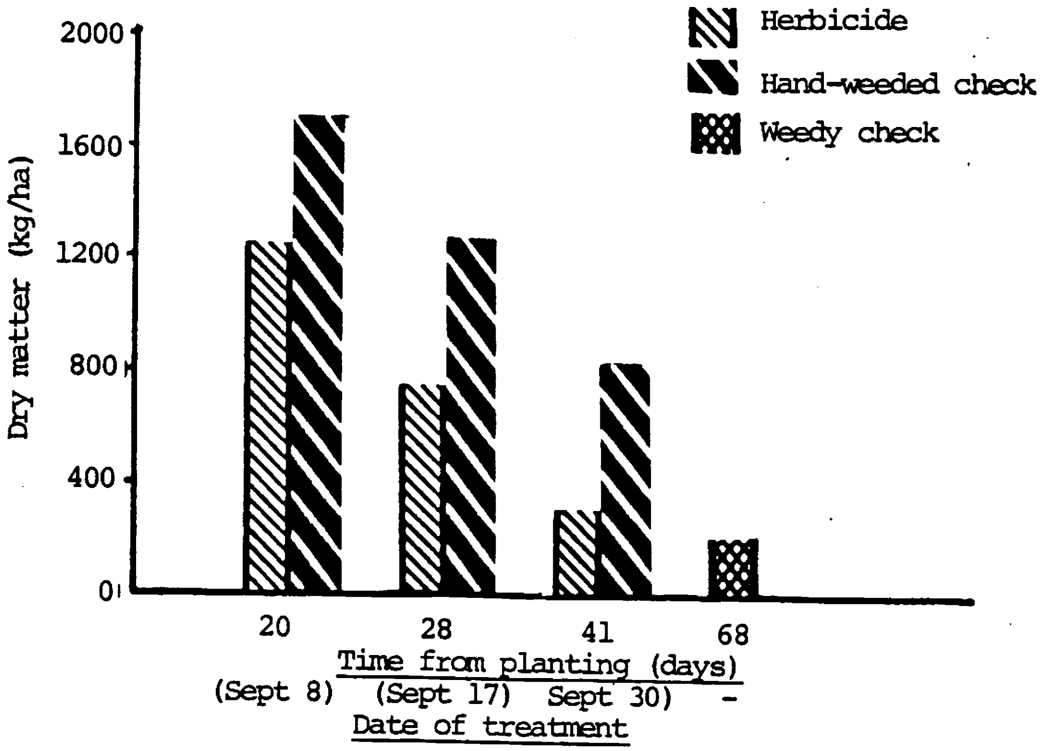
None of the treatments injured the alfalfa. On the contrary, yield increased in every case compared to the untreated check as a result of the wheat control. In the fall cut, dry weight of alfalfa in the weedy check was only 17% of that on the "always clean check" (223 vs 1,278 kg/ha, respectively). Although hairy nightshade was controlled early with 2,4-DB in plots where wheat had never been planted (always clean check), it recovered and interfered with the growth of the alfalfa. In the rest of the experiment, wheat was the dominant species and did not allow the hairy nightshade to recover. For this reason, it is more logical to consider the first date of handweeding as the weed clean check, although this treatment was cleaned 20 days after planting.

In the fall cut, there were no differences in alfalfa yields among herbicides or rates of herbicides but yields differed with the time of application. In the period 20 to 41 days after planting, for each day the application was delayed, alfalfa yield on 2 November was reduced by 42 kg/ha (Figure 3). There was a similar response to the handweeding (40 kg/ha/day reduction) but, at each date, yields were, in every case, approximately 500 kg/ha higher than the corresponding herbicide treatment (Figure 3).

Alfalfa plants growing alone, tended to branch, whereas plants subjected to the interference of wheat did not branch and were taller and thinner (Figures 4 and 5). The plants tended to branch immediately after the wheat was removed by hand, but, in the plots where the wheat was sprayed, the alfalfa kept growing for several days with a similar pattern as if it still were suffering wheat competition.

Individual alfalfa plants weighed more in the handweeded plots than in the herbicide treatments at the corresponding dates of application. However, in the two first dates, there was a positive response to higher rates of the herbicides indicating that the difference "herbicide vs handweeding" could be related to the efficiency in removing competition (Figure 6).

Fig. 3. Alfalfa forage yield on 3 November 1982, as influenced by the control of volunteer wheat by hand-weeding or with herbicide treatments at three different dates.



There was a significant effect of treatments ($p < 0.01$). Herbicide treatments were analyzed as factorial: there was no effect of herbicide or rate but the effect of time of application was significant ($p < 0.01$). Thus, within the same time of application, all herbicide treatments were considered as replications for the purpose of studying a regression of yield vs time of application. There was a significant ($p < 0.01$) relationship between yield of alfalfa and time of application.

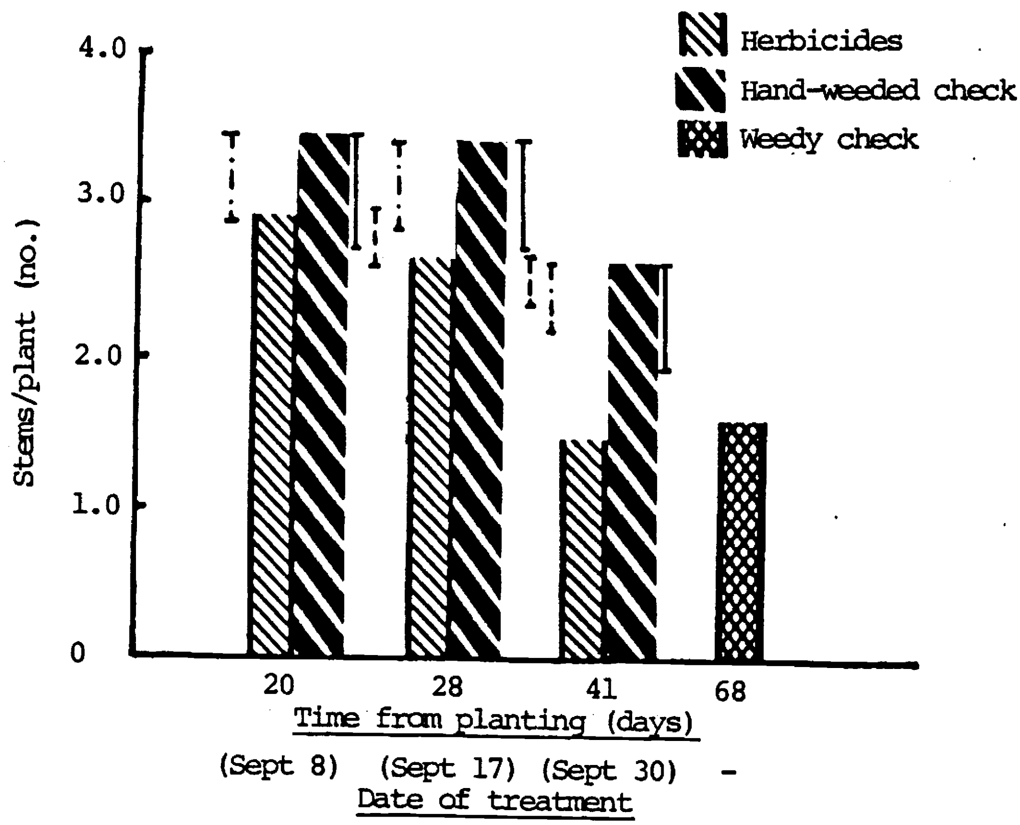
$$y = 2025 - 42.3\,x \quad r^2 = 0.88 \text{ (in kg/ha)}$$

There was also a significant ($p < 0.05$) relationship between yield of alfalfa and time of hand-weeded.

$$y = 2445.4 - 40.3\,x \quad r^2 = 0.64 \text{ (in kg/ha)}$$

The lines were tested by comparing a full model vs a reduced model. The lines were significantly different ($p < 0.01$). Then the slopes were tested and proved to be not significantly different, whereas the intercepts differed significantly ($p < 0.01$).

Fig. 4. Number of stems per plant of alfalfa on 10 November 1982, as influenced by the control of volunteer wheat by hand-weeding or with herbicide treatments at three different dates.

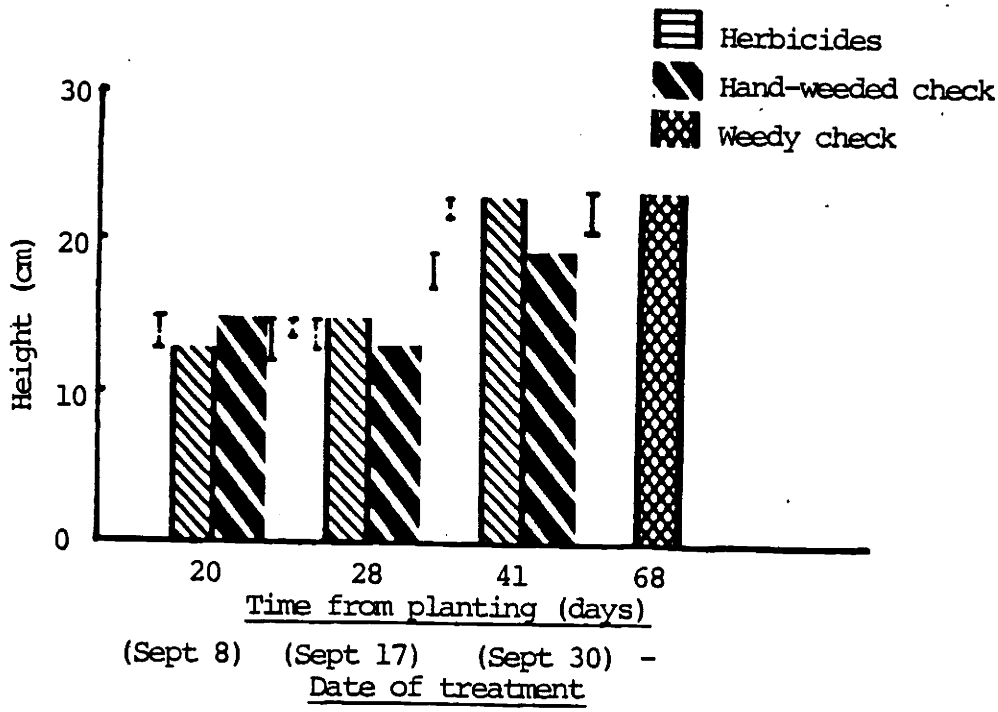


There was a significant effect of treatments ($p < 0.01$). Herbicide treatments were analyzed as factorial: there was no significant effect of herbicide or rate but the effect of time of application was significant ($p < 0.01$). Thus, within the same time of application, the average of all herbicide treatments is used to compare.

