AN ABSTRACT OF THE THESIS OF

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Title: THE HERBICIDE HOE 23408: SOIL PERSISTENCE, SPRING WHEAT CULTIVAR TOLERANCE, AND INTERACTION WITH BROADLEAF HERBICIDES

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HOE 23408 [4-(2', 4'-dichlorophenoxy)-phenoxy-α-propionic methylester] is a promising new compound for control of wild oats and other grass weeds in small grains. Several factors influencing its use for this purpose were investigated.

Greenhouse bioassay studies were conducted in 1975 to determine relative persistence of HOE 23408 in four western Oregon soils following application in the fall and winter. Wild oats (*Avena fatua* L.) were used as a test plant. Soil from each of three application timings at all four locations contained measurable amounts of herbicide.

Generally, residue levels in soil treated at the same herbicide rate approximately 1, 2, and 4 months before sampling were similar. Possibly less herbicide reached the soil from postemergence

treatments, compensating for the longer degradation time of the pre-emergence treatments. Variation in residue levels among locations occurred. This may be explained by differences in smoothness of seedbeds and amounts of plant residue at the various locations.

A study was conducted to determine persistence of HOE 23408 applied to bare soil on April 29, 1975. Wild oats and corn (Zea mays L.) were used as bioassay plants. Evaluation of plants seeded into the plots at intervals showed a gradual reduction in levels of herbicide through the season. At 1 lb/A, neither species planted 9 weeks after application was injured, indicating that no significant carry-over can be expected from this rate applied in spring wheat. Two and 4 lb/A persisted longer, causing injury to test plants seeded 9 weeks after treatment.

A field experiment was established to evaluate the effect of combining each of four commercially used broadleaf herbicides with 1 and 2 lb/A of HOE 23408 on control of wild oats and barnyardgrass (Echinochloa crus-galli (L.) Beauv.) and on yield of Fielder spring wheat. The addition of bromoxynil improved the effect of HOE 23408 on wild oats but reduced its effectiveness on barnyardgrass. Addition of 2,4-D LV ester, MCPA LV ester, or dicamba amine reduced its activity on both wild oats and barnyardgrass. Delaying the application of 2,4-D for 3 or 7 days eliminated the antagonistic effect but a delay of only 1 day was not sufficient. No detrimental effect on yield was observed from any treatment.

A tolerance study was conducted in three commercially used spring wheat cultivars (Waldron, Twin, and WS-1). Excellent tolerance to HOE 23408 was observed in all cultivars, even when the rate was increased from 1 lb/A (proposed use rate) to 4 lb/A.

The Herbicide HOE 23408: Soil Persistence, Spring Wheat Cultivar Tolerance, and Interaction With Broadleaf Herbicides

by

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DEDICATION

For their love and support in their
children's education, I dedicate this thesis
to my parents.
To my daughter, Sonja, for her love and patience
during my long years of study,
I also dedicate this thesis.

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THE HERBICIDE HOE 23408: SOIL PERSISTENCE, SPRING WHEAT CULTIVAR TOLERANCE, AND INTERACTION WITH BROADLEAF HERBICIDES

INTRODUCTION

The two species of wild oats, *Avena fatua* L. and *A. ludoviciana* Dur., are serious, widespread annual weeds of temperate arable crops, especially cereals (25).

The tremendous economic losses caused by this noxious weed are based on:

1. reduction of yield and quality of grain (54),
2. added expenses of tillage, and other control methods, and
3. high cost of removing wild oat seeds from wheat (39).

Intensive production of cereals has greatly contributed to the increased distribution of wild oats. Seed dispersal is primarily by contaminated crop seeds (39). Thurston (49) stated:

> The wild oat plant, by virtue of its high rate of reproduction, long survival of its seeds in field soil, and its strong competitiveness, has itself contributed to the fact that its control has become a matter of urgency.

There are two approaches to wild oat control presently used: chemical and cultural control. Neither of these has succeeded in eradicating this weed but both can be helpful in reducing the problem.

Currently registered chemicals for wild oat control in small grains are: triallate, diallate, and barban. Each of these have advantages and disadvantages but none gives the farmer a consistent solution to the wild oat problem. In order to maximize crop yields and to accomodate a rapidly growing population, constant efforts are being made to develop new more effective herbicides for wild oat control.

Hoechst Corporation recently introduced a very promising compound to fight some of the most common grass weeds in cereal crops. Initial experiments in the United States with HOE 23408 4-(2',4'-Dichlorphenoxy)-phenoxy-d-propionic methylester were conducted under field conditions in 1973 (2,4). It showed excellent promise in spring and winter wheat and barley applied preplant incorporated, preemergence, and postemergence (2, 14, 36).

The objectives of this thesis were:

(a) to study the soil persistence of HOE 23408 under greenhouse and field conditions,

(b) to evaluate the effect of HOE 23408 alone and in combination with broadleaf herbicides on control of wild oat and barnyardgrass, and

(c) to study the tolerance of three spring wheat cultivars to HOE 23408.

LITERATURE REVIEW

Morphology of Wild Oats

The wild oat (*Avena fatua* L.) plant is an annual grass. Its taxonomic position explains the main characteristics of this noxious weed. It is one of the most important species of the tribe Avenae, subfamily Pooideae of the family Poaceae (47).

Culms are erect, hollow, jointed and stout, usually 30 to 150 cm tall. Leaves are numerous, the blades are flat, 4-8 mm wide, and scabrous. No auricules are present but ligules are well-developed with numerous teeth.

The panicles are loose and open so the slender branches are more or less horizontally spreading, forming a cone. Spikelets are mostly 3-flowered. Glumes are about 2.5 cm long and both are longer than the first lemma. The rachilla and the base of the lemma are clothed with long stiff brownish or whitish hairs. A stout, geniculate, twisted awn, 3 to 4 cm long, is always present. Disarticulation occurs above the glumes immediately upon ripening. At the base of the grain is an oval scar sometimes referred to as the "sucker-mouth". Wild oat seedling leaves are usually twisted counter-clockwise when viewed from above, the opposite of wheat, making early identification in the field easier (25, 26, 32, 39).

Morphological differences between cereal and wild oat seedlings are very important. Wild oats emerge by elongation of the first internode which brings the growing point of the plant near the soil surface. Wheat emerges by elongation of the coleoptile with the growing point remaining near the seed during early plant growth. Research indicates that the area of the greatest susceptibility to injury with some soil-applied herbicides is the growing point of both wheat and wild oats. Thus herbicide placement above the wheat growing point in the soil zone containing the oat growing point can result in good control of wild oats (39).

Hack (24) reported that deep-germinating wild oats are more difficult to control. He explained that deep-germinating wild oat plants have narrower leaves which absorb less chemical and that the node is formed at a greater soil depth. Sometimes several nodes are formed at different depths and if the top one is killed, a lower node can resprout. This resprouting characteristic is not restricted to chemically treated plants. Kirk and Pavlychenko (29) found that wild oat seedlings could be cut so that one or more segments, provided that they included a node, could root and grow new plants.

Wild oat plants may also exhibit strong neotenic characteristics, finishing their development in juvenile stage. When growing conditions are unfavorable, they flower early and develop only a few seeds. Lack of moisture in the soil is the most common reason for developing neotenic forms (46).

Life Cycle

The overtopping, drooping inflorescences of wild oats are visible in infested fields after flowering, which can occur over a period of 5 to 6 weeks. They produce viable seeds within 7 to 10 days after heading. Wild oats reach maturity and about 80% of the seeds shatter by the time the crop is harvested. This early shedding ensures the return of a high population of wild oat seeds in the soil (25, 39). Some infested fields in Alberta, Canada, have been studied to determine the amount of *Avena fatua* L. seeds in the top 6 inches of soil, and up to 70 bushels per acre have been found (39).

The wild oat seed has primary dormancy at maturity for protection against early fall germination and subsequent killing by winter frosts. Secondary dormancy or high temperature dormancy prevents seeds from germinating during the summer, allowing the plant to survive the cultivation of a fallow year.

The degree of dormancy will vary with a particular wild oat population. Nalewaja (39) reported results from Lethbridge, Alberta, that plants grown in soil with high moisture under a cool temperature of 60° F produced almost completely dormant seeds (99%), while plants grown in dry, warm soil (80° F) gave seeds that were only 19% dormant. These results are useful for planning for fall tillage control of wild oats in years of "non-dormant" seed production.

Chepil (13) found that, contrary to most other weeds, wild oats will not germinate readily when lying on the surface of the ground.

Many workers have conducted studies on the dormancy and longevity of wild oat seeds in the soil since they are the key factors in breaking the life cycle of this weed species. Naylor and Simpson (40) reported that the control of dormancy in _A. fatua_ L. seeds is due to a gibberellin - inhibitor antagonism. At least one inhibitor has been shown to intervene specifically in sugar production and this effect can be reversed by GA. The evidence presented supports the view that control of germination during the period of after-ripening is through changes in inhibitor content rather than in endogenous gibberellin.

Popular opinion that once a soil becomes infested with wild oats, a certain percentage of the seeds retain their viability for many years is not supported by experimental results (53). Tingey (53) found that a small percentage of seeds of wild oats persisted up to June of the third year. He also found that wild oats showed more of a tendency to emerge in the fall than in the spring from each of 1, 3, and 6 inches of seeding depth, when seeded in late October.

Chepil also found that the maximum period of dormancy of wild oats is 3 to 4 years but that the majority of the viable seeds (80%) germinated in the first year followed by 18% in the second, 2% in the third, and only 2 seeds out of a thousand in the fourth year (Figure 1.) He found that seeds originating from the secondary florets of a spikelet showed a greater tendency for dormancy than the larger seeds originating at the base of the spikelet.

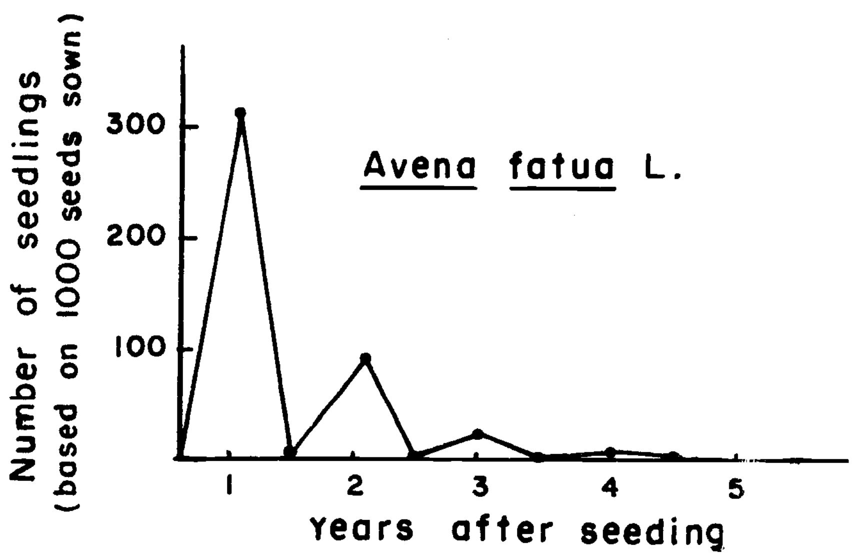

Figure 1. Yearly totals of seedlings emerging from cultivated soil during 5 years after seeding. (Taken from Chepil (13)).

Thurston (51) did extensive studies on the biology of wild oats. She found that no wild oats survived over a 61-month period. Survival was a little better when seeds were buried to a depth of 15 cm rather than 5 cm.

Several workers found that the depth of burying and frequency of cultivation gave different results in germination of wild oats (25, 28, 39, 51, 52). In general, these studies show that almost no germination will occur outside the peak seasons, so cultivation does not promote wild oat germination out of fall and spring flushes.

Temperature also appears to be an important factor for wild oat seed germination as indicated by Friesen (9) and Shebeski (19). They found that the greatest number of seeds germinated at 70° F when the experiment was conducted in a growth chamber and no germination occurred above 90° F or below 40° F. They also reported that in contrast to these results, field experiments by Lagget and Banting in Alberta demonstrated that the largest percentage of wild oat seeds germinate between 34° F and 50°F while the percentage that will germinate after the soil temperature rises above 50° F falls off rapidly.

Abu-Irmaileh (1) wrote that in his experiments in Corvallis, Oregon, wild oat germination occurred in two waves: in the winter and in the spring. Possibly, another wave occurs in the summer if enough moisture is available. Moisture is, therefore, the major factor in influencing wild oat germination, he concluded. Tillering, according to Abu-Irmaileh, took place in late February and March while spring-germinated wild oat plants hardly developed any tillers in winter wheat. The heading stage appeared to be in late June, and the life cycle was concluded with seed shattering in July before harvest, no matter when it germinated.

A report by Wood (54) gives us a general idea of the range of environmental conditions to which wild oats are adapted. "While occurring over a very wide range of soil, climatic and other conditions, wild oats are inclined to be 'choosey' as to environment. The preference seems to be for the cool moist conditions."

Wild Oat Competition

Several workers agree that the most important effect of wild oats in infested crop fields is the tremendous yield loss (8, 11, 17, 39, 54). Competition between wild oats and cultivated cereals is primarily for plant nutrients, water, and light. Yield reduction is influenced by the crop's competitive ability, density of the wild oat population, and time of wild oat emergence (11, 39, 52).

Thurston reported in 1962 (52) that wild oats were controlled by a dense crop of an autumn-sown cereal in naturally infested fields. The crop was not important provided that it grew well on the site; its effectiveness depended on its density when wild oats germinated in the spring. Winter wheat and winter rye were equally effective in suppression of the wild oats. Even in the light crop of barley, wild oats grew much less vigorously than in fallow plots. Beyond a certain crop density, depending on soil fertility, further increase in crop density did not decrease the size of wild oats. The heaviest crop did not completely suppress the wild oats but competed with the seedlings. A heavy crop in a dry year may cause the soil to be dry enough to prevent some wild oat seeds from germinating.

At first the young *Avena fatua* L. is relatively weak because of limited size and number of seminal roots. At this stage, it can be successfully suppressed by vigorous cereal crops with more extensive seminal root systems. Barley is especially effective in this respect (25). If the wild oat survives this period and is allowed to develop its extensive crown roots, a cultivated cereal crop will not effectively smother it. Once established, *A. fatua* is capable of absorbing up to three times as much water as the cultivated oat and twice the quantity of nitrogen and phosphorus from the soil (25).

Bowden and Friesen (11) found that 10 to 40 wild oat plants per square yard caused a significant yield reduction of wheat grown on summer fallow land and stubble with added phosphorus fertilizer. As much as 70 to 100 wild oats per square yard were needed to significantly depress the yield of wheat grown on stubble land without additional fertilizer.

Nalewaja (39) agrees that actual crop yield loss in a given field will depend upon growing conditions. In fields of high soil fertility, yield losses from wild oats in wheat are greater than under low fertility. However, when barley is fertilized, competition from wild oats and the percent yield reductions are decreased. He concludes than an effective wild oat control program is essential when fertilizer is used to maximize crop yields, especially for wheat.

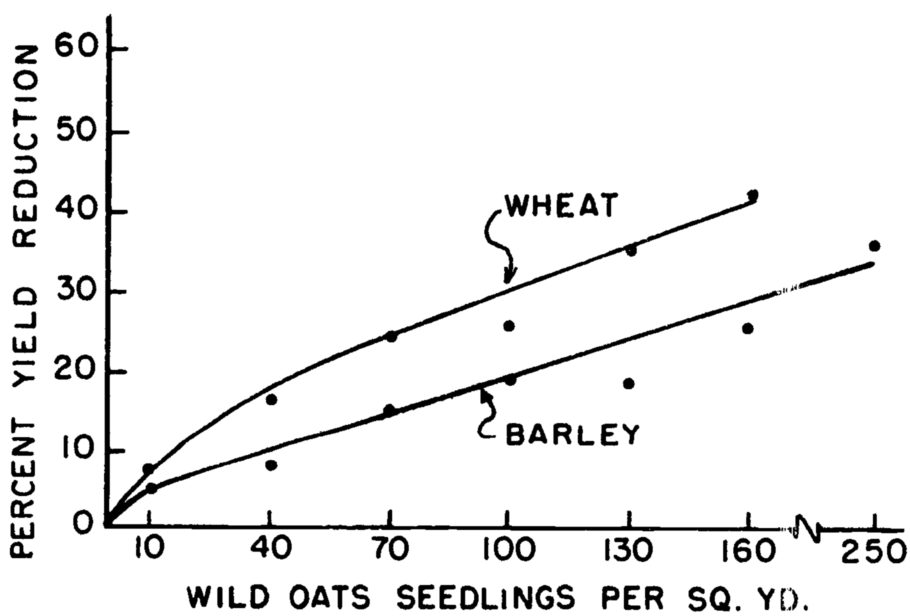

Figure 2. Percent yield reduction caused by various wild oat densities in wheat and barley. (Taken from Nalewaja (39).)

In studies by Dew (17), significant losses in yield were obtained by a certain number of wild oat plants per unit area. This number was called the "critical density", but did not quantify the crop loss associated with the varying weed populations in different crops. Dew introduced the "competitive index" for estimating crop loss due to weeds using regression methods of analyses. He analysed the results of Bell and Nalewaja (8) from 1968, and Bowden and Friesen from 1967 (11) and found that the crop loss due to wild oats was proportional to the weed-free yield. In other words, the wild oats and crop compete equally for moisture, nutrients, and light, and when potential weed-free yield is high, so is the loss due to a given number of wild oats. These tests also show the relative competitive ability of the various crops, and they agree that barley is a more competitive crop than wheat.

Abu-Irmaileh (1) studied elements of the competitive effects of wild oats on winter wheat in the Willamette Valley of Oregon. Grain yield was reduced 32% and number of wheat tillers was reduced 36% when high densities of wild oats were present (175-198 weeds per square yard).

He also found that only continuous weeding of wild oats resulted in a significant increase in yield. One wild oat weeding was not enough to give a significant yield increase, but it was better when done in the early spring. This was explained by the author's statement that wild oats were germinating continuously during the growing season.

The wild oat plants which germinated just prior to or at the time of crop emergence in the winter resulted in a more severe problem than spring-germinated plants. Wild oat control treatments, Abu-Irmaileh concluded, should be timed to those plants which germinate with the crop.

Wild Oat Control

Both cultural and chemical methods are presently used to control wild oats. In the past, much work has been done, but research efforts to date have not provided control measures to eradicate this weed. More scientific investments must be dedicated to the development of new herbicides which will give improved results.

Cultural Methods

Authors from different states with different soils, climatic conditions, and different cropping systems have proposed diverse ways for controlling wild oats using cultural practices. All agree, however, that whichever method is used it must be carried on for several years before satisfactory control of wild oats is obtained, but complete eradication will almost never be achieved. Almost all cultural practices are based on dormancy characteristics of wild oats by promoting germination in a false seedbed and then subsequent destruction of seedlings.

Nalewaja (39) reports from North Dakota that cultural control includes sowing of clean crop seed and delayed crop seeding.

Delayed seeding takes advantage of secondary dormancy and permits several cultivations prior to crop seeding. However, it was reported by several workers that delayed seeding is not consistent with maximum crop yields (12, 33, 39).

Brown (12) from Manitoba, lists several possible methods for cultural control of wild oats in a continuous grain system of farming. He suggests that the most efficient methods include delayed seeding of an early maturing crop such as barley, post-seeding cultivation, careful management of summer fallow, and inclusion of winter rye in the rotation as a very competitive crop.

Methods such as fall tillage, pre-seeding tillage, and summer fallow modified according to local conditions and crop management systems can also be successfully utilized. Post-seeding cultivation with rod weeders can be used but the crop should be seeded deeper (12).

According to Willard, wild oats are not a weed problem in Ohio because regular rotations include corn and forage crops. In Iowa, Sylwester states that after small grains, corn, and soybeans are returned to clover and alfalfa, wild oats are controlled by repeated mowing (cited by Wood (54)).

Chemical Control

In small grains, present usage of chemicals for wild oat control is restricted in choice and inconsistent in effect. Only three chemicals are registered and commercially used. Triallate and diallate are used preemergence incorporated and barban is applied postemergence (39).

Triallate and Diallate

Research indicates that the key to success of triallate and diallate is proper timing and incorporation after broadcast application of these highly volatile herbicides (39).

At .75 lb/A, triallate gave significantly better wild oat control with a 3-inch incorporation than with .75-inch incorporation. The common lack of moisture in the top inch of soil in the field may explain less weed control from shallow incorporation (18).

In some seasons and on certain soil types, the rapid, uniform and thorough incorporation is difficult to achieve and may also give an unsatisfactory seedbed. Crop injury can occur if the chemical gets into the crop seed zone. These disadvantages are avoided by the more recently introduced granular formulation of triallate which does not require soil incorporation and which also can be applied postemergence. However, very accurate application of granules requires specialized equipment which limits their use (25). A distinct advantage of the granular formulation over liquid is that the former can be applied in the fall stubble land carrying a moderate to heavy cover of straw (23).

Miller and Nalewaja (37) found that the stage of growth of wild oats in spring wheat did not influence its control with a postemergence treatment of triallate. The granular formulation was more effective than the emulsifiable concentrate (E.C.) and season-long wild oat control was obtained with a rate of 2.24 kg/ha. Some wheat injury was observed with higher rates of granular triallate (2.8 and 3.36 kg/ha). Moisture was the main factor influencing its efficiency and it was noticed that under dry conditions control was poor because the herbicide remained bound to the carrier. The liquid formulation was less effective under moist soil conditions because the herbicide was volatilized rapidly.

Diallate and triallate are used in the same manner; however, the former is registered only in barley and the latter has a greater margin of crop safety to wheat and barley.

Barban

Proper timing is imperative for effective wild oat control with barban. It must be applied when wild oats are in the 1 1/2 to 2 leaf stage of growth. Barban is used for control of *Avena fatua* L. in wheat, barley, and other crops.

Placement of the barban droplet upon a specific area of the wild oat plant is directly related to the degree of control obtained. A droplet applied at the base of the first leaf is 40 times more effective than a droplet placed at the tip of the first leaf. An increase of spraying pressure decreases the size and increases the number of droplets per area, which is essential in reaching the susceptible base of the first leaf (39).

Timing is also important in acheiving crop selectivity when barban is used for control of A. fatua L. in wheat. The greatest selectivity occurs between 9 and 14 days after the wheat has emerged. After that period, selectivity decreased to the point that it is completely lost in some instances (20, 39). Barban selectivity for wild oats in wheat was greater at 27^{o} and 21^{o} C than at 16^{o} and 10^{o} C (41).