Thus, to compare:

1. Among times of herbicide application = LSD, 5% = 0.315 - - - -
2. Among all checks = LSD, 5% = 0.772 ———
3. Herbicide at a given date vs. any check = LSD, 5% = 0.59 -·-·-·-

Fig. 5. Height of alfalfa on 9 October 1982, as influenced by the control of volunteer wheat by hand-weeding or with herbicide treatments at three different dates.

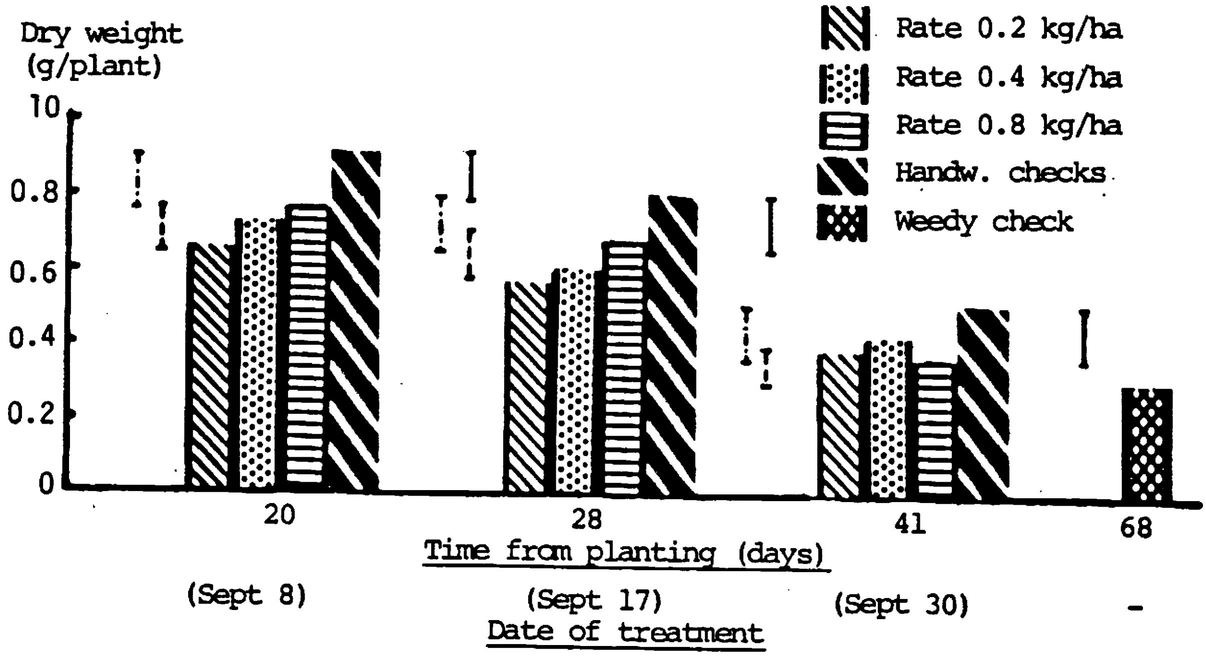


There was a significant effect of treatments ($p < 0.01$). Herbicide treatments were analyzed as factorial: there was no significant herbicide or rate effects but the effect of time of application was significant ($p < 0.01$). Thus, to compare between times of application, the average of all herbicide treatments within each time is used.

Thus, to compare:

1. Among time of herbicide application = LSD, 5% = 1.14 - - - -
2. Among checks = LSD, 5% = 2.8 ———
3. Herbicide vs check = LSD, 5% = 2.36 -·-·-·-

Fig. 6. Weight per plant of alfalfa (shoot + root) on 5 November 1982, as influenced by the control of volunteer wheat by hand-weeding or herbicide treatments at three dates.



There was a significant effect of treatment ($p < 0.01$). Herbicide treatments were analyzed as factorial: there was no significant herbicide effect but the effects of rate and application were significant ($p < 0.05$ and 0.01, respectively). Thus, to compare the effect of rate, the average of the two herbicides at each rate and date is used.

To compare:

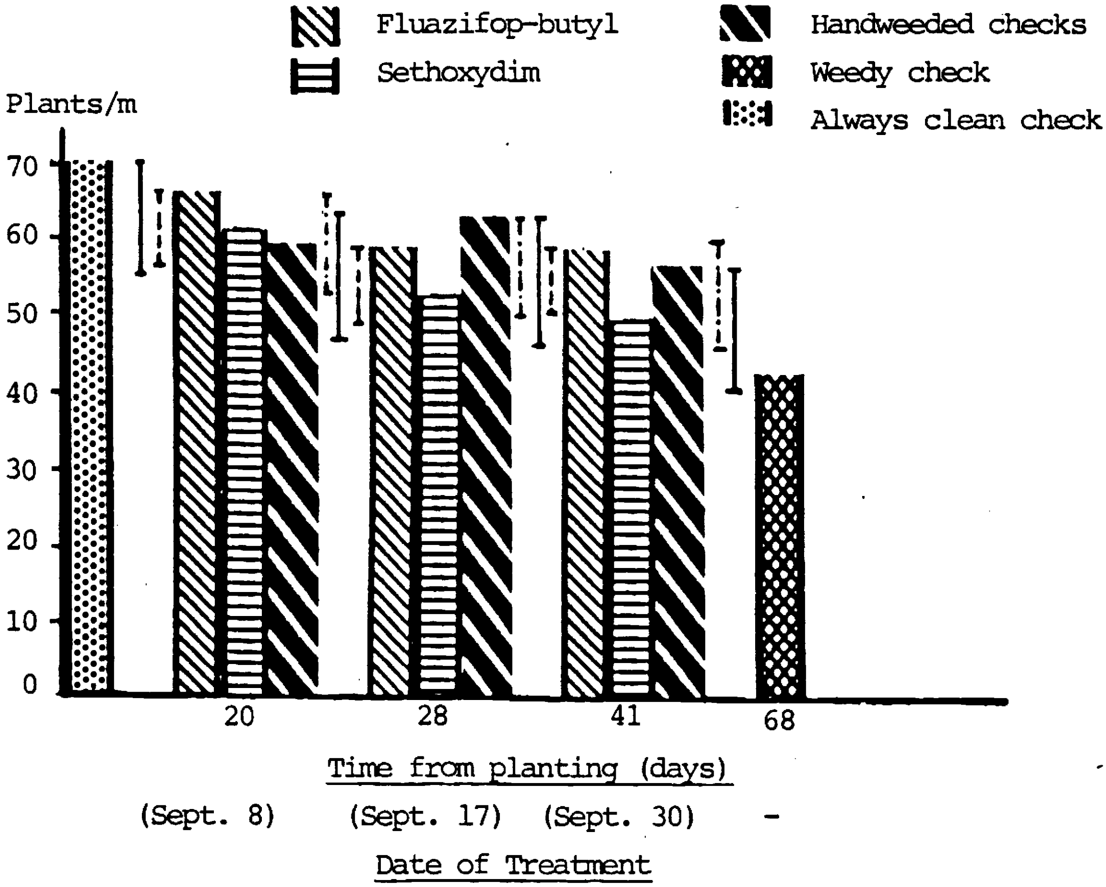
1. Among rates: LSD, 5% = 0.115 - - - -
2. Among checks: LSD, 5% = 0.163 ———
3. Rate vs checks: LSD, 5% = 0.141 -·-·-·-

The population of alfalfa also tended to decline as control was delayed (Figure 7). Plots treated with fluazifop-butyl occasionally had more plants than the handweeded ones. However, handweeded plots are not a good reference of maximum alfalfa population because some plants might have accidentally been removed in the process of weeding. Although broadleaf weeds suppressed the growth of the "always clean" check, they probably did not affect the stand; therefore, the "always clean" check is probably the best indicator of the original alfalfa population.

In the spring (15 March, 1983) applications, the low rate of sethoxydim (0.2 kg/ha) again was inadequate to kill the wheat. All the other treatments suppressed the wheat and increased alfalfa yield compared to the weedy check to the same extent as the handweeded did at the corresponding date of application. Nevertheless, even with the hand-weeded treatment, when removal of wheat was delayed until 15 March, alfalfa yield was reduced 63% more than it was when wheat competed only until the first date of control in the fall. If wheat was never controlled alfalfa yield was reduced 85% (Figure 8).

The final alfalfa yields from the fall-treated plots indicated that the low rate of sethoxydim allowed too much wheat regrowth during the winter, which, in every case, reduced alfalfa yield. The difference in alfalfa forage yield observed in the fall harvest comparing hand-weeded

Fig. 7. Alfalfa population on 10 November 1982, as influenced by the control of volunteer wheat by hand-weeding or with the herbicide treatments at three different dates.