Barban effectiveness was enhanced under good soil fertility conditions as well as by vigorous crop competition (1).

Other Herbicides

Intensive research efforts are currently in progress with several herbicides for wild oat control in small grains.

Difenzoquat (Avenge) has received a temporary use permit for postemergence application in wheat and barley.

Colbert, et al. (15) reported data from several trials in the Pacific Northwest states, Utah, California, and Arizona from 1972-74. They found that in commonly grown varieties of wheat and barley, difenzoquat at 0.62 to 1.0 lb a.i./A was effective in controlling wild oats. Some slight injury was reported but it was not accompanied by yield reduction.

Miller and Nalewaja (34) found that satisfactory wild oat control was obtained in spring wheat and barley with difenzoquat. However, in some locations in North Dakota, rates necessary for good wild oat control resulted in wheat injury. No injury was observed in barley.

Suffix (SD 30053) and its analog SD 29761 were very promising for postemergence wild oat control but future development of these herbicides in the United States is questionable (2, 16).

When applied postemergence, Nitrofen (Tok) gave wild oat control in winter wheat in Western Oregon which was comparable to the commercially used herbicides. It also controlled Italian ryegrass (*Lolium multiflorum* Lam.) (42). This herbicide often has performed fair to excellent in winter wheat but timing of the application is still under investigation because some crop injury was evident and wild oat control has been inconsistent (2).

All of these herbicides often give excellent wild oat control. However, each of them have some disadvantages when used for wild oat control in small grains.

Difenzoquat often has a narrow margin of safety in wheat. Timing and crop variety tolerance studies need to be conducted prior to widespread use of difenzoquat. Also neither difenzoquat nor SD 29761 control other grasses. Because of its low solubility, the activity of nitrofen is obtained only if the top layer of soil is sufficiently moist to allow emerging shoot tissue of the weed seedling to absorb it (10).

Experimental Herbicide HOE 23408

American Hoechst Corporation is developing HOE 23408 as a selective herbicide for control of many weedy annual grass species. It is active when applied preplant incorporated, preemergence, and postemergence.

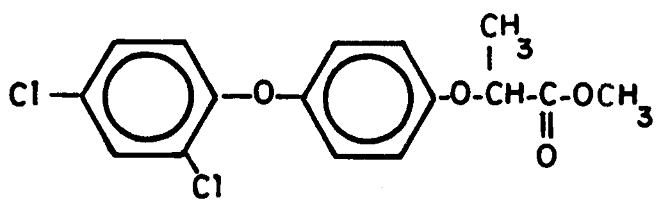

Figure 3. HOE 23408
4-(2', 4'-dichlorophenoxy)-phenoxy-
d-propionic methylester

Acute oral LD 50 has been found to be 580 mg/kg of body weight for male rats.

HOE 23408 is formulated as a 3.0 lb/gal a.i. emulsifiable liquid.

The mode of action of HOE 23408 is not yet completely understood. The growth of susceptible plants is arrested after a lag phase of 4 to 7 days after treatment. A drastic reduction in CO_2 consumption can be measured. Plant symptoms differ from species to species.

Wild oat shows scattered chlorotic blotches which coalesce with time. Root development is strongly suppressed and plants can be easily pulled from the soil. Ryegrass develops a rusty color prior to its death. Corn shows little color change but stem weakening at ground level causes the plant to fall over and die. Green foxtail is also controlled.

Many agronomic and vegetable crops have shown a wide margin of safety to HOE 23408. Its potential agronomic use is in wheat, barley, sugar beets, soybeans, cotton, alfalfa, sunflower, etc. (4).

Compatibility With Broadleaf Herbicides

Effectiveness of some herbicides for control of grass weeds in small grains is sometimes reduced by combination treatments with broadleaf herbicides.

Colbert, etal. (15) reported no antagonism from tank-mix combinations of difenzoquat (Avenge) with either 2,4-D, MCPA, or bromoxynil in wheat and barley.

Amen (3) found that addition of 2,4-D amine and MCPA to difenzoquat reduced wild oat control, but only 2,4-D gave lower yields while MCPA out yielded the untreated checks of wheat and barley.

Zimdahl and Foster (55) had no yield reduction but significantly lower wild oat control resulted when difenzoquat or SD 29761 was combined with 2,4-D or MCPA amine in barley.

Arnold and O'Neal (5) found only amine formulations of 2,4-D and MCPA decreased wild oat control while ester formulations had no influence when combined with difenzoquat and applied to wheat.

Contrary to these results, Miller and Nalewaja (34) found that the addition of dimethylamine salt of 2,4-D appeared to increase wild oat control with difenzoquat while the same formulation of MCPA did not reduce it.

Behrens, et al. (7) reported that combinations of difenzoquat + MCPA, SD 29761 + bromoxynil, and HOE 23408 + MCPA gave reduced wild oat control in wheat and barley compared to the wild oat herbicides alone. The addition of bromoxynil did not reduce wild oat control with difenzoquat nor did the addition of barban increase wild oat control.

Colbert (16) found that 2,4-D amine nullified the effect of SD 30053, an analog of SD 29761, as a wild oat killer. Significant reduction was observed even when 2,4-D amine was applied 1 and 2 weeks prior to SD 30053. He reported further that Nalewaja found similar results with dicamba, bromoxynil, and picloram.

At several locations in North Dakota in 1974, Miller and Nalewaja (36) conducted experiments with spring wheat to evaluate weed control and crop response from HOE 23408 in combination with several broadleaf herbicides. The addition of MCPA, 2,4-D, or bromoxynil + MCPA reduced wild oat control 20-50% when applied as a tank-mixture.

Chow (14) reported that only bromoxynil and bentazon could be mixed with HOE 23408 without greatly affecting its wild oat herbicidal properties or causing barley injury.

HOE 23408 SOIL PERSISTENCE EXPERIMENTS

Fall and Winter Treatments — Greenhouse Bioassay

No present herbicides are completely effective for the control of wild oats in winter wheat because of the failure of wild oat seeds to germinate uniformly and the short persistence of chemicals used.

Germination occurs in two major waves, winter and spring. Between these major waves, germination can also occur if weather conditions are favorable.

Knowledge of the relative soil persistence of HOE 23408 is very important. It will give us the length of time for effective wild oat control and will also indicate which application timing may be most effective. The objective of the greenhouse bioassay was to determine the relative persistence of HOE 23408 in four western Oregon soils following application in the fall and winter.

Materials and Methods

Soil samples were taken from four locations in the Willamette Valley where HOE 23408 had been applied to winter wheat (Appendix Table 1). At each location, samples were taken from plots treated at two rates at three timings, preemergence (PRE), early postemergence (EPE), and late postemergence (LPE). The two rates of HOE 23408 were 1 lb/A and 2 lb/A. Samples were taken from a depth of 6 inches using a manual probe. A uniform amount was taken from each of four replications and then bulked. Characteristics of soils sampled are given in Table 1.

Table 1. Analysis of pH and organic matter content sampled for greenhouse bioassay.

Location	pH	O. M. %	Soil Type
1. Monmouth	5.2	4.7	Carlton silty clay loam (light phase)
2. Carlton	4.8	4.5	Carlton silty clay loam
3. Woodburn	4.6	4.8	Woodburn silt loam
4. Hyslop	5.3	3.5	Woodburn silt loam

Daily rainfall and soil and air temperatures are presented in Appendix Tables 13 and 14.

After sampling, the soil was dried, screened, and placed in 2 by 2 inch plastic pots in the greenhouse on February 27, 1975. Twelve wild oat seeds were planted 1/4 inch deep in each pot and subirrigated.

Pots were arranged in a randomized complete block design with four replications. There were four pots per treatment, one from each location, within each block.

Each pot was fertilized with 12-6-6 liquid fertilizer (Ortho-Grow) which was applied to the soil at intervals to maintain good

Table 2. Symptom code for the effect of HOE 23408 on wild oats.

Numerical grade	Description of plants
0 - - - - - - - - - - - - - - -	No symptoms of injury. Plants vigorous and tall with fully developed tillers.
1 - - - - - - - - - - - - - - -	
2	
3	
4	Intermediate stages of increasing injury*
5	
6	
7	
8	
9 - - - - - - - - - - - - - - -	Plants dead

*Injury is defined as:

a. decrease in height and vigor of plants as well as in number of tillers

b. foliar desiccation and necrosis. Leaves are rolled and desiccated with reddish-brown color, initially with tip burn.

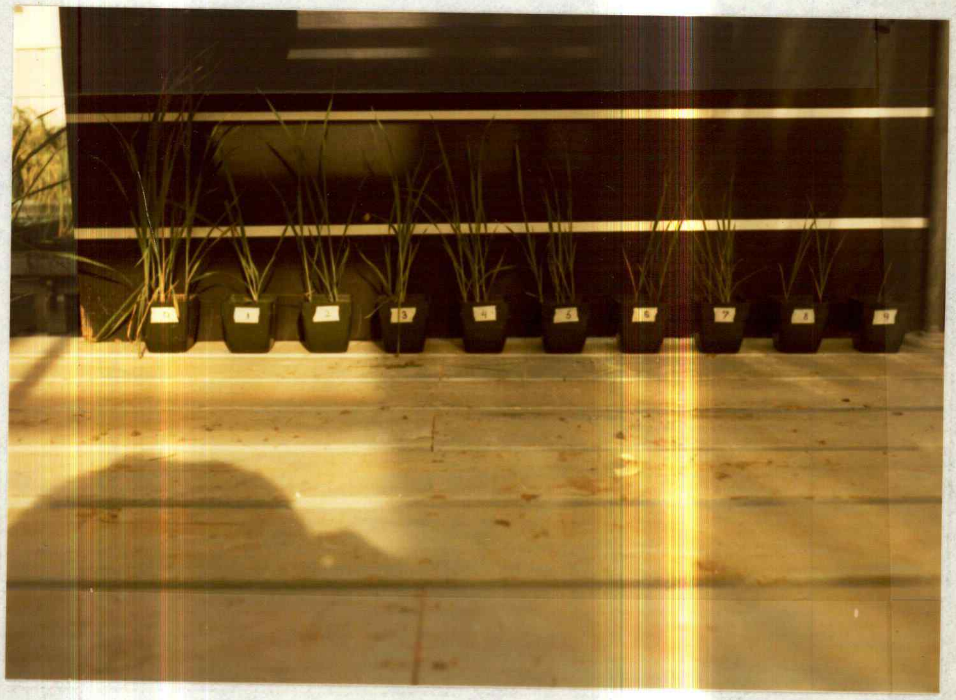

Figure 4.

plant growth.

Wild oats were visually evaluated for formative effect and harvested for fresh shoot weights when 24 days old, on April 12, 1975. The symptom code for the visual evaluations is presented in Table 2 and Figure 4.

In order to determine a wild oat response for a known amount of chemical and to correlate these responses with the bioassay responses, soil was collected from untreated areas in the fields listed in Table 1.

After drying and screening, the soil was placed in 6-inch tall cans, sprayed with a track-mounted greenhouse sprayer at rates ranging from 0.05 to 0.8 lb/A (Table 4), and then thoroughly mixed in a soil blender. Four 2 by 2 inch pots were filled with soil from each treatment from each location and arranged in a randomized complete block design with two replications. Twelve wild oat seeds were planted per pot and plants were kept at the same irrigation, fertilizer, and greenhouse conditions as indicated above. They were also evaluated and harvested at the same date.

Results and Discussion

Results from the greenhouse experiments are presented in Tables 3 and 4, and Appendix Tables 1, 2, 3, and 4.

Soils collected from all four locations contained measurable amounts of herbicide, even 4 months after treatment. Wild oat injury was apparent from visual evaluations and fresh weight reduction at both rates and at all timings (Table 3).

In general, residues from all treatment dates were less than 50% of the amount applied. However, correlations between field-treated and greenhouse-treated soils were difficult because of poor germination of wild oats and inconsistencies in the results.

At most locations, residue levels did not differ much from the same herbicide rate applied at approximately 1, 2, and 4 months prior to sampling. Possibly, the lack of expected differences could be due to a canopy effect of emerged plants and root uptake by heavy weed populations. At the first application date (PRE), HOE 23408 was applied to bare soil so all applied chemical became soil active. At EPE, part of the HOE 23408 applied was retained on above-ground portions of weed and wheat plants so only part of it reached the soil. At LPE application, even more chemical was retained on the leaves and stems of plants because of more advanced stage of growth. This could result in a decreased amount of HOE 23408 that actually reached the soil.

Apparent residues of HOE 23408 were differentamong locations. Soil collected from Hyslop treated at 1 lb/A caused appreciably more injury than soil from the other three locations treated at the same

Table 3. Response of wild oats grown in the greenhouse in soil from four locations treated at three timings.

Treatment	Rate lb/A	Timing[b]	Monmouth Fr. wt. %reduc.	Monmouth Injury ratings[a]	Carlton Fr. wt. %reduc.	Carlton Injury ratings[a]	Woodburn Fr. wt. %reduc.	Woodburn Injury ratings[a]	Hyslop Fr. wt. %reduc.	Hyslop Injury ratings[a]
HOE 23408	1	PRE	26	3.12	30	2.25	24	3.37	62	4.50
HOE 23408	1	EPE	30	3.33	42	2.83	17	3.33	55	3.87
HOE 23408	1	LPE	38	4.12	31	3.37	32	3.17	56	4.12
HOE 23408	2	PRE	50	4.87	37	3.50	59	6.00	61	4.75
HOE 23408	2	EPE	49	5.37	38	4.12	61	5.37	74	6.00
HOE 23408	2	LPE	53	5.75	27	3.67	68	7.00	67	5.50
Check	0		0	1.50	0	2.25	0	1.50	0	0.37

[a] Ratings average of two independent evaluators. Based on 0-9 scale where 0 = no injury and 9 = plants dead.

[b] PRE = preemergence, EPE = early postemergence, and LPE = late postemergence.

Table 4. Response of wild oats grown in soil collected from four locations and treated in the greenhouse prior to planting.

Treatment	Rate lb/A	Monmouth		Carlton		Woodburn		Hyslop	
		Fr. wt. % reduc.	Injury ratings[a/]	Fr. wt. % reduc.	Injury ratings[a/]	Fr. wt. % reduc.	Injury ratings[a/]	Fr. wt. % reduc.	Injury ratings[a/]
HOE 23408	.05	56	2.50	- 9	.50	-10	2.00	33	3.25
HOE 23408	.10	55	4.00	26	3.00	-19	3.00	51	4.25
HOE 23408	.15	50	4.00	16	2.50	-15	.50	54	2.50
HOE 23408	.20	55	3.00	48	2.20	30	2.25	57	4.75
HOE 23408	.40	69	5.50	64	4.00	66	5.50	71	5.00
HOE 23408	.80	73	6.50	84	6.75	88	8.25	83	7.00
Check	0	0	0.50	0	1.50	0	1.25	0	.75

[a/] Ratings average of two independent evaluators. Based on 0-9 scale where 0 = no injury and 9 = plants dead.

rate. At 2 lb/A, soil from Carlton contained much less residue than from the other three locations. Residues at Monmouth were intermediate and were highest at Woodburn and Hyslop.

A possible reason for the generally increased activity found at Hyslop might be seedbed preparation. The seedbed was the best of all four locations, with no stubble left on the surface. Stubble is often a strong adsorbent which ties up the chemical and decreases its availability and activity in the soil. This is supported by the fact that the soil collected from the treated plots at Carlton had the lowest injury ratings and less growth reductions than the other soils. The seedbed at Carlton was the poorest with much stubble left on the surface of the soil.

Differences between locations, besides quality of seedbed and amount of stubble left, could occur because of different weed populations present in the field. The highest population was at Carlton and this correlates with the lowest HOE 23408 activity.

We can conclude that during the winter in the Willamette Valley, HOE 23408 persisted for several months. Late applications of HOE 23408 did not increase the length of time that weeds could be controlled. The later applications have lower soil activity than expected, possibly because of the canopy effect and root uptake of larger weeds and crop plants.

Spring Treatment - Field Bioassay

Materials and Methods

In the spring of 1975, a field trial was established to study soil persistence of HOE 23408 applied at the approximate time proposed for HOE 23408 applications in spring wheat.

Bioassay plants selected to monitor the soil persistence of HOE 23408 were wild oats (*Avena fatua* L.) and corn (*Zea mays* L.), both rated as moderately sensitive (4).

The experiment was established at the Schmidt Research Farm near Corvallis, Oregon, on April 29. The soil type was a Woodburn silt loam with a pH of 5.4 and 3% organic matter content. The experimental design was a split block with four replications. Figure 5 shows the plot plan for this experiment.

The treatments applied were:

Treatment	Rate
1. HOE 23408	1.0 lb/A proposed use rate
2. HOE 23408	2.0 lb/A two times proposed use rate
3. HOE 23408	4.0 lb/A four times proposed use rate
4. Check	No chemical

All treatments were applied to the soil surface with a bicycle-wheel plot sprayer using 8002 nozzles at 28 lb/square inch pressure. The spray volume was 25 gallons of water per acre. The 1974 formulation of HOE 23408 was used.

Test plants were seeded at five timings:

1. Zero timing (test plants seeded immediately after herbicide application).
2. 1 week after herbicide application.
3. 2 weeks after herbicide application.
4. 4 weeks after herbicide application.
5. 9 weeks after herbicide application.

At each planting date, a strip through each plot was broadcast seeded to wild oats and then rototilled. An adjacent strip was rototilled and planted to Jubilee sweet corn.

Good soil moisture was maintained by sprinkler irrigation and 50 lb/A of nitrogen was applied to maintain good plant growth.

Visual evaluations of reduction in plant growth were made prior to harvesting. A scale of 0 to 100% was used to estimate test plant injury. A zero rating indicated no visible difference from the check. A rating of 100% represented complete plant elimination.

Test plants from each timing were harvested when 62 days old. The harvested area was 1 square yard. Plant counts were taken for both test species. Fresh weights of shoots of wild oats were determined. Corn plants were dug and removed intact. Roots were removed and washed. Fresh weights were taken separately for roots and shoots.

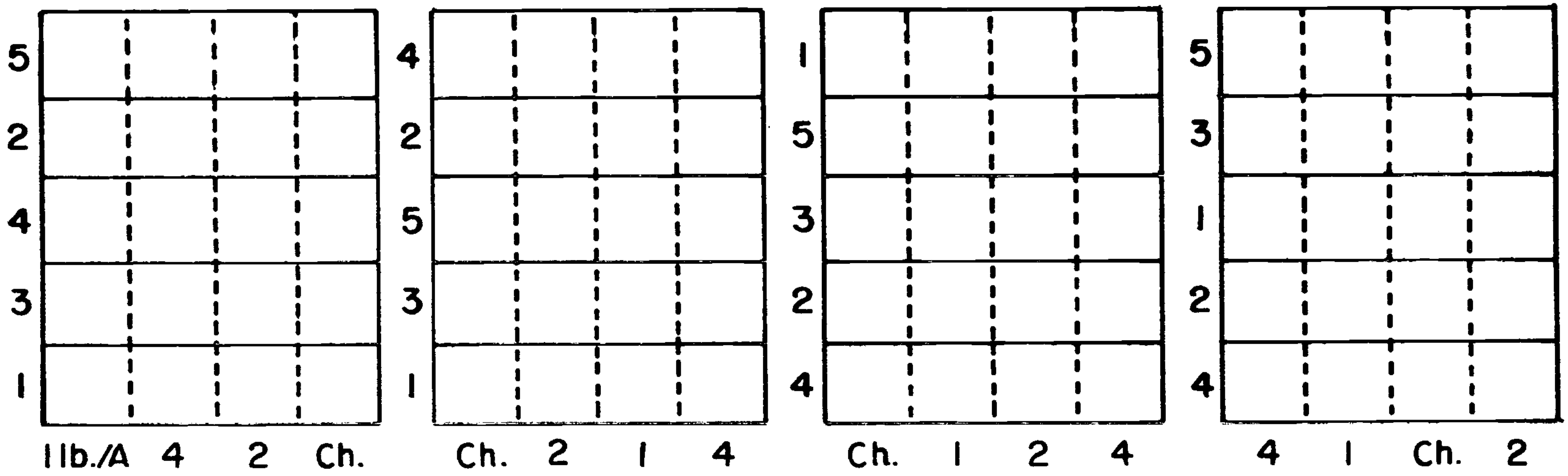

Figure 5. Plot diagram for field bioassay trial at Schmidt Farm.

All weight data were converted to a percentage of the check and subjected to analysis of variance. Plant count data (x) were transformed by the formula $\sqrt{x + 1}$ to stabilize variance and then converted to a percentage of the check and subjected to analysis of variance.

Results and Discussion

The results of this experiment are recorded in Tables 5, 6, and 7, Figure 6, and Appendix Tables 5 - 12.

Application of HOE 23408 at zero timing resulted in almost completely lethal response for both test species for each herbicide rate examined. All rates were significantly different from the check and at 1 lb/A there was a 90% reduction in both plant counts and weights of wild oats and corn.

When seeded 1 week after HOE 23408 application, both test species gave similar responses as at zero timing. At both timings there were no significant differences observed between rates except when compared with the check.

Evaluation of plants seeded 2 weeks after application indicated that residues from 1 lb/A of HOE 23408 were decreasing; however, injury did occur. Ratings of corn and wild oats showed 25% and 57% growth reduction, respectively. At 2 lb/A, growth reduction was 42% and 82%, respectively. At 1 lb/A, weights of both test species were reduced about 50% when compared to the respective checks. The number of wild oat plants was reduced 49% and of corn plants 23%. Significant differences existed between 1 and 2 lb/A of HOE 23408 in all categories of data except for the number of corn plants. There were no significant differences between the 2 and 4 lb/A rates at this planting date. Especially the higher rate gave almost complete plant elimination of both species.

The fourth timing gave results that are difficult to explain. The test plants were growing less vigorously than at the third timing and the stand was thinner. Weight data show similar results for both species. A possible reason was that plants seeded 4 weeks after HOE 23408 application were in competition with mayweed (Anthemis cotula L.) which grew very rapidly at the seeding stage of the test species.