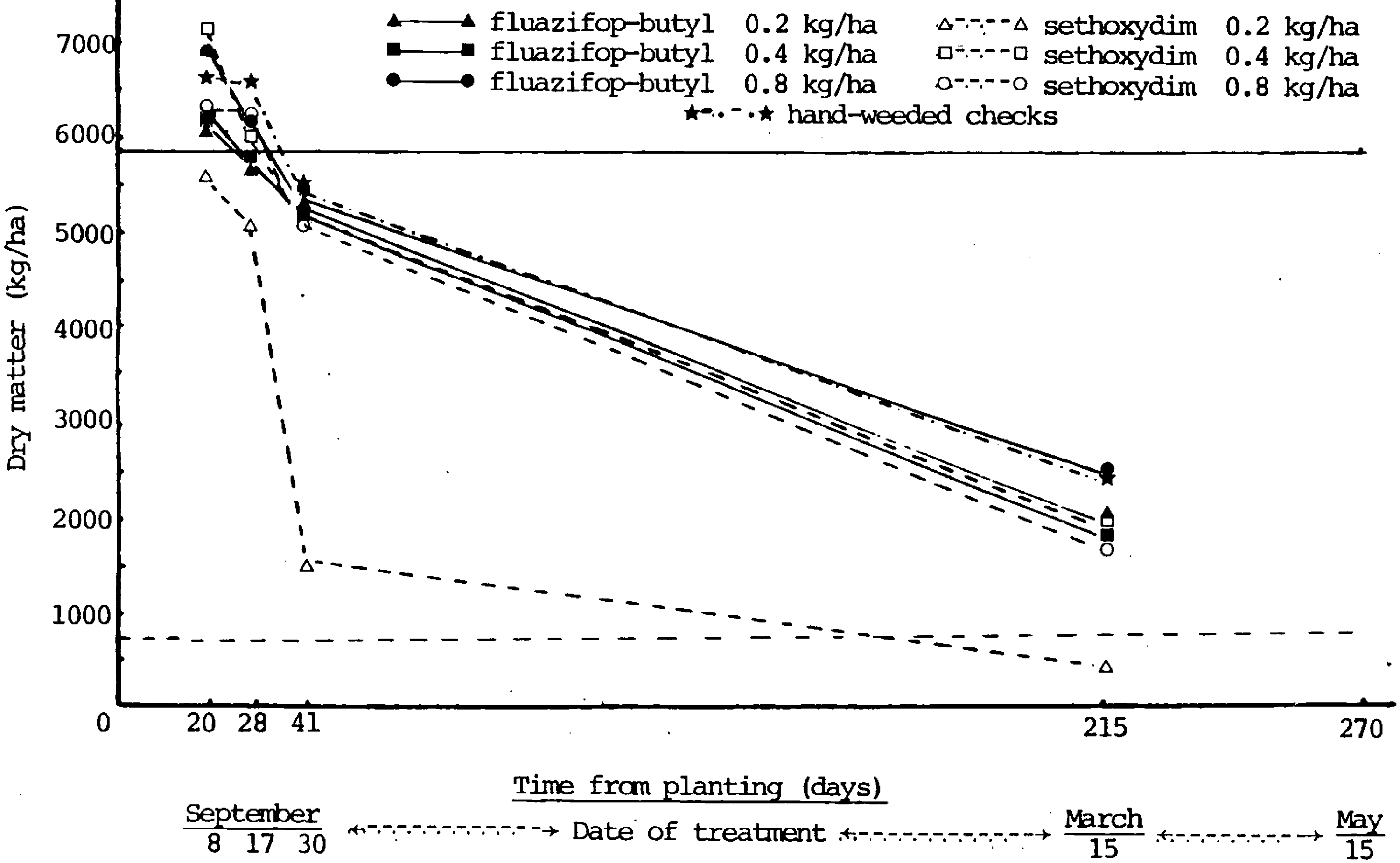


There was a significant effect of treatments ($p<0.01$). Herbicide treatments were analyzed as factorial: there was a significant effect of time of application ($p<0.05$) and herbicide ($p<0.05$) but the effect of rates was not significant. Thus, at each time of application, the average of the three rates of each herbicide is used to compare.

To compare:

1. Among herbicides = LSD, 5% = 9.3 ------
2. Among checks = LSD, 5% = 16.1 ————
3. Herbicide vs checks = LSD, 5% = 13.1 -·-·-·

Fig. 8. Alfalfa forage yield on 18 May 1983, as influenced by the control of volunteer wheat by hand-weeding or with fluazifop-butyl or sethoxydim at three rates and four dates.



treatments versus herbicide treatments, was no longer evident. This might be explained by the fact that the plots in which wheat had been removed by hand in the fall were reinfested during the winter to a greater extent than those plots sprayed with herbicides at the corresponding dates. The reason is probably that, whereas the effective herbicide treatments were successful in killing the growing points of the wheat, this was not always the case when the wheat plants were removed with the knife in the handweeded plots. Therefore, there was more wheat in the earlier handweeded plots than in those corresponding to effective herbicide treatments (Table 9).

In the two first dates of application, higher rates of both herbicides resulted in slightly higher yields than lower rates. Nevertheless, the final yield showed the same general trend observed in the fall harvest indicating that alfalfa yield was depressed as control was delayed beyond 20 days after planting (Figure 9). Grouping the treatments that controlled wheat (all except sethoxydym at 0.2 kg/ha) at each date, there was a significant ($p < 0.01$) linear decrease in alfalfa yields of 64 kg/ha for each day that wheat control was delayed in the period between 20 to 41 days after planting. This represents a 21% reduction in 21 days or 1% reduction per day.

Table 9. Wheat foliage remaining at harvest time (15 May 1983) after the application of fluazifop-butyl and sethoxydim at three different rates and four dates of application in the year of establishment of alfalfa.

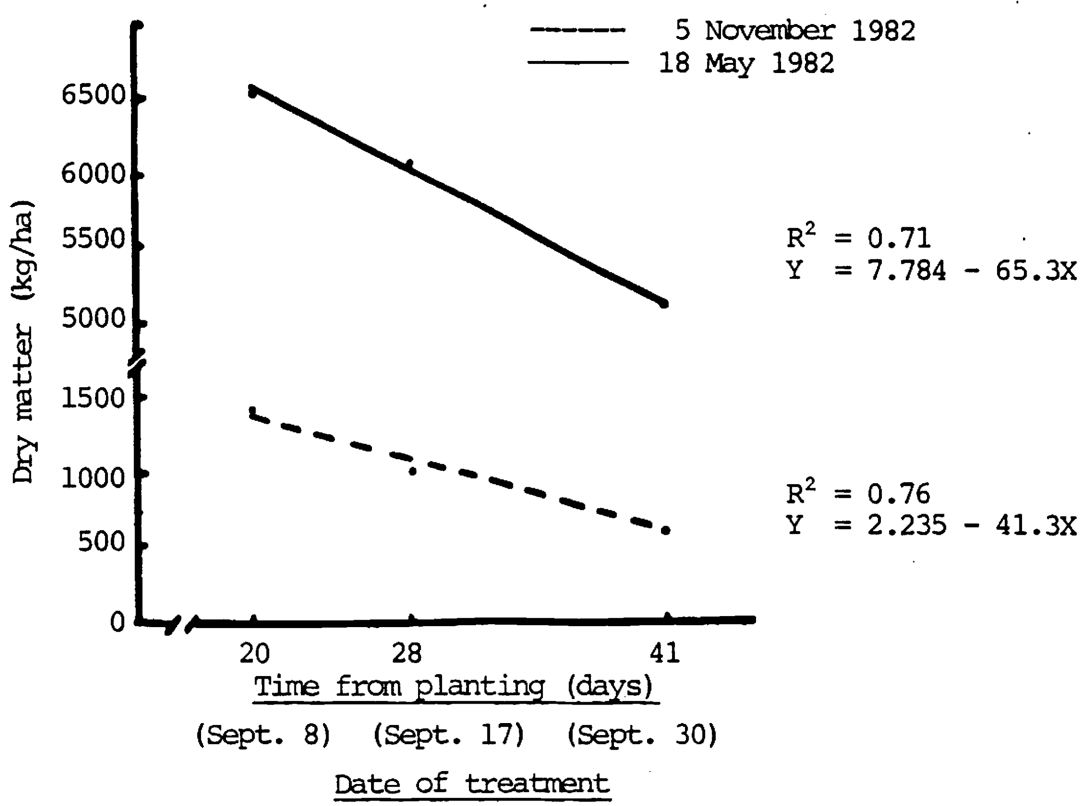
Treatments		Herbicides	
Time of application	Rate[b]	Fluazifop-butyl	Sethoxydim
		Wheat dry weight[c]	
	(kg/ha)	(kg/ha)	
Early (fall)	0.2	311	1281
	0.4	189	116
	0.8	0	273
Medium (fall)	0.2	0	759
	0.4	263	294
	0.8	48	239
Late (fall)	0.2	0	6323
	0.4	0	1348
	0.8	0	0
Spring	0.2	2399	4447
	0.4	2126	3291
	0.8	2066	2714
		Checks	
Always clean check		0	
Hand-weeded early (fall)		605	
Hand-weeded medium (fall)		477	
Hand-weeded late (fall)		117	
Hand-weeded spring		0	
Always weedy		9691	

[a]Early (fall) = September 8; alfalfa 2 true leaves; wheat 1 to 2 tillers and 14 cm tall.
Medium (fall) = September 17; alfalfa 4 leaves; wheat 5 tillers and 16 cm tall.
Late (fall) = September 30; alfalfa 15 cm tall, wheat 17 tillers and 26 cm tall. March 15; alfalfa and wheat more than 30 cm tall.

[b]All herbicide treatments included phytobland oil at 2.3 l/ha.

[c]LSD = 970 kg/ha.

Fig 9. Alfalfa forage yield on 5 November 1982 and 18 May 1983 as influenced by date of control of wheat in the fall of 1982.[a]



[a]In the fall harvest, each point represents the average of the hand-weeded treatment and all the herbicide treatments. In the spring harvest, each point represents the average of the hand-weeded treatments and all herbicide treatments except sethoxydim at 0.2 kg/ha. This treatment was the only one which resulted in a significant lack of fit from fitting a linear response.

COMPARISON OF ROOT AND FOLIAR UPTAKE OF FLUAZIFOP-BUTYL APPLIED POSTEMERGENCE TO WHEAT

There is still very little information on several aspects of the mode of action of fluazifop-butyl which are essential for its efficient use. A field experiment was conducted to determine the relative importance of root and foliar uptake of fluazifop-butyl applied postemergence to volunteer wheat.