In plots planted 9 weeks after herbicide application, no significant differences existed between the check and 1 lb/A HOE 23408 rate, indicating that no residual activity can be expected which would harm a fall-seeded crop when HOE 23408 is applied up to 1 lb/A in spring wheat. The higher rates still significantly differed from the check and the 1 lb/A of HOE 23408 treatment. The 2 lb/A treatment was rated at 27% reduction when compared to the check in both test species. Weight data and plant counts showed similar results. The highest rate was still very active, reducing wild oat and corn growth by 55% and 50%, respectively. Weight data and plant counts showed similar or greater reductions. Significant differences between 1, 2, and 4 lb/A existed in all categories of data for the fifth timing.

It would be difficult to predict a soil half-life from the data in this experiment. The inconsistencies between data from the third and fourth planting dates make accurate interpretation impossible. This study does show that 1.0 lb/A of HOE 23408 had diminished after 9 weeks to almost non-toxic levels. In contrast, the greenhouse bio-assay studies showed a rather slow disappearance after approximately the same time interval when the herbicide was applied in the fall.

Additional studies are needed to more completely understand the persistence of HOE 23408. Studies should be conducted to determine the routes of HOE 23408 disappearance from the soils, including importance of rainfall, microorganisms, soil temperatures, soil type, and other environmental factors.

Table 5. Ratings of injury of corn and wild oats in HOE 23408 spring persistence trial at the Schmidt Farm.[a]

Treatment	Rate lb/A	Rating Date	Ratings Corn	Ratings Wild Oats
HOE 23408	1	June 30	91	95
HOE 23408	2		96	99
HOE 23408	4		99	100
Check	0		0	0
HOE 23408	1	July 8	97	94
HOE 23408	2		96	94
HOE 23408	4		99	99
Check	0		0	0
HOE 23408	1	July 15	25	57
HOE 23408	2		42	82
HOE 23408	4		74	98
Check	0		0	0
HOE 23408	1	July 31	42	60
HOE 23408	2		67	80
HOE 23408	4		86	93
Check	0		0	0
HOE 23408	1	August 30	5	4
HOE 23408	2		27	27
HOE 23408	4		50	55
Check	0		0	0

[a] Ratings based on 0-100 percent scale where 0 = no injury and 100 = plants dead.

Table 6. Response of wild oat plants in HOE 23408 spring persistence trial at the Schmidt Farm.

Treatment	Rate lb/A	Harvest Date	Shoot Weight (% reduc.)	Number plants (% reduc.)
HOE 23408	1	June 30	90.9	89
HOE 23408	2		98.8	98
HOE 23408	4		99.6	99
Check	0		0	0
HOE 23408	1	July 8	88.8	86
HOE 23408	2		96.8	94
HOE 23408	4		97.5	98
Check	0		0	0
HOE 23408	1	July 15	53.0	49
HOE 23408	2		83.6	86
HOE 23408	4		93.9	96
Check	0		0	0
HOE 23408	1	July 31	66.9	64
HOE 23408	2		76.1	85
HOE 23408	4		92.1	87
Check	0		0	0
HOE 23408	1	August 30	-0.2	3
HOE 23408	2		25.3	30
HOE 23408	4		62.4	64
Check	0		0	0

[a] L. S. D (.05) = 16.80% for comparison between rates across timings for shoot weights

L. S. D. (.05) = 15.75% for comparison between rates within timings for shoot weights

[b] L. S. D. (.05) = 10.88% for comparison between rates across timings for number of plants

L. S. D. (.05) = 12.67% for comparison between rates with timings for number of plants

[a] Based on pooling error b and c in Appendix Table 11

[b] Based on pooling error b and c in Appendix Table 12

Table 7. Response of corn plants in HOE 23408 at spring persistence trial at the Schmidt Farm.

Treatment	Rate lb/A	Harvest Date	Root Wt. (% reduc.)	Shoot Wt. (% reduc.)	No. Plants (% reduc.)
HOE 23408	1	June 30	90.2	92.5	64
HOE 23408	2		97.9	97.7	88
HOE 23408	4		99.8	99.6	96
Check	0		0	0	0
HOE 23408	1	July 8	92.1	94.8	74
HOE 23408	2		94.1	93.4	83
HOE 23408	4		99.8	98.9	96
Check	0		0	0	0
HOE 23408	1	July 15	55.2	46.1	23
HOE 23408	2		72.6	63.2	32
HOE 23408	4		93.0	81.3	68
Check	0		0	0	0
HOE 23408	1	July 31	52.5	66.5	18
HOE 23408	2		79.2	80.3	44
HOE 23408	4		95.2	93.0	80
Check	0		0	0	0
HOE 23408	1	August 30	6.7	0.4	8
HOE 23408	2		30.8	36.2	25
HOE 23408	4		56.6	70.5	61
Check	0		0	0	0

[a] L.S.D. (.05) = 14.91% for a comparison between rates across timings for root weights

L.S.D. (.05) = 14.76% for a comparison between rates within timings for root weights

[b] L.S.D. (.05) = 15.24% for comparison between rates across timings for shoot weights

L.S.D. (.05) = 15.85% for comparison between rates within timings for shoot weights

[c] L.S.D. (.05) = 17.24% for comparison between rates across timings for number of plants

L.S.D. (.05) = 17.25% for comparison between rates within timings for number of plants

[a] Based on pooling error b and c in Appendix Table 7

[b] Based on pooling error b and c in Appendix Table 8

[c] Based on pooling error b and c in Appendix Table 9

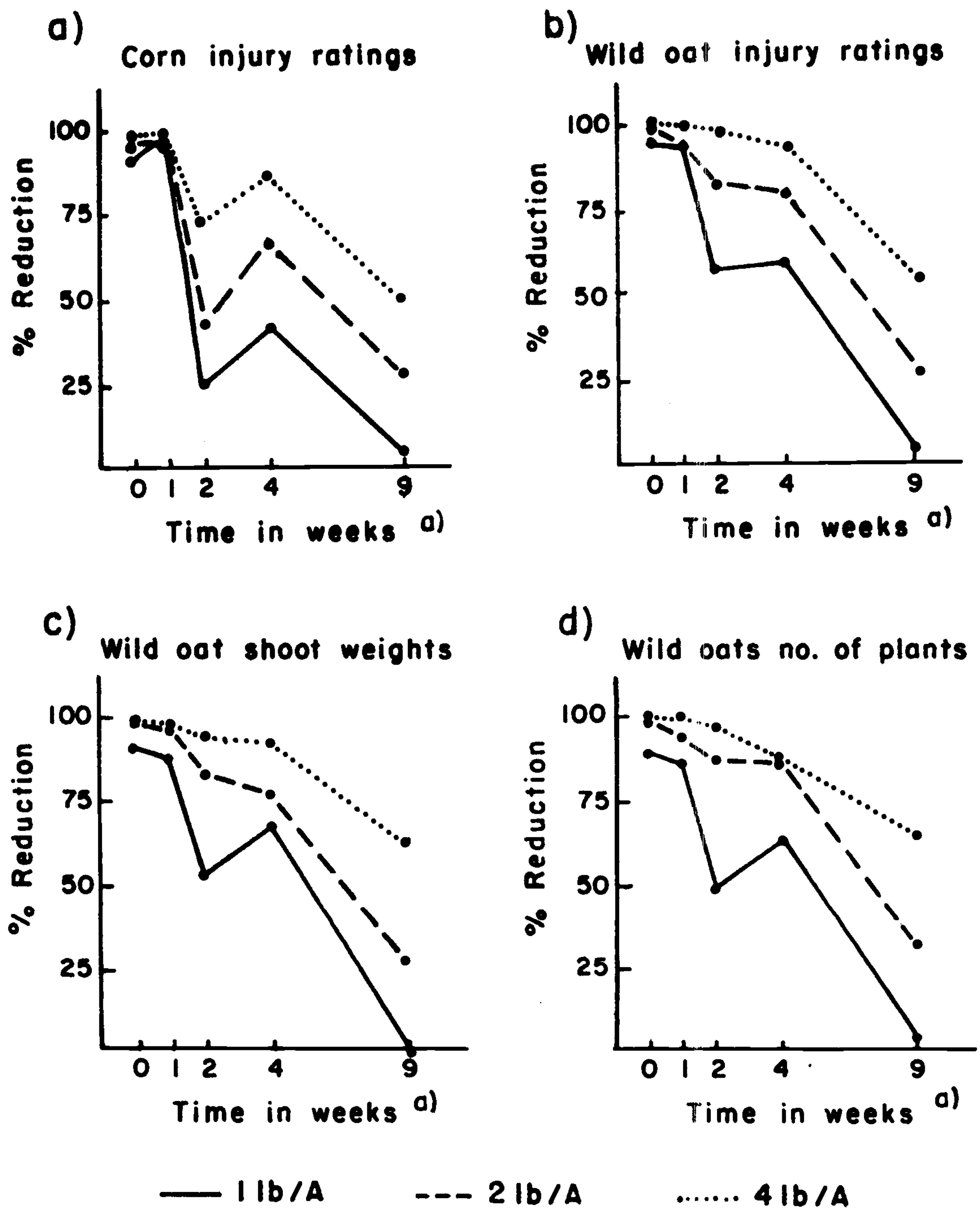

Figure 6. Response of wild oats and corn in HOE 23408 field bioassay at Schmidt Farm.

[a]Weeks from herbicide application to seeding test species.

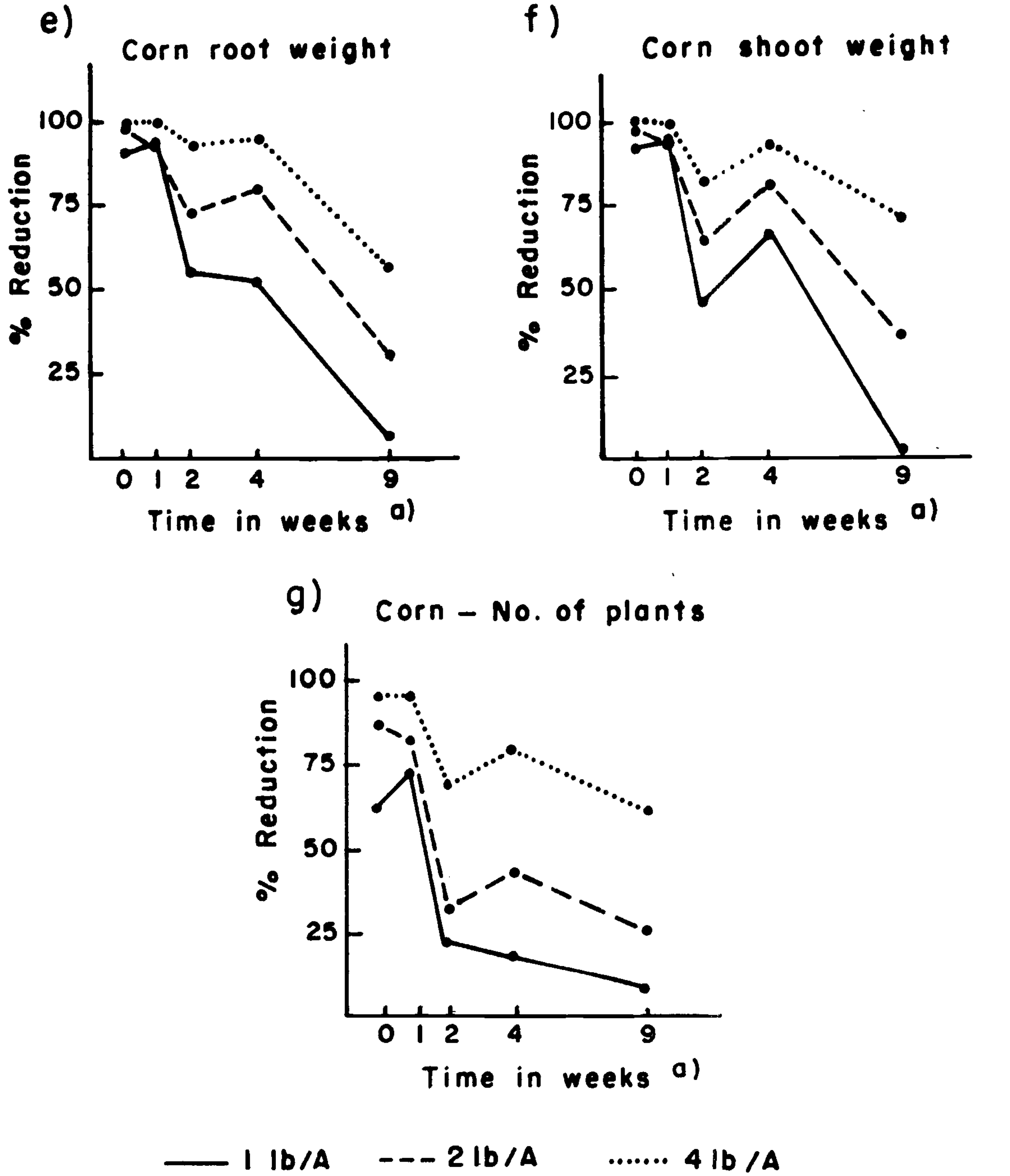

Figure 6. Response of wild oats and corn in HOE 23408 field bioassay at Schmidt Farm.

[a]Weeks from herbicide application to seeding test species.

HOE 23408 BROADLEAF HERBICIDE COMBINATION STUDY IN SPRING WHEAT

HOE 23408 has shown promise as a herbicide for grass weed control in wheat but it does not control most broadleaf weeds. Several workers have shown evidence that some commonly used broadleaf herbicides reduce the effectiveness of HOE 23408 for the control of certain grass species in wheat when applied as a tank-mixture. However, not all broadleaf herbicides have been studied and there is no information concerning possible split and delayed applications. The following experiment was established to study some of those questions.

Materials and Methods

A field experiment was established at the Schmidt Research Farm near Corvallis, Oregon, on June 1, 1975. The objective of the trial was to evaluate the effect of HOE 23408 alone and in combination with four commercially used broadleaf herbicides for control of wild oats (*Avena fatua* L.) and barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.).

The soil was a Woodburn silt loam with a pH of 5.4 and 3.0% organic matter content. Fielder cultivar of spring wheat was sown on April 22 at the rate of 90 lb/A. The experimental design was a randomized complete block with four replications. Wild oat and barnyardgrass were seeded separately in strips across the back one-third of the plots. The front was seeded to wheat. Plot size was 40 by 10 ft.

Herbicide treatments were applied on June 1, 1975, with a bicycle-wheel plot sprayer using water as the carrier. At the time of application, the wheat was in the 3 1/2 to 4 1/2 leaf stage on the main shoot. Wild oats were in the 3 1/2 to 5 leaf stage on the main shoot, and 75% of the barnyardgrass had 2 to 3 tillers. After the treatments were applied, the plot area was seeded to wheat and hand weeded.

Application of 2,4-D low volatile ester in treatments 9, 10, and 11 was delayed 1, 3, and 7 days respectively (Table 8). Application data are given in Appendix Table 16.

Visual evaluations, by two independent evaluators, of wild oat and barnyardgrass control were made on July 10. A scale of 0 to 100% was used to estimate weed control, where 0 indicated no visible effect on density and growth of plants, and 100% represented complete kill of treated plants.

Wheat was harvested on September 9 with a small plot combine with a 4.8 ft header. The harvested grain samples were cleaned and yield data were subjected to analysis of variance.

Results and Discussion

Results are summarized in Table 8. Complete data are given in Appendix Tables 15, 16, and 17.

Wild Oat Control. Postemergence treatments of HOE 23408 were much more effective for wild oat control when applied alone than when applied in tank-mixtures with 2,4-D low volatile ester, MCPA low volatile ester, or dicamba amine. Tank-mixtures of 1 or 2 lb/A of HOE 23408 with these broadleaf herbicides caused large reductions in the effectiveness of HOE 23408 against wild oats.

Delaying the treatments of 2,4-D low volatile ester resulted in less antagonism of the herbicidal properties of HOE 23408 on wild oats. A 1-day delay was not long enough to completely eliminate antagonsim, but 3 or 7 days gave results similar to treatments of HOE 23408 applied alone. It appears from the data obtained, that the closer the applications of 2,4-D low volatile ester to HOE 23408 applications, the less effective HOE 23408 will be in controlling wild oats.

Bromoxynil showed no antagonistic effect when applied in a tank-mixture with HOE 23408. In fact, when compared with the treatment of 1 lb/A of HOE 23408 alone (42.5% control), a treatment of 1 lb/A of HOE 23408 plus 0.50 lb/A bromoxynil gave 63.1% control.

Table 8. Wild oat and barnyardgrass control and yield response to HOE 23408 alone and in combination with four broadleaf herbicides.

Treatment	Rate lb/A	% Wild Oat Control	% Barnyardgrass Control	Yield Bu/A
HOE 23408	1	42.5	54.4	29.4
HOE 23408	2	75	89.7	30.6
2,4-D LV ester	.75	4.4	6.2	26.4
MCPA LV ester	.75	7.5	18.7	28.1
dicamba amine	.25	1.2	2.5	28.7
bromoxynil ester	.50	3.1	2.5	28.8
HOE 23408 + 2,4-D	1 + .75	10.6	31.9	29.8
HOE 23408 + 2,4-D	2 + .75	35	50.6	27.6
HOE 23408 + 2,4-D (1 day delay)	1 + .75	21.2	58.1	27.1
HOE 23408 + 2,4-D (3 days delay)	1 + .75	40	47.5	27.5
HOE 23408 + 2,4-D (7 days delay)	1 + .75	58.7	66.2	26.3
HOE 23408 + MCPA	1 + .75	15	39.4	28.2
HOE 23408 + MCPA	2 + .75	45.6	73.7	28.4
HOE 23408 + dicamba	1 + .25	11.9	48.1	27.1
HOE 23408 + dicamba	2 + .25	13.7	65	27.7
HOE 23408 + bromoxynil	1 + .50	63.1	16.9	29.8
HOE 23408 + bromoxynil	2 + .50	79.4	48.7	27.8
Check	0	0	0	29.4

Barnyardgrass Control. Application of HOE 23408 with 2,4-D low volatile ester as a tank-mixture resulted in decreased barnyardgrass control (31.9%) when compared with HOE 23408 applied alone (54.4%). A delayed application of only 1 day increased control to 58.1% and to 66.2% when delayed 7 days. Low barnyardgrass control (47.5%) cannot be explained in the treatment where 2,4-D low volatile ester application was delayed 3 days.

Both MCPA low volatile ester and dicamba amine reduced the effectiveness of HOE 23408 when applied in tank-mixture at both rates of HOE 23408.

In contrast to the synergistic effect of HOE 23408 and bromoxynil for wild oat control, this tank-mixture showed a large reduction in effectiveness on barnyardgrass control. Antagonism was observed at both rates of HOE 23408 examined.

Less wild oat and barnyardgrass control was obtained in this experiment than would be expected from reports in the literature. A possible reason is that weather conditions were drier than normal and no surfactant was used which could increase the effectiveness of the herbicides used.

There were no significant differences between treatments when yield data were analyzed (Appendix Table 17). The conclusion, therefore, is that no detrimental effect to yield exists when HOE 23408 is applied to spring wheat alone or in combination with the tested broadleaf herbicides at any rate examined.

My research data has shown that wild oat and barnyardgrass control with HOE 23408 was antagonized by the hormonal type of herbicides (2,4-D LV ester, MCPA LV ester, and dicamba amine). Bromoxynil, a contact herbicide, also antagonized HOE 23408 for barnyardgrass control, but did not show the same effect on wild oats. Delayed applications of 2,4-D LV ester following HOE 23408 reduced the antagonism but detailed studies are needed to determine the optimum delay. Tank-mixture with bromoxynil will save time and the farmer will cover his field only once for wild oat control. On the other hand, data showing antagonism between HOE 23408 and bromoxynil was noticed for barnyardgrass control. This leads us to conclude that detailed studies should be conducted for each major grass weed species in wheat such as *Setaria* sp. and others. Other new broadleaf herbicides that may have potential for use in small grains also should be evaluated in tank-mixtures with HOE 23408.

HOE 23408 CULTIVAR TOLERANCE STUDY IN SPRING WHEAT

Materials and Methods

At the Schmidt Experimental Farm near Corvallis, Oregon, a field experiment was established on May 22, 1975, to study the tolerance of three commercially used spring wheat cultivars to HOE 23408.

The soil was Woodburn silt loam with pH 5.4 and 3.0% organic matter content. The spring wheat cultivars, Waldron, Twin, and WS-1, were sown at 90 lb/A on April 22. Waldron is a hard red spring wheat which is commonly grown in North Dakota. Twin is a soft white cultivar and WS-1 is a hard white cultivar. The experimental design was a split plot with four replications. The cultivars were the main plots and herbicide rates were the subplots. The size of the subplots was 30 by 10 ft.

Postemergence herbicide treatments were applied on May 22 with a bicycle-wheel plot sprayer using water as the carrier. Herbicide rates and stages of growth of wheat cultivars at the time of treatment were:

Rates of HOE 23408	Stage of Growth
1 lb/A - proposed use rate	Waldron - 3 1/2 leaf, 30% 1 tiller
2 lb/A - two times proposed use rate	Twin - 3 to 3 1/2 leaf, 25% 1 tiller
4 lb/A - four times proposed use rate	WS-1 - 3 1/2 leaf, 30% tiller
No chemical	

Application data are given in Appendix Table 18. The 1975 formulation of HOE 23408 was used.

Wheat was harvested on September 3 with a small plot combine with a 4.8 foot header. The harvested grain samples were cleaned and yield data were subjected to analysis of variance.

Results and Discussion

No visible effects on the wheat were observed from any of the treatments.

Yield results are illustrated in Figure 7 and Appendix Tables 18 and 19. Low grain yields were due to unseasonably cool wet weather in the early spring, making early planting impossible, followed by a very dry late spring. There were no significant differences between treatments within each cultivar. All three cultivars exhibited excellent tolerance to HOE 23408. Consistent reductions in yield, compared to the lower rates, were observed in each cultivar at the 4 lb/A treatment but these differences were not statistically significant.

Significant differences at the 5% level were found between cultivars. Cultivar WS-1 yielded highest and Twin had the lowest yield (Appendix Table 19).