Materials and Methods

Wheat was seeded in plots consisting of one row 2 m long spaced 1.5 m apart. Treatments were replicated four times in a randomized complete block design. Approximately 100 seeds were planted by hand 2 cm deep in each plot on 1 September 1982. Nitrogen at 80 kg/ha was broadcast by hand on bands 50 cm wide over the seeded rows of wheat and incorporated later by sprinkler irrigation. On 13 September, the wheat was thinned to 50 uniform plants per plot spaced approximately 4 cm apart.

On 16 September, when wheat had two tillers and was 12 cm tall, fluazifop-butyl at 0.2 kg a.i./ha was sprayed in water at 200 L/ha on a band 0.5 m wide from a single nozzle on a knapsack sprayer in the following manners:

a) Herbicide applied to shoots only.

b) Herbicide applied to soil only followed by 10 mm of overhead irrigation.

c) Herbicide applied to both shoot and soil (conventional application).

d) Herbicide applied to both shoot and soil followed the next day by 10 mm of overhead irrigation.

e) No herbicide.

To expose the shoot only (treatment a), a layer of vermiculite at the base of the wheat plants and two sheets of plastic overlapping the vermiculite kept the herbicide from reaching the soil. After spraying, the sheets were taken away and the vermiculite was removed with a vacuum cleaner.

To expose the roots only (treatment b), each wheat plant was covered with a glass test tube inserted into the soil immediately before spraying. Within 15 minutes of the application, 10 mm of simulated sprinkler irrigation was applied in a 50 cm band over the row. This water washed the herbicide from the test tubes and would have tended to move it into the soil to expose the wheat roots. The test tubes were removed within 5 minutes of irrigating.

To expose both shoot and root (treatments c and d), the herbicide was applied conventionally to the foliage and surrounding soil. In treatment d, 10 mm of simulated sprinkler irrigation was applied to the treated area the day after spraying. It was assumed that, by this time, material on the foliage would not be washed off but the herbicide on the soil would still be available to be moved into the soil.

The 10 mm of simulated irrigation were applied in four increments at 0.5-h intervals to avoid puddling and runoff. A 5-day period without irrigation was prescribed for treatment c. However this period was reduced to 4 days because of 14 mm of rainfall on 20 September.

The wheat was observed periodically in the days following treatment for development of symptoms. On 10 October (15 days after the application), living and dead plants were counted, and the volume of wheat foliage relative to that of the untreated check was estimated. On 6 October, all the plants were cut 0.5 cm above the soil surface with a hand clipper. Fresh weight, dry weight, and percentage dry matter of the wheat foliage were determined.

Results

The response of wheat was similar in all plots where the foliage was treated regardless of soil exposure or overhead irrigation. Chlorosis was evident and growth had ceased as early as 4 days after the application. Ten days after the treatment, the leaves were severely chlorotic. Fifteen days after treatment, the wheat plants were all dead and equal in appearence in all treatments in which foliage was treated (Table 10).

No chlorosis was evident within the first week in the treatment in which only the soil had been exposed to the herbicide. Nine days after the application, very minor chlorosis was present but it was no longer visible 3 days later. The plants then grew normally without symptoms, except that they appeared very slightly smaller and their yield was less than that of the untreated plants (Table 10).

These results indicate that fluazifop-butyl, applied to wheat at the two- tiller stage, affects the plant principally via foliar exposure, and that root exposure is not important for the herbicide to be effective.

Table 10. Response of wheat to fluazifop-butyl at 0.2 kg/ha (plus phytobland oil at 2.3 L/ha) applied to prescribed parts of wheat that had two tillers. [a]

Treatments: Area exposed	Treatments: Irrigat.	Plants killed	Foliage volume [b]	Height	Dry weight [c]
		(%)	(%)	(cm)	(g)
Shoot only	-	100	0	0	9.9 c
Soil only	10 mm immed.	0	88	15	59.3 b
Shoot + soil	-	100	0	0	7.9 c
Shoot + soil	10 mm n.day.	100	0	0	8.6 c
Untreated	-	0	100	21	78.8 a

a. The entire experiment received 14 mm of rainfall 4 days after the application, and all the plots were irrigated normally thereafter.

b. Visual estimate of volume of normal green foliage relative to that of the untreated check.

c. Means followed by the same letter do not differ at the 0.05 level according to Duncan's Multiple Range Test. Data were transformed to the Log (x + 1) before statistical analysis.

EFFECT OF SOIL MOISTURE CONTENT AT THE TIME OF APPLICATION ON THE ACTIVITY OF FLUAZIFOP-BUTYL APPLIED POSTEMERGENCE TO WHEAT

Through irrigation, there is the possibility of manipulating soil moisture in the alfalfa crop. Thus, it is important to determine whether high or low soil moisture conditions at the time of herbicide application affect the activity of the herbicides. The objective of this experiment was to study the effect of soil moisture on the activity of fluazifop-butyl when applied postemergence to volunteer wheat.

Materials and Methods

This study was conducted in the fall of 1982. The plots consisted of one row of wheat 2 m long and were spaced 1.5 m apart. Approximately 100 seeds of wheat were planted per plot on 1 September. Nitrogen at 80 kg/ha was broadcast by hand on a band 50 cm wide over the seeded rows of wheat and incorporated later by sprinkler irrigation.

On 13 September, each plot was thinned to 50 plants spaced approximately 4 cm apart. Treatments were replicated four times in a randomized complete block design. Two levels of herbicide (0 and 0.2 kg/ha) of fluazifop-butyl) were combined in a factorial arrangement with two levels of soil moisture, "low" (8%), and "high" (15%).

A method described by West et al.(72) was used to obtain different moisture levels. On 13 September, a ditch 12 cm deep was dug along each side of each wheat row and spaced 10 cm away from the row. These ditches increased the soil surface exposed to the atmosphere and thus increased evaporative loss of moisture. For several days before the application, the plots in which the moisture level was to be low were protected from rainfall with plastic sheets, which were removed immediately after the rain was over. The high moisture plots received natural rainfall during that period and, 3 days before the application (1 October), the ditches were filled with water to saturate the soil.

On the day of the herbicide application (4 October), three soil samples from a depth of 2 to 12 cm were extracted per plot, placed in closed metal cans, weighed, and dried for 48 h at 110 C to determine moisture content (Appendix table 2).

The herbicide was applied in water at 200 L/ha in a band 0.5 m wide with a knapsack sprayer with a single nozzle. Four days after the application, the whole experiment received 14 mm of rainfall and was irrigated periodically thereafter.

Fifteen and 30 days after the application (19 October and 3 November, respectively), the percentage of wheat foliage relative to that of the "untreated, high moisture" treatment was visually estimated, and the degree of chlorosis was determined. On 3 November, living and dead plants were counted, and the percentage of living plants was determined. On the same date, one meter of row from the center of each plot was cut with a hand clipper near the soil surface, and fresh and dry weights were determined.

Results

The moisture stress itself reduced wheat foliage. At the time of spraying, wheat in plots with "low" moisture content (8%) had 8 tillers and was 13 cm tall, while in the "high" moisture plots (15%), it had 11 tillers and was 15 cm tall. Although growth was resumed normally when the plots were irrigated 3 days after the application, the difference in foliage between the two levels of soil moisture remained until the end of the experiment.

The herbicide affected wheat similarly at both moisture levels. Fifteen days after application, the wheat was chlorotic and had stopped growing. At the time of harvest (28 days after application) there was no new growth in any of the treated plots (Table 11). A higher foliage yield in the "high" moisture treated plots compared to those with "low" moisture, was due to the difference in size at the time of application; the percentage weight reduction caused by the herbicide however, was similar for each level of moisture (42 and 52% reduction for the "low" and "high" levels, respectively).

Table 11. Percentage of living plants, amount of foliage, and dry weight of wheat 28 days after the application of fluazifop-butyl (0.2 kg/ha + phytobland oil at 2.3 L/ha) at two soil moisture levels.

Treatments		Wheat		
Herbicide	Soil moisture	Living plants	Foliage amount	Dry weight[a]
	(%)	------(%)--------		(g/m)
Untreated	8	100	88	127 b
Treated	8	0	20	74 c
Untreated	15	100	100	164 a
Treated	15	0	29	79 c

a. Means followed by the same letter do not differ at the 0.05 level according to Duncan's Multiple Range Test.

RESPONSE OF WHEAT TO FLUAZIFOP-BUTYL APPLIED ALONE OR IN TANK MIX COMBINATION WITH 2,4-DB DIMETHYLAMINE SALT

Tank mixes of grass killer herbicides with 2,4-DB would be a very convenient practice in order to achieve broad spectrum weed control in alfalfa with only one trip over the field. Reduction in the activity of the grass killer has been reported in tank mix combinations of severals grass killer herbicides with phenoxy type herbicides. The objective of this experiment was to determine and quantify possible interactions when tank mixing fluazifop-butyl with 2,4-DB for the control of volunteer wheat.

Materials and methods

On 21 June, the area of the experiment was fertilized with 80 kg/ha of nitrogen incorporated with a rototiller 12 cm deep. Winter wheat was seeded the same day with a Tye drill at a rate of 80 kg/ha, 4 cm deep and in rows 18 cm apart.

Treatments were replicated five times in a randomized complete block design. Plots contained three rows of wheat 5 m long and were separated by irrigation furrows at each side. The experiment was furrow irrigated as needed for favorable wheat growth.

Herbicides were applied in water at 200 L/ha with a knapsack sprayer with a single nozzle. At the time of application, 19 July, wheat had seven tillers and was 25 cm tall. Fluazifop-butyl was applied at four rates (0.12, 0.18, 0.24, and 0.36 kg ai/ha) alone or in combination with 2,4-DB dimethylamine salt at 1.8 kg ae/ha. All treatments included oil concentrate except 2,4-DB applied alone.

All data were collected from the central row of each plot. Fifteen days after the application (3 August), the degree of chlorosis was rated. On 23 August, the dead and living plants were counted within 100 consecutive plants per plot. On 2 September, the volume of green foliage, as a percentage of the untreated check, was visually estimated. On 3 September, foliage from 1.5 m of the central row was cut near the soil surface, and fresh and dry weights of the foliage were determined.