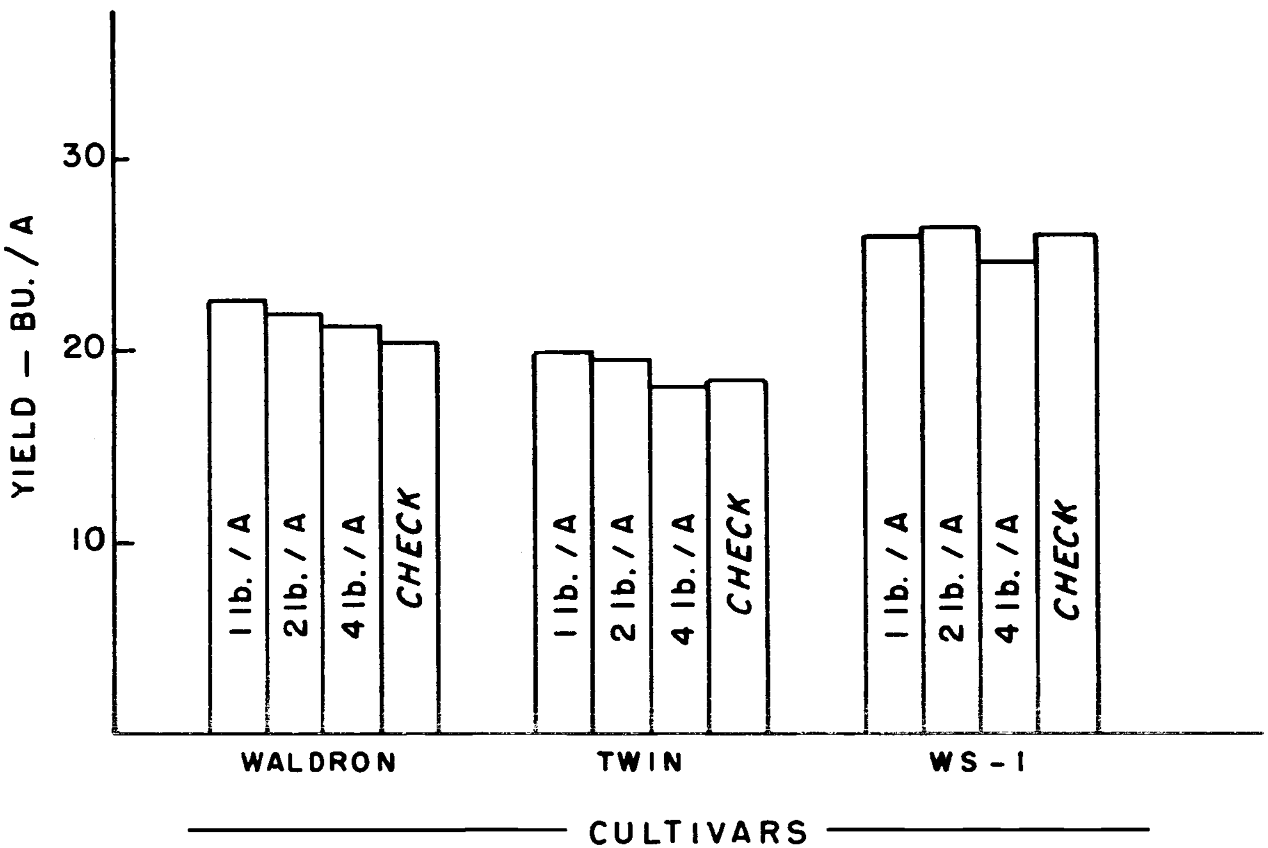

Figure 7. Yield response of spring wheat cultivars to different rates of HOE 23408 herbicide.

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APPENDIX

Appendix Table 1. Injury ratings of wild oats grown in the greenhouse in soil treated at three timings from four locations.[a]

			Monmouth Location 1					Carlton Location 2					Woodburn Location 3					Hyslop Location 4				
Treatment	Rate lb/A	Timing[b]	R1	R2	R3	R4	Avg	R1	R2	R3	R4	Avg	R1	R2	R3	R4	Avg	R1	R2	R3	R4	Avg
HOE 23408	1	PRE	3	3	4	2.5	3.12	2	3	2	2	2.25	3	3.5	5	2	3.37	4	3.5	6	4.5	4.50
HOE 23408	2	PRE	4.5	4.5	6	4.5	4.87	4	1.5	4.5	4	3.50	6.5	---	5.5	6	6.00	4	5	5	5	4.75
HOE 23408	1	EPE	3.5	---	4.5	2	4.50	3.5	3.5	---	1.5	2.83	---	2.5	3.5	4	3.33	2.5	4.5	6	2.5	3.87
HOE 23408	2	EPE	4	5.5	6	6	5.37	5	3	5.5	3	4.12	5	6	5.5	5	5.37	5.5	6	6	6.5	6.00
HOE 23408	1	LPE	2	4.5	5.5	4.5	4.12	3.5	4.5	3	2.5	3.37	3	1.5	5	4	3.17	4.5	5.5	4	2.5	4.12
HOE 23408	2	LPE	8	5.5	5.5	4	5.75	4.5	4	2.5	---	3.67	6.5	7	6.5	8	7.00	7	4	8	3	5.50
Check	0		0.5	0.5	3	2	1.50	3	3	3	0	2.25	2.5	1	1	1.5	1.50	1	0.5	0	0	0.37

Monmouth Date of Treatment	Carlton Date of Treatment	Woodburn Date of Treatment	Hyslop Date of Treatment
PRE - Oct. 22, 1974	PRE - Nov. 5, 1974	PRE - Nov. 1, 1974	PRE - Oct. 29, 1974
EPE - Dec. 16, 1974	EPE - Dec. 9, 1974	EPE - Dec. 10, 1974	EPE - Nov. 25, 1974
LPE - Jan. 17, 1975	LPE - Jan. 20, 1975	LPE - Jan. 17, 1975	LPE - Jan. 2, 1975
Date of Sampling	Date of Sampling	Date of Sampling	Date of Sampling
Feb. 17, 1975	Feb. 22, 1975	Feb. 21, 1975	Feb. 20, 1975

[a] Ratings average of two independent evaluators. Based on 0-9 scale where 0 = no injury and 9 = plants dead

[b] PRE = preemergence, EPE = early postemergence and LPE = late postemergence.

Appendix Table 2. Average fresh shoot weights of wild oats (g/plant) grown in the greenhouse in soil treated at three timings from four locations.

Treatment	Rate lb/A	Timing[a/]	Monmouth Location 1 R1	R2	R3	R4	Avg	Carlton Location 2 R1	R2	R3	R4	Avg
HOE 23408	1	PRE	.4056	.6359	.2734	.6487	.4909	.6828	.5154	.6633	.5492	.6029
HOE 23408	2	PRE	.4689	.3763	.1672	.2986	.3277	.4288	.8312	.3734	.5163	.5374
HOE 23408	1	EPE	.3805	-----	.3840	.6101	.4582	.4927	.4132	-----	1.4916	.4972
HOE 23408	2	EPE	.3661	.2680	.2916	.4290	.3387	.4259	.6750	.4479	.5794	.5320
HOE 23408	1	LPE	.5150	.4142	.4288	.2779	.4089	.4418	.4327	.7842	.6856	.5860
HOE 23408	2	LPE	.0985	.2754	.5003	.4012	.3118	.5229	.6228	.7574	-----	.6344
Check	0		1.0348	.5600	.3895	.6543	.6596	.7340	.6289	.5849	1.4946	.8606

Monmouth:

Date of Treatment

PRE - Oct. 22, 1974

EPE - Dec. 16, 1974

LPE - Jan. 17, 1975

Date of Sampling

Feb. 17, 1975

Carlton:

Date of Treatment

PRE - Nov. 5, 1974

EPE - Dec. 9, 1974

LPE - Jan. 20, 1975

Date of Sampling

Feb. 22, 1975

Appendix Table 2 (continued).

Treatment	Rate lb/A	Timing[a/]	Woodburn Location 3 R1	R2	R3	R4	Avg	Hyslop Location 4 R1	R2	R3	R4	Avg
HOE 23408	1	PRE	.3874	.5005	.2056	.9132	.5017	.6215	.4205	.2045	.3204	.3917
HOE 23408	2	PRE	.2124	-----	.3494	1.6507	.2678	.4363	.4749	.2358	.4723	.4044
HOE 23408	1	EPE	-----	.9556	.3684	.3267	.5202	.6355	.4255	.2571	.5474	.4656
HOE 23408	2	EPE	.3175	.1712	.2773	.2703	.2590	.3350	.2061	.2853	.2774	.2759
HOE 23408	1	LPE	.4487	.6449	.2718	-----	.4551	.4026	.2958	.3818	.7412	.4553
HOE 23408	2	LPE	.2358	.2277	.2063	.1574	.2068	.2485	.3724	.1802	.5452	.3365
Check	0		.4961	.8109	.7152	.6188	.6602	1.1261	.7882	1.4492	.7491	1.0281

Woodburn (Location 3):

Date of Treatment

PRE - Nov. 1. 1974

EPE - Dec. 10, 1974

LPE - Jan. 17, 1975

Date of Sampling

Feb. 21, 1975

Hyslop (Location 4):

Date of Treatment

PRE - Oct. 29, 1974

EPE - Nov. 25, 1974

LPE - Jan. 2, 1975

Date of Sampling

Feb. 20, 1975

[a/] PRE = preemergence, EPE = early postemergence and LPE = late postemergence.

Appendix Table 3. Average fresh shoot weights of wild oats (g/plant) planted in untreated soil from four locations, treated in the greenhouse prior to planting.

	Rate	Monmouth Location 1			Carlton Location 2			Woodburn Location 3			Hyslop Location 4		
Treatment	lb/A	R1	R2	Avg	R1	R2	Avg	R1	R2	Avg	R1	R2	Avg
HOE 23408	.05	.3555	-----	.3555	1.5634	.8501	1.2068	-----	.7435	.7435	.5585	.7177	.6381
HOE 23408	.10	.3570	.3648	.3609	.7679	.8676	.8163	.8189	.7907	.8048	.4734	.4736	.4735
HOE 23408	.15	.5042	.3053	.4048	1.4032	.4553	.9293	.6132	.9375	.7752	.5419	.3466	.4443
HOE 23408	.20	.4226	.3083	.3655	.5081	.6368	.5725	.4602	.4791	.7697	.2689	.5482	.4086
HOE 23408	.40	.3070	.1994	.2532	.3985	-----	.3985	-----	.2334	.2334	.2829	-----	.2829
HOE 23408	.80	.2393	.2029	.2211	.1267	.2372	.1820	.1366	.0271	.0819	-----	.1607	.1607
Check	0	1.0348	.5600	.7974	.6289	1.4946	1.0618	.7152	.6188	.6670	1.1261	.7882	.9572

Appendix Table 4. Injury ratings of wild oats planted in untreated soil from four locations, treated in the greenhouse prior to planting.[a]

Treatment	Rate lb/A	Monmouth Location 1			Carlton Location 2			Woodburn Location 3			Hyslop Location 4		
		R1	R2	Avg	R1	R2	Avg	R1	R2	Avg	R1	R2	Avg
HOE 23408	.05	2.5	---	2.5	---	1	.5	---	2	2	3	3.5	3.2
HOE 23408	.10	4	4	4	3.5	2.5	3	2.5	3.5	3	4.5	4	4.2
HOE 23408	.15	3.5	4.5	4	1.5	3.5	2.5	0.5	0.5	0.5	2	3	2.5
HOE 23408	.20	2	4	3	2	2.5	2.2	2	2.5	2.2	5	4.5	4.7
HOE 23408	.40	5	6	5.5	4	---	4	---	5.5	5.5	5	---	5
HOE 23408	.80	7	6	6.5	7.5	6	6.7	7.5	9	8.2	---	7	7
Check	0	.5	.5	.5	3	0	1.5	1	1.5	1.2	1	.5	.7

[a] Ratings average of two independent evaluators. Based on 0-9 scale where 0 = no injury and 9 = plants dead.