Results

2,4-DB at 1.8 kg/ha reduced the activity of fluazifop-butyl on wheat. The antagonistic effect was overcome when the rate of the grass killer was increased 50 % or more (Table 12, Figure 10).

Table 12. Response of volunteer wheat to fluazifop-butyl applied alone or in combination with the diethylamine salt of 2,4-DB.

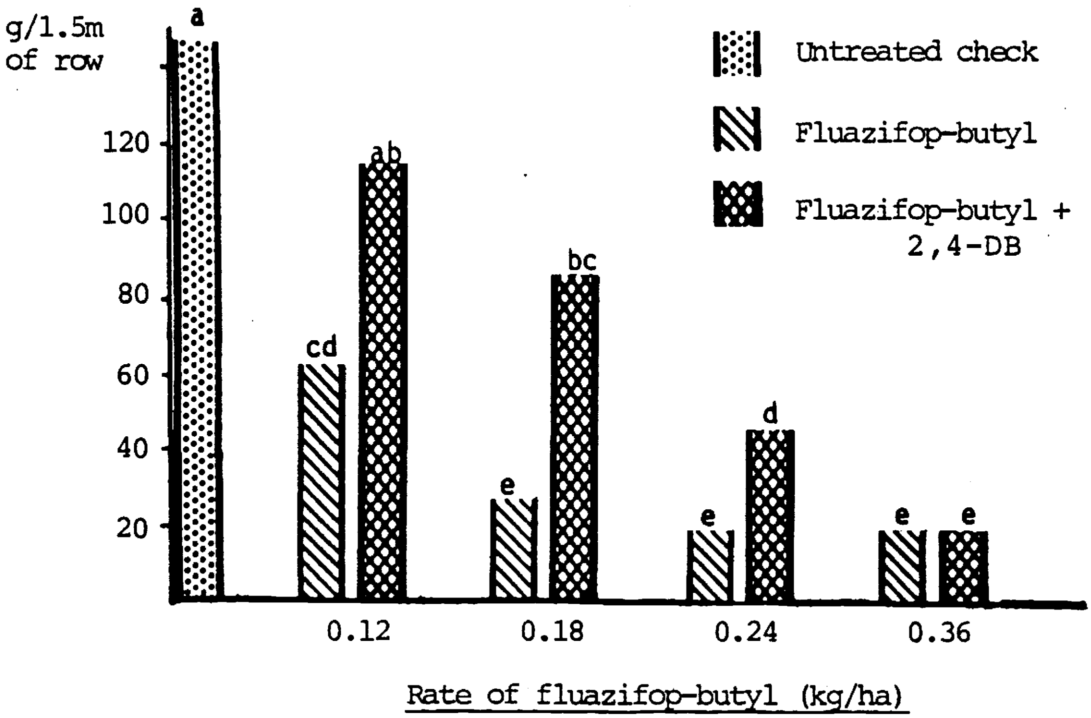
Treatments				
Herbicide	Rate[a]	Chlorosis[b,c]	Living plants[b]	Foliage amount[b]
	(kg/ha)	(Rating)	-------(%)	-------
Fluaz.-butyl + 2,4-DB	0.12 + 1.8	5.5 d	99 a	58 a
Fluaz.-butyl + 2,4-DB	0.18 + 1.8	6.7 cd	98 a	46 a
Fluaz.-butyl + 2,4-DB	0.24 + 1.8	8.9 b	60 c	17 d
Fluaz.-butyl + 2,4-DB	0.36 + 1.8	9.5 b	8.de	2.ef
Fluaz.-butyl	0.12	7.4 c	85 b	32 c
Fluaz.-butyl	0.18	9.3 b	15 d	6 e
Fluaz.-butyl	0.24	9.7 ab	1 e	0.4 f
Fluaz.-butyl	0.36	9.9 a	0	0
2,4-DB	1.8	0	100	100
Untreated	-	0	100	100

[a]All treatments, except 2,4-DB alone, had phytobland oil at 2.3 l/ha.

[b]Within columns, means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with values of 0 or 100 in all replications were not included in the statistical analysis. Data were transformed to the arcsin [SQR (x)] before statistical analysis. Chlorosis, lving plants, and foliage amount were rated 15, 25, and 43 days after the application, respectively.

[c]Rating = 0 no chlorosis; 10 completely chlorotic.

Fig. 10. Dry weight of wheat sprayed with fluazifop-butyl alone or in combination with the dimethylamine salt of 2,4-DB at 1.8 kg/ha.[a]



[a]Bars with the same letters do not differ at the 0.05 level according to Duncan's MRT. Data were transformed to the Log (x + 1) before statistical analysis.

DISCUSSION

Volunteer wheat suppressed the alfalfa growth and even killed many of the alfalfa plants during the fall. It also continued to compete throughout the year, and markedly reduced yield at the spring harvest.

The population in the fall experiment, was uniformly dense (139 pl/m^2 = 1,390,000 pl/ha), and was probably as competitive as any of the volunteer wheat infestations that might develop in new seedings of alfalfa. Moreover, the high level of nitrogen fertilizer (80 kg/ha) would favor the wheat more than the alfalfa. Thus the conditions of the experiment allowed the wheat to express its full competitive potential against the alfalfa.

Lower densities of wheat plants could probably suppress alfalfa to the same extent because individual wheat plants would grow larger in thinner stands(3), and the total competitive effect would probably be similar to that in these studies.

Alfalfa yield was reduced by about 1% each day that control of volunteer wheat was delayed in the period from 20 to 41 days after planting. Therefore, wheat should be controlled not later than the 20th day after planting to avoid yield reductions. Fluazifop-butyl and sethoxydim are two effective herbicides for that purpose. Alfalfa seedlings tolerated both herbicides at rates many times higher than those needed to control wheat, when applied to plants of a wide range of sizes, beginning at the unifoliate stage. These results are similar to those of other authors (5,39,49). Wheat was susceptible to both herbicides at any stage from the two- leaf seedlings to fully tillered plants 30 cm tall that had formed a dense ground cover.

Rates needed to control wheat differed under different conditions for both herbicides. Control was better when the herbicides were applied in the fall to alfalfa seeded in August, than in the summer to wheat seeded in May. Possibly, no single factor explains those differences, but, favorable soil moisture in the days before the application, more humid conditions at the time of application, and cooler weather after the application, may have helped the activity of the herbicides applied in the fall. It is fortunate that control was best in the late summer and fall, which is when volunteer wheat control is needed.

In general, control was better when the herbicides were applied at the one- to five- tiller stages than at the earliest stage (two to three leaves). These results differ from those obtained by Oliver et al. (50) in which several other species were more susceptible to these herbicides at the two- to four- leaf stages than at later stages. Our results differ also, from the general concept that most herbicides tend to be more effective on plants at the seedling stage (1). Under our conditions, when the herbicides were applied at sub-lethal rates, the exposed tissue was burned and root and shoot stopped growing. However, within a few days, new roots and new tillers free of symptoms developed. Because of the time it took for new growth to start - up to a month under cold conditions - the buds that originated that regrowth, had to be dormant at the time of application. Also the fact that the new growth was free of symptoms suggests that those buds were not affected at all by the herbicide.

Parker (51) indicated that the failure of most herbicides to kill dormant buds is assumed to be due to the lack of metabolic activity in them, and a lack of water or other material flowing into the organs. He also indicated that buds that are dormant at the time of treatment, are often killed, only because they are released from dormancy by the herbicide injury to the apex, and then receive lethal quantities of the herbicide. We cannot explain why fewer buds were killed in the younger plants.

In each of four experiments, and at every stage of growth of the wheat, fluazifop-butyl injured wheat more than the same rates of sethoxydim. Fluazifop-butyl applied in the fall at 0.18 kg/ha, controlled wheat at any stage and reduced wheat vigor with rates as low as 0.06 kg/ha. Sethoxydim had to be applied at 0.24 to 0.4 kg/ha to kill wheat at all stages in the fall. Although at a rate of

0.18 kg/ha, it was active enough to reduce wheat foliage to less than 10% relative to the untreated check, our results indicated that, in plots sprayed with sethoxydim at 0.2 kg/ha, the surviving 15% of wheat plants, were able to recover, compete during winter and spring, and reduce alfalfa yields. Therefore, a grower should apply either 0.2 kg/ha of fluazifop-butyl or 0.4 kg/ha of sethoxydim to ensure satisfactory control and optimum yields.

Within a certain range, the rate of herbicide required to kill wheat does not vary greatly with the stage of development of the wheat. Early applications therefore are more important to avoid alfalfa yield reductions due to competition than to lower the rate of the herbicide. The decision when to spray, thus, will ultimately be based on the balance of enough wheat growth to control erosion and the cost of delaying that treatment, expressed as kilograms of alfalfa hay per unit area. Therefore, the flexibility to choose the date of application offered by fluazifop-butyl and sethoxydim will represent a great advantage for the grower compared with the current options of spraying with propham or pronamide in late fall.

Wheat continued to affect the alfalfa after being sprayed. From each time of control, the handweeded plots yielded more alfalfa than the corresponding herbicide-treated plots. One effect of the interference of wheat was to reduce the number of stems per plant of alfalfa. Haynes

(33) mentioned that shade may suppress bud initiation at the crown level of legume species. The number of stems was reduced as control was delayed and was lowest where wheat was not controlled at all. But there were also fewer stems in the treated plots compared to the handweeded plots from each time of treatment. This suggested that competition for light still took place after the herbicides had stopped the growth of the wheat. However, competition for light could hardly explain the differences in yield between the herbicide-treated plots and the handweeded plots from the first time of application. At the time of that treatment, wheat foliage covered no more than 5 to 10% of the whole area of the plot, and ceased growing soon after the application. Perhaps the difference was due to some stimulating effect of the handweeding "per se" on the alfalfa. It could also have been related to a detrimental effect of allelopathic substances released by the decomposing wheat in the treated plots. Such an allelopathic effect has been recently reported as a factor involved in weed control by a mulch of wheat killed by herbicides (58).

It had already been shown that activity of sethoxydim is mainly through through foliar exposure (18). Our results indicate that fluazifop-butyl has a similar behavior. This concept has practical importance. The activity of the herbicides will depend more on environmental and plant conditions at the time of application that influence foliar uptake, rather than any conditions affecting uptake from the soil. Thus, rainfall or sprinkler irrigation after the application does not enhance activity, and can even be detrimental if it occurs within the first few hours after the application. This is hard to reconcile with the good control obtained by Dowler (23) with the two herbicides applied in the water of sprinkler irrigation (through herbigation).

The fact that the herbicides are mostly foliar active, determines that their activity is also less dependent on soil moisture "per se" at the time of application, although it certainly may be modified by the water status of the plant. In spite of that, Rushing and Murray (63) observed no differences in the activity of sethoxydim applied to sorghum plants under a wide range of moisture stress conditions. Similarly, we observed no differences in the activity of fluazifop-butyl when sprayed to wheat plants under a moderately low (8%) or high (15%) soil moisture level. Because fluazifop-butyl killed all the wheat under both low and high soil moisture, it is possible that the rate (0.2 kg/ha) was too high to show any difference in the activity of the herbicide. Besides, we cannot tell if the degree of water stress was sufficient to cause the alteration in the plant, described by Muzik (43), that would lead to a modification of the penetration, translocation, and activity of the herbicide inside the plant. According to Hanson and Hitz (28), plant water status is a function of both soil water supply and the evaporative demand of the atmosphere. Thus, soil moisture could be relatively low, but the evaporative demand at the time of the application could have been low enough that there was no water stress in the plant.

So we can not affirm that the activity fluazifop-butyl was not affected by water stress in the plant. But, whether the plants were under stress or not, the results indicate that fluazifop-butyl at 0.2 kg/ha controlled wheat effectively, even if soil moisture levels were low because of a prolonged period without rain or irrigation before application.

Fluazifop-butyl and sethoxydim control only grass weeds. Other control measures must be applied if broadleaf weeds are a problem. The reduction in control of volunteer wheat by fluazifop-butyl because of the combination with 2,4-DB in our preliminary experiment, confirms the antagonism between these two herbicides reported by Stonebridge (66). Further studies should determine if there is similar antagonism with lower rates of 2,4-DB and at other phenologic stages of wheat. Also it should be determined whether the activity of 2,4-DB on broadleaf species or the selectivity of either herbicide on the alfalfa is modified in any way by the mixture. Nevertheless, our results indicate that the reduction in wheat control can be overcome by higher rates of fluazifop-butyl. Thus the combination may still be an alternative, if it is profitable compared to other mixtures or compared to separate applications spaced a few days apart to avoid the interaction.

LITERATURE CITED

1. Åberg, E. and V. Steckó. 1976. Internal factors affecting toxicity. Pages 175-201. in L.J. Audus, (ed.) Herbicides. Vol. II. Academic Press, New York.

2. Akobundu, I.O., R.D. Sweet, and W.B. Duke. 1975. A method for evaluating herbicide combinations and determining herbicide synergism. Weed Sci. 23:20-25.

3. Arnon, I. 1975. Physiological aspects of dryland farming . V.S. Gupta, (ed.). Oxford and IBH Publishing Co. 137 p.

4. BASF Wyandotte Corp. 1980. Poast Experimental Herbicide, Technical Data Sheet. BASF Agric. Chem. Div. Parsippany, New Jersey. 4pp.

5. Bell, C.E. and J. Castro. 1982. Evaluation of grass herbicides for bermudagrass control in established alfalfa. Proc. West. Soc. Weed Sci. 35:112-113.

6. Blackman, G.E. and J.N. Black. 1959. Physiological and ecological studies on the growth of different species in the vegetative phase. Ann. Bot. 23:51-63.

7. Blaser, R.E., T. Taylor, W. Griffeth, and W. Skrdla. 1956. Seedling competition in establishing forage plants. Agron. J. 48:1-6.

8. Calpouzos, C.A., G.A. Lee, and C.D. McNeal. 1980. Survey of weed complexes in alfalfa seed fields in Idaho. Proc. West. Soc. Weed Sci. 33:127-132.

9. Campbell, J.R. and Penner. 1981. Factors affecting the activity of bentazon with diclofop and BAS -9052 2-(N-ethoxybutyrimidoyl)-5-(2-ethylthiopropyl)-3-hydroxy-2-cyclohexen-1- one. Abstr., Weed Sci. Soc. Am. p. 13.

10. Campbell, J.R. and D. Penner. 1981. Absorption and translocation of BAS 9052 OH 2-(1-ethoxymino)-butyl-5-(2-(ethylthio)-propyl)-3- hydroxy-- cyclohexane -1-one). Abstr., Weed Sci. Soc. Am. p. 108.

11. Campbell, J.R. and D. Penner. 1981. Metabolism of BAS 9052 by susceptible and tolerant plant species. Proc. North Cent. Weed Control Conf. 36:33-34.

12. Chandler, J.M. 1981. Biotypic responses of bermudag-

rass (Cynodon dactylon (L.) Pers.) to postemergence herbicides. Abstr., Weed Sci. Soc. Am. pp. 91-92.

13. Chase, R.L. 1982. Reduce overall yield with weed control in alfalfa, but ... . Proc. West. Soc. Weed Sci. 35:144-146.

14. Chow, P.N.P. 1982. Herbicidal activation of BAS 9052 with surfactants and additives for wild oat (Avena fatua) control. Abst., Weed Sci. Soc. Am. pp 17-18.

15. Colby, S.R., J.R. Bone, and A.A. Akhavein. 1982. PP009, a selective herbicide for control of perennial and annual grasses. Abstr., Weed Sci. Soc. Am. p.14

16. Coleman-Harrell, M.E., G.A. Lee, and E.P. Eldredge. 1979. Evaluation of several herbicides for weed control and crop tolerance in newly seeded alfalfa. West. Soc. Weed Sci. Res. Prog. Rep. pp. 110-112.

17. Cranmer, J.R. and J.D. Nalewaja. 1981. Additives and BAS 9052 OH phytotoxicity. Proc. North. Cent. Weed Control Conf. 36:96.

18. Cranmer, J.R. and J.D. Nalewaja. 1981. Environment and BAS 9052 OH phytotoxicity. Proc. North. Cent. Weed Control Conf. 36:26.

19. Crane, S., P.J. Sollazzo, and R.D. Ilnicki. 1981. Efficacy of postemergence spray dates in soybeans. Proc. Northeast. Weed Sci. Soc. 35:61.

20. Dawson, J.H. and R.G. Harvey. 1981. Management systems for weeds in alfalfa. Pages 303-315. in D. Pimentel, (ed.) Handbook of Pest Management, Vol. III, CRC Press, Inc. pp. 303-315.

21. Dawson, J.H. and C.M. Rincker. 1982. Weeds in new seedings of alfalfa (medicago sativa) for seed production: competition and control. Weed Sci. 30:20-25.

22. Dorentzio, W.A. and R.F. Norris. 1979. Antagonistic effects of desmedipham on diclofop activity. Weed Sci. 27:539-544.

23. Dowler, C.C. 1982. Activity of selected herbicides applied postemergence through irrigation. Proc. South. Weed Sci. Soc. 35:397.

24. Drew, B.N. 1982. Postemergence fluazifop-butyl for control of grasses in oilseeds and grain legumes. Abstr., Weed Sci. Soc. Am. p.113.

25. Evans, J.O. and R.W. Gunnell. 1982. Postemergence wild oat and green foxtail control in seedling alfalfa. West. Soc. Weed Sci. Res. Prog. Rep. pp 108-109.

26. Ford, W.P., J.W. Burno, D.W. Evans, and R. Parker. 1981. Establishing alfalfa for hay in irrigated central Washington EB 0959. Coop. Ext. College of Agric., W.S.U., Pullman, WA. 6 pp.

27. Handly, J.V., R.H. Callihan, and D.C. Thill. 1982. Downy brome control in alfalfa. West. Soc. Weed Sci. Res. Prog. Rep. pp 110-111.

28. Hanson, A.D. and W.D. Hitz. 1982. Metabolic responses of metabolites to plant water deficits. Annu. Rev. Plant Physiol. 33:163-203.

29. Harden, J., E. Ellison, and C. Cole. 1982. Annual grass control in soybeans with sethoxydim. Proc. South. Weed Sci. Soc. 35:29.

30. Hargrave, M.R., M.W. Grubbs and S.D. Walkins, 1982. Control of rhizome johnsongrass with fluazifop-butyl in Western irrigated cotton. Proc. West. Soc. Weed Sci. 35:150-160.

31. Hartzler, R.G. and C.L. Foy. 1982. Factors affecting performance of postemergence grass herbicides. Proc. South. Weed Sci. Soc. 35:96.

32. Hartzler, R.G. and C.L. Foy. 1982. Evaluation of BAS 9052 OH alone and in combination with acifluorfen or bentazon for control of large crabgrass (Digitaria sanguinalis L.). Abstr., Weed Sci. Soc. Am. p 35.

33. Haynes, R.J. 1980. Competitive aspects of the grass-legume association. Adv. Agron. 33:227-261.

34. Himmelstein, F.J. and R.A. Peters. 1981. Comparison of three postemergence grass herbicides on a new alfalfa seeding. Proc. Northeast. Weed Sci. Soc. 35:70-74.

35. ICI Americas Inc. Fusilade experimental herbicide. Technical Information. ICI Americas Inc. Agric. Chem. Div. Goldsboro, North Carolina. 4 pp.

36. Kells, J.J., W.F. Meggit and D. Penner. 1981. Factors influencing grass control with selective postemergence herbicides. Proc. North Cent. Weed Control Conf. 26:21-22.

37. Klauzer, J. and W.E. Arnold. 1981. Annual grass and broadleaf control as influenced by diclofop-methyl, difenopenten, and sethoxydim herbicide combinations with bentazon. Proc. North Cent. Weed Control Conf. 36:99.

38. Leroux, G.D. and R.G. Harvey. 1980. Influence of BAS 9052 on perennial grass control and production of alfalfa. Proc. North Cent. Weed Control Conf. 35:127.

39. Miller, S.F., L.C. Burril, F. Fraser, and A. Deutsch. 1981. New herbicide evaluation, multicrop screening trial, spring 1981. Internat. Plant Prot. Cent. Doc. 40-A-81. 57 pp.

40. Morse, P.M. 1978. Some comments on the assessment of joint action in herbicide mixtures. Weed Sci. 26:58-71.

41. Morrison, I.N. and T. Mayer. 1981. Green foxtail and wild oat control in seedling alfalfa. Res. Rep. Can. Weed Cmm. (Western Section). p. 5.

42. Moyer, J.R. 1981. Tolerance of legumes to herbicides (Screen trial). Res. Rep. Can. Weed Comm. (Western Section). pp. 45-46.

43. Muzik, R.J. 1976. Influence of environmental factors on toxicity to plants. Pages 203-247. in L.J. Audus, (ed.) Herbicides. Vol. II. Academic Press, New York.

44. Nalewaja, J.D., S.D. Miller, and A.G. Dexter. 1980. Field crops - soybeans, sugarbeets, and new herbicides. Proc. North Cent. Weed Control Conf. 35:43-45.

45. Nash, R.G. 1981. Phytotoxic interaction studies-techniques for evaluation and presentation of results. Weed Sci. 29:147-155.

46. Norris, R.F. 1981. Weed competition in seedling alfalfa. Abstr. Weed Sci. Soc. Am. p. 86.

47. Norris, R.F., D.R. Ayres, and R.A. Lardelli. 1980. Multi-crop postemergence summer annual grass control screening trial. West. Soc. Weed Sci. Res. Prog. Rep. pp. 326-327.

48. Norris, R.F., D.R. Ayres, and R.A. Lardelli. 1980. Postemergence control of yellow foxtail in established alfalfa. West. Soc. Weed Sci. Res. Prog. Rep. p.174.

49. Norris, R.F., R.A. Lardelli, and D.R. Ayres. 1981. Postemergence wild oat control in seedling alfalfa. West. Soc. Weed Sci. Res. Prog. Rep. p. 181.

50. Oliver, L.R., D.G. Mosier, and O.W. Howe. 1982. A comparison of new postemergence herbicides for control of annual grasses. Abstr., Weed Sci. Soc. Am. p. 17.

51. Parker, C. 1976. Effects on the dormancy of plant organs. Pages 165-187. in L.J. Audus (ed.). Herbicides. Vol. I. Academic Press, New York.

52. Parker, R. 1982. Postemergence green foxtail control in established alfalfa. West. Soc. Weed Sci. Res. Prog. Rep. p. 114.

53. Parker, W.B. and L. Thompson. 1982. The utility of sethoxydim in soybean weed management systems. Proc. South. Weed Sci. Soc. 35:29.

54. Pearson, J.O. 1980. Postemergence graminicide for broadleaf crops. Abstr., Weed Sci. Soc. Am. p. 114.

55. Pendleton, J.W. 1957. Fall seed alfalfa with winter wheat? Agron. J. 49:567-568.

56. Peters, R.A. 1980. Postemergence control of crabgrass with BAS 9052 OH in new alfalfa and red clover seedings. Proc. Northeast. Weed Sci. Soc. 34:101.

57. Pike, D.R. and J.F. Stritzke. 1982. Effect of seeding rate and cutting date on cheat-alfalfa competition. Proc. South. Weed Sci. Soc. 35:76.

58. Putman, A.R., J. DeFrank, and J.P. Barnes. 1982. Exploitation of allelopathy for weed control in annual and perennial cropping systems. Proc. North Am. Symp. on Allelopathy. 22 pp.

59. Ready, E.L. and J. Wilkerson. 1982. Postemergence control of Rhizome johnsongrass (Sorghum halepense (L.) Pers.) with PP009 as affected by drought stress. Abstr., Weed Sci. Soc. Am. p. 15.

60. Rhodes, G.N. and H.D. Coble. 1982. Interaction of sethoxydim and bentazon. Proc. South. Weed Sci. Soc. 35:346.

61. Ritter, R.L. and T.C. Harris. 1982. Interactions of postemergence soybean herbicides. Proc. Northeast.

Weed Sci. Soc. 35:63-68.

62. Rosser, S.W., P.S. Zorner, W.W. Witt, and G.L. Olson. 1982. Uptake of fluazifop-butyl and accumulation of its free acid metabolite in johnsongrass. Proc. South. Weed Sci. Soc. 35:339.

63. Rushing, D.W. and D.S. Murray. 1982. Effect of moisture stress on sethoxydim activity. Proc. South. Weed Sci. Soc. 35:345.

64. Saleh, H.S. and G.R. Oliver. 1982. Response of volunteer corn and soybeans to diclofop or sethoxydim as influenced by corn height, carrier volume, herbicide rate, and corn cultivars. Proc. Nort Cent. Weed Control Conf. 36:25.

65. Sciarappa, W.J., Jr. 1979. Postemergence grass control in soybeans with BAS 9052 OH. Proc. Northeast. Weed Sci. Soc. 35:10.

66. Stonebridge, W.C. 1981. Selective postemergence grass weed control in broadleaf arable crops. Outlook Agric. 10:385-392.

67. Swisher, B. and F.T. Corbin. 1982. The behavior of sethoxydim in soybean and johnsongrass (Sorghum halepense (L.) Pers.). Part I. Penetration, distribution, and metabolism in intact plants. Abstr., Weed Sci. Soc. Am. pp. 126-127.

68. Swisher, B. and F.T. Corbin. 1982. The behavior of sethoxydim in soybean and johnsongrass (Sorghum halepense (L.) Pers.). Part II. Uptake and metabolism in cell cultures. Abstr., Weed Sci. Soc. Am. p. 93.

69. Tammes, P.L. 1964. Isoboles, a graphic presentation of synergism in pesticides. Neth. J. Plant Pathol. 70:73-80.

70. Temme, D.G., R.G. Harvey, R.S. Fawcett, and A.W. Young. 1979. Effects of annual weed control on alfalfa forage quality. Agron. J. 71:51-54.

71. Umeda, K. and G. Kapusta. 1981. Postemergence rhizome johnsongrass (Sorghum halepense (L.) Pers.) control in soybeans with BAS 9052 (2-(N-ethoxybutyrimidoyl)-5-(20 ethylthiopropyl) -3-hydroxy-2-cyclohexen-1-one), difenopenten, and mefluidide. Abstr., Weed Sci. Soc. Am. p. 11.

72. West, L.D., J.H. Dawson, and A.P. Appleby. 1980.

Factors influencing barnyardgrass (Echinochloa crus-galli) control with diclofop. Weed Sci. 28:366-371.

APPENDIX

Appendix Table 1. Daily rainfall (mm) and irrigation schedule of all experiments, Prosser, Washington, 1982.[a]

Day	April	May	June	July	August	September	October
1							
2						(1b)	
3			(3)		(2a)		
4							1.0
5	1.3				(1a,7)		
6	2.5	(3)				(2b)	
7							2(5,6)
8				(1a,7)			(1b,4)
9							(2b)
10					23.3		
11			(1a,7)				0.5
12	14.0						
13		(3)				1.2(1b)	
14							
15			(1a,7)				
16							
17			(3)				
18		1.0					
19		(3)				(4)	
20	(3)				(4)	14(5.6)	
21	(3)	(3)	(1a,2a)	(1a,2a,7)	(1b)		
22	(3)						5.3
23	(3)				(4)		
24					(2a,4)		
25			(1a,2a,7)		(1b)		12.2
26	(3)				(4)		2.5
27		(3)				13	
28	8.0	6.0	21	(1a,7)			
29			2			0.3	27.4
30	(3)			3.0	(2b)		
31							
Total monthly rain-fall	26	7.0	23	3.0	23.3	50.9	

[a]Amount of rainfall is characterized with numbers without brackets. The numbers in brackets indicate the number of experiments irrigated on that date, according to the following code:

(1) Tolerance of alfalfa, spring (1a), fall (b), sprinkler irrigated.
(2) Susceptibility of wheat, spring (2a), fall (2b), furrow irrigated.
(3) Response of alfalfa seedlings, sprinkler irrigated.
(4) Selective control of wheat in alfalfa, sprinkler irrigated.
(5) Site of uptake, sprinkler irrigated.
(6) Soil moisture content, sprinkler irrigated.
(7) Interaction on, furrow irrigated.

Appendix Table 2. Soil moisture content at the time of application of fluazifop-butyl to wheat plants.

Treatments		Replications				
Herbicide	Prescribed soil humidity	I	II	III	IV	Avg
	(%)	(%)				
Untreated	Low	9.3	8.3	8.5	8.9	8.5
Treated	Low	8.5	8.4	7.8	8.5	8.3
Untreated	High	14.9	15.1	14.1	14.2	14.6
Treated	High	14.5	15.0	15.4	14.8	14.9

Appendix
Table 3. Growth reduction of wheat 8 to 10 days after the application of fluazifop-butyl and sethoxydim at several rates at three stages of growth, in the summer of 1982.

Treatments		Growth reduction[b]		
		Stages of growth when treated		
Herbicide	Rate[a]	(2 leaves)	(1 to 2 tillers)	(5 tillers)
	(kg/ha)	- - - - - - - - -	(%)	- - - - - - - - - - -
Fluazifop-butyl	0.06	15 f	35 d	-
	0.12	65 d	75 bc	-
	0.18	85 c	75 bc	55 cd
	0.24	99 a	85 abc	70 bc
	0.36	-	98 a	70 bc
	0.48	-	-	90 a
Sethoxydim	0.06	5 g	20 d	-
	0.12	50 e	75 bc	-
	0.18	75 d	80 bc	45 d
	0.24	95 b	73 c	60 cd
	0.36	-	90 a	65 cd
	0.48	-	-	85 ab
Untreated	-	0	0	0

[a]All herbicide treatments included phytobland oil at 3.4 l/ha.

[b]Visual estimation of the degree at which growth had ceased after the application related to the untreated check.

Within the same column, means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with values of 0 in all the replications were not included in the statistical analysis. Data were transformed to the Arcsin (SQR (x)) before statistical analysis.

Appendix Table 4. Number and height of new tillers of wheat 15 days after the application of fluazifop-butyl and sethoxydim at three stages of growth, in the summer of 1982.

Treatments		Stages of growth when treated[b]					
		(2 leaves)		(1 to 2 tillers)		(5 tillers)	
Herbicide	Rate[a]	(Height)	(Tillers/pl)	(Height)	(Tillers/pl)	(Height)	(Tillers/pl)
	(kg/ha)	(cm)	(no.)	(cm)	(no.)	(cm)	(no.)
Fluazifop-butyl	0.06	16.2 bc	5.4 a	18.0 b	6.1 ab	-	-
	0.12	14.4 cd	5.3 a	11.0 d	2.9 e	-	-
	0.18	12.5 de	4.1 b	8.0 e	1.2 fg	14.7 bc	1.9 cd
	0.24	7.6 f	0.8 c	0	0	0	0
	0.36	-	-	0	0	0	0
	0.48	-	-	-	-	0	0
Sethoxydim	0.06	16.8 ab	5.5 a	21.0 a	7.0 a	-	-
	0.12	16.3 bc	5.4 a	14.6 c	5.5 bc	-	-
	0.18	14.8 bc	5.2 a	11.0 d	4.6 cd	16.6 d	5.7 b
	0.24	10.7 e	3.7 b	10.4 de	3.8 de	13.5 c	2.9 c
	0.36	-	-	9.5 de	2.4 ef	12.9 c	1.2 de
	0.48	-	-	-	-	7.6 e	0.8 e
Untreated	-	18.8 a	5.1 a	21.8 a	6.8 a	26.0 a	7.3 a

[a]All herbicide treatments included phytobland oil at 2.3 l/ha.

[b]Within column, means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with mean of 0 were not included in the statistical analysis.

Appendix
Table 5. Number and height of new tillers of wheat 30 days after the application of fluazifop-butyl and sethoxydim at three stages of growth in the summer of 1982.

Treatments		Stages of growth when treated[b]					
		(2 leaves)		(1 to 2 tillers)		(5 tillers)	
Herbicide	Rate[a]	(Height)	(Tillers/pl)	(Height)	(Tillers/pl)	(Height)	(Tillers/pl)
	(kg/ha)	(cm)	(no.)	(cm)	(no.)	(cm)	(no.)
Fluazifop-butyl	0.06	24.0 a	7.5 a	31.0 bc	7.5 a	-	-
	0.12	24.0 a	7.0 a	25.2 d	5.7 bc	-	-
	0.18	21.0 b	6.3 ab	18.9 e	4.6 c	19.9 c	6.4 ab
	0.24	14.0 c	5.3 b	13.7 f	5.0 c	14.9 de	4.4 cd
	0.36	-	-	10.4 f	4.9 c	10.3 f	3.4 d
	0.48	-	-	-	-	0	0
Sethoxydim	0.06	25.6 a	7.7 a	33.9 ab	7.8 a	-	-
	0.12	25.0 ab	7.6 a	30.0 c	7.3 a	-	-
	0.18	24.0 a	7.6 ab	29.5 c	8.0 a	27.1 b	6.7 ab
	0.24	21.0 a	6.7 b	25.0 d	6.6 ab	20.5 c	6.7 ab
	0.36	-	-	21.2 e	5.7 bc	17.2 d	5.4 bc
	0.48	-	-	-	-	14.0 e	4.0 cd
Untreated	-	26.0 a	7.3 a	35.0 a	7.5 a	35.0 a	7.5 a

[a]All herbicide treatments included phytobland oil at 2.3 l/ha.

[b]Within columns, means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT.

Appendix Table 6. Growth reduction of wheat 8 to 10 days after the application of fluazifop-butyl and sethoxydim at several rates at three stages of growth, in the fall of 1982.

Herbicide	Rate[2]	Growth reduction[b]		
		Stages of growth when treated		
		(2 leaves)	(1 to 2 tillers)	(5 tillers)
	(kg/ha)	(%)		
Fluazifop-butyl	0.06	40 c	70 c	-
	0.12	90 ab	90 ab	-
	0.18	95 a	95 a	85 bc
	0.24	95 a	100	85 bc
	0.36	100	100	85 bc
	0.48	100	100	90 ab
Sethoxydim	0.06	30 c	55 d	-
	0.12	70 b	90 b	-
	0.18	95 a	95 a	75 c
	0.24	100	100	80 bc
	0.36	100	100	90 bc
	0.48	100	100	98 a
Untreated	-	0	0	0

[a]All herbicide treatments included phytobland oil at 2.3 l/ha.

[b]Visual estimation of the degree at which growth had ceased after the application related to the untreated check.

Within the same column, means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with values of 0 or 100 in all the replications were not included in the statistical analysis. Data were transformed to the Arcsin (SQR (x)) before statistical analysis.

Appendix Table 7. Number and height of new tillers of wheat 15 days after the application of fluazifop-butyl and sethoxydim at 3 stages of growth in the fall of 1982.

Treatments		Stages of growth when treated[b]					
		(2 leaves)		(1 to 2 tillers)		(5 tillers)	
Herbicide	Rate[a]	(Height)	(Tillers/pl)	(Height)	(Tillers/pl)	(Height)	(Tillers/pl)
	(kg/ha)	(cm)	(no.)	(cm)	(no.)	(cm)	(no.)
Fluazifop-butyl	0.06	10.7 b	2.9 a	7.7 c	2.6 c	-	-
	0.12	7.7 c	1.3 b	0	0	-	-
	0.18	6.0 cd	0.8 b	0	0	0	0
	0.24	6.0	0.2	0	0	0	0
	0.36	0	0	0	0	0	0
	0.48	0	0	0	0	0	0
Sethoxydim	0.06	11.7 ab	2.9 a	10.3 b	4.4 b	-	-
	0.12	8.2 c	1.4 b	7.5 c	1.4 d	-	-
	0.18	5.0 d	0.5 b	6.3 c	1.2 d	0	0
	0.24	5.0	0.5	0.	0	0	0
	0.36	0	0	0	0	0	0
	0.48	0	0	0	0	0	0
Untreated	-	13.2 a	3.6 a	17.5 a	5.4 a	21	6.7

[a]All herbicide treatments included phytobland oil at 2.3 l/ha.

[b]Within columns, means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with 0 values in one or more replications were not included in the statistical analysis.

Appendix
Table 8. Number and height of the new tillers of wheat 30 days after the application of fluazifop-butyl and sethoxydim at three stages of growth in the fall of 1982.

Treatments		Stages of growth when treated[b]					
		(2 leaves)		(1 to 2 tillers)		(5 tillers)	
Herbicide	Rate[a]	(Height)	(Tillers/pl)	(Height)	(Tillers/pl)	(Height)	(Tillers/pl)
	(kg/ha)	(cm)	(no.)	(cm)	(no.)	(cm)	(no.)
Fluazifop-butyl	0.06	16.0 bc	6.6 a	16.8 c	6.2 ab	-	-
	0.12	11.7 de	4.4 b	9.7 e	3.2 d	-	-
	0.18	10.5 de	3.5 bc	0	0	0	0
	0.24	11.3	2.0	0	0	0	0
	0.36	7.3	1.8	0	0	0	0
	0.48	0	0	0	0	0	0
Sethoxydim	0.06	18.8 ab	6.4 a	22.5 b	6.2 ab	-	-
	0.12	13.7 cd	4.5 b	15.3 c	5.5 b	-	-
	0.18	9.7 e	3.0 c	13.2 d	5.2 c	11.8 b	3.4 b
	0.24	8.8 e	2.6 c	9.2 e	1.9 e	11.2 b	2.7 b
	0.36	6.0	1.0	0	0	0	0
	0.48	5.7	1.0	0	0	0	0
Untreated	-	20.8 a	6.7 a	27.7 a	6.7 a	2.7 a	6.7 a

[a]All herbicide treatments included phytobland oil at 2.3 l/ha.

[b]Within columns, means followed by the same letter do not differ at the 0.05 level according to Duncan's MRT. Treatments with values 0 in one or more replications were not included in the statistical analysis.

Appendix
Table 9a. Temperature, relative humidity, and evaporation at the application dates, 1982.

Date	Temperature (°C) max	Temperature (°C) 8 a.m.	Temperature (°C) min	RH% max	RH% 8 a.m.	RH% min	Evaporation (mm)
May 11	21	7	5	94	90	34	5.8
May 25	28	17	12	74	70	28	7.9
June 8	22	16	5	72	62	24	5.3
June 29	24	16	16	98	90	58	8.6
July 8	27	16	11	85	70	33	7.9
July 12	33	22	11	85	68	27	24.6
July 16	21	14	4	85	66	36	5.8
July 20	33	21	13	81	70	25	8.9
July 22	28	14	4	88	65	36	10.2
July 23	25	16	9	74	70	32	9.1
September 8	28	16	12	80	80	35	5.1
September 13	20	18	5	70	54	38	9.1
September 16	20	8	3	80	74	32	5.1
September 17	23	12	8	81	70	32	4.6
September 21	18	11	7	97	96	44	3.3
September 30	18	8	6	-	-	-	4.3
October 1	18	7	3	-	-	-	3.8
October 4	21	7	3	-	-	-	7.9

(-) Data not available.

Appendix
Table 9b. Average monthly temperature for the period of the studies at the Irrigated Agricultural Research and Experiment Center, Prosser, Washington, 1982.

Month	Temperature (°C) Mean daily max	Temperature (°C) Mean daily min	Evaporation Monthly (mm)
April	14	1	120
May	23	5	180
June	31	10	262
July	30	12	2560
August	28	10	114.3
September	23	8	66.8
October	-	-	-