Appendix Table 5. Injury ratings of corn and wild oats in the HOE 23408 persistence trial at the Schmidt Farm.[a/]

Treatment	Rate lb/A	Date	R1 Corn	R1 Wild Oats	R2 Corn	R2 Wild Oats	R3 Corn	R3 Wild Oats	R4 Corn	R4 Wild Oats	Average Corn	Average Wild Oats
			%Red	%Red								
HOE 23408	1	June 30	85	85	90	99	90	98	100	99	91.2	95.2
HOE 23408	2		100	100	85	99	100	99	99	100	96	99.5
HOE 23408	4		100	100	95	100	100	100	100	99	98.7	99.7
Check	0		0	0	0	0	0	0	0	0	0	0
HOE 23408	1	July 8	95	95	99	98	99	90	95	95	97	94.5
HOE 23408	2		100	99	95	98	100	99	90	80	96.2	94
HOE 23408	4		99	98	100	100	99	99	99	100	99.2	99.2
Check	0		0	0	0	0	0	0	0	0	0	0
HOE 23408	1	July 15	40	50	30	50	30	70	0	60	25	57.5
HOE 23408	2		50	90	70	99	20	80	30	60	42.5	82.2
HOE 23408	4		85	95	80	99	80	99	50	99	73.7	98
Check	0		0	0	0	0	0	0	0	0	0	0
HOE 23408	1	July 31	65	50	30	65	45	70	30	55	42.5	60
HOE 23408	2		75	75	70	80	75	85	50	80	67.5	80
HOE 23408	4		85	90	95	98	90	95	75	90	86.2	93.2
Check	0		0	0	0	0	0	0	0	0	0	0
HOE 23408	1	August 30	10	10	0	0	10	5	0	0	5	3.7
HOE 23408	2		40	30	15	25	25	20	30	35	27.5	27.5
HOE 23408	4		65	55	35	50	50	55	50	60	50	55
Check	0		0	0	0	0	0	0	0	0	0	0

[a/] Ratings based on 0-100% scale where 0 = no injury and 100 = plants dead.

Appendix Table 6. Root and shoot weights of corn (g/sq. yd.) and number of plants in the HOE 23408 persistence trial at Schmidt Farm.

			R1			R2			R3			R4			Average			Percent of Check		
Treatment	Rate lb/A	Hvst Date	Root Wt.	Shoot Wt.	No. plts.	Root Wt.	Shoot Wt.	No. plts.	Root Wt.	Shoot Wt.	No. plts.	Root Wt.	Shoot Wt.	No. plts.	Root Wt.	Shoot Wt.	No. plts.	Root Wt.	Shoot Wt.	No. plts.
HOE 23408	1	June 30	2.4	9.1	4	4.7	16.4	2	1.3	5.3	2	.6	2.0	1	2.27	8.2	2.25	9.8	7.5	36
HOE 23408	2		0	0	0	1.8	9.7	2	.1	.4	1	0	0	0	.49	2.5	.75	2.1	2.3	12
HOE 23408	4		0	0	0	.9	1.9	1	0	0	0	0	0	0	.05	.5	.25	.2	.4	4
Check	0		22.6	114.1	5	27.1	143.8	5	20.8	87.7	6	21.8	93.7	9	23.1	109.9	6.25	100	100	100
HOE 23408	1	July 8	1.75	8.9	3	1.2	5.1	1	4.3	22.0	1	3.2	9.1	1	2.6	11.2	1.50	7.9	5.2	26
HOE 23408	2		0	0	0	2.1	30.0	2	2.8	13	1	2.9	14.1	2	1.9	14.3	1.25	5.9	6.6	17
HOE 23408	4		0	0	0	0	0	0	.2	9.3	1	0	0	0	.06	2.3	.25	.2	1.1	4
Check	0		32.2	257.1	5	62.2	450.4	5	13.8	63.7	4	23.4	95.8	9	32.9	216.8	5.75	100	100	100
HOE 23408	1	July 15	33.0	177.5	9	57.8	489.5	11	19.4	121.0	9	25.5	236.5	12	33.9	256.1	10.25	44.9	53.9	77
HOE 23408	2		25.4	261.0	13	7.0	111.5	5	27.8	201.2	12	22.6	126.2	6	20.7	175.0	9	27.4	36.8	68
HOE 23408	4		7.6	85.5	5	2.1	99.5	2	4.6	49.0	5	6.9	121	5	5.3	88.7	4.25	7.0	18.7	32
Check	0		97.8	665.3	16	78.6	563.5	8	54.2	388.9	8	71.9	282.5	21	75.6	475.0	13.25	100	100	100
HOE 23408	1	July 31	54.8	263.1	13	45.3	385.2	12	33.4	168.1	11	9.6	33.7	5	35.8	212.5	19.30	47.5	33.5	82
HOE 23408	2		30.8	293.8	11	7.8	63.2	6	19.8	116.8	7	4.4	27.5	4	15.7	125.3	7	20.8	19.7	56
HOE 23408	4		5.2	65.6	2	.7	37.6	1	6.9	46.6	5	[illegible]	27.0	4	5.6	44.5	2.50	[illegible]	[illegible]	20
Check	0		124.0	1086.9	18	60.4	600.1	8	96.3	777.9	18	20.5	73.1	6	75.3	634.5	12.50	100	100	100
HOE 23408	1	August 30	259.2	1313.5	18	397.3	2953.2	19	341.7	2747.6	21	417.0	3402.1	25	353.8	2604.1	20.80	93.3	99.6	92
HOE 23408	2		180.0	901.5	12	315.5	2025.6	20	277.6	1828.5	20	276.4	1911.4	16	262.4	1666.8	17.00	69.2	63.8	75
HOE 23408	4		119.6	613.1	10	249.6	761.3	8	181.7	553.7	12	107.6	1158.0	5	164.6	771.5	8.80	43.4	29.5	39
Check	0		226.4	1279.7	14	465.7	3130.8	26	481.2	2962.3	25	344.3	3081.1	26	379.4	2613.5	22.70	100	100	100

Appendix Table 7. Analysis of variance for corn root weight data in Appendix Table 6 after conversion to percent of the check.

Source	d.f.	SS	MS	F
Replications	3	25.64	8.55	0.07
Timings	4	25775.25	6443.81	49.61**
Error a	12	1558.54	129.88	
Rates	3	90264.27	33088.09	306.40**
Error b	9	883.79	98.20	
Timing x Rates	12	11991.06	999.26	9.18**
Error c	36	3919.11	108.86	
Total	79	134417.66		

**Significant at 1% level

Appendix Table 8. Analysis of variance for corn shoot weight data in Appendix Table 6 after conversion to percent of the check.

Source	d.f.	SS	MS	F
Replications	3	780.98	260.33	1.28
Timings	4	22882.40	5720.60	28.04**
Error a	12	2448.25	204.02	
Rates	3	85248.21	28416.07	177.07**
Error b	9	1437.83	159.76	
Timings x Rates	12	12683.73	1056.98	9.29**
Error c	36	4096.24	113.78	
Total	79	129577.24		

**Significant at 1% level

Appendix Table 9. Analysis of variance for number of plants data in Appendix Table 6 after conversion of percent of the check to $\sqrt{x+1}$.

Source	d.f.	SS	MS	F
Replications	3	1260.14	420.05	1.30
Timings	4	7814.62	1953.65	6.05**
Error a	12	3874.32	322.86	51.69**
Rates	3	22636.35	7545.45	51.69**
Error b	9	1313.84	145.98	
Timings + Rates	12	3495.11	291.26	2.00*
Error c	36	5240.03	145.56	
Total	79	45634.42		

* Significant at 5% level
**Significant at 1% level

Appendix Table 10. Shoot weights of wild oats (g/sq.yd.), and number of plants in the HOE 23408 persistence trial at Schmidt Farm.

Treatment	Rate lb/A	Hvst Date	R1 Shoot Wt.	R1 No. pl/ sq.yd.	R2 Shoot Wt.	R2 No. pl/ sq.yd.	R3 Shoot Wt.	R3 No. pl/ sq.yd.	R4 Shoot Wt.	R4 No. pl/ sq.yd.	Average Shoot Wt.	Average No. pl/ sq.yd.	Percent of Check Shoot Wt.	Percent of Check No. pl/ sq.yd.
HOE 23408	1	June 30	61.9	34	20.9	17	41.8	20	94.1	56	56.8	27.5	9.1	11.0
HOE 23408	2		14.4	9	0	0	5.2	3	9.8	9	7.3	5.2	1.2	2.0
HOE 23408	4		0	0	7.3	2	2.2	2	0	0	2.4	1	.4	.5
Check	0		622.1	246	516.4	217	639.6	225	710.5	340	622.2	257	100	100
HOE 23408	1	July 8	16.3	7	34.8	5	43.1	6	40.0	12	33.5	7.5	11.2	14
HOE 23408	2		2.4	1	8	1	4.6	3	23.5	7	9.6	3	3.2	6
HOE 23408	4		23.8	4	0	0	0	0	6.5	1	7.6	1.2	2.5	2
Check	0		408.6	78	371.4	59	186.2	36	236.5	39	300.7	53	100	100
HOE 23408	1	July 15	206	52	32.3	8	70.6	27	51.7	19	90.1	26.5	47.0	51
HOE 23408	2		29.9	7	14.9	5	59.1	11	22.1	5	31.5	7.0	16.4	14
HOE 23408	4		27.1	5	0	0	12.5	2	4.7	2	11.7	2.2	6.1	4
Check	0		207.1	34	226.8	55	154.8	46	177.7	71	191.6	51.5	100	100
HOE 23408	1	July 31	190.1	93	263.8	157	166.5	167	81.2	117	175.4	133.5	33.1	36
HOE 23408	2		176	31	188.7	95	97.7	76	28.1	23	122.6	56	23.9	15
HOE 23408	4		76.5	14	25.4	77	46.4	55	19.5	44	41.9	47.5	7.9	13
Check	0		869.5	313	446.9	521	505.2	326	298.4	309	530.0	367.2	100	100
HOE 23408	1	August 30	1080.1	391	954.2	362	785.6	418	1180.8	498	1000.2	417.2	100.2	97
HOE 23408	2		874.2	242	901.4	203	594.4	352	611.8	324	745.5	300.3	74.7	70
HOE 23408	4		494.3	118	331	160	438.2	174	236.4	172	375	156	37.6	36
Check	0		1152.6	408	1011.4	386	835.4	490	993.8	434	998.3	429.5	100	100

Appendix Table 11. Analysis of variance for shoot weights data in Appendix Table 10 after conversion to percent of the check.

Source	d.f.	SS	MS	F
Replications	3	200.06	66.68	0.36
Timings	4	26366.91	6591.73	35.55**
Error a	12	2224.94	185.41	
Rates	3	92935.37	30978.46	568.36**
Error b	9	490.55	54.50	
Timings x Rates	12	13108.30	1092.36	7.89**
Error c	36	4972.83	138.42	
Total	79	140298.96		

**Significant at 1% level

Appendix Table 12. Analysis of variance for number of plants data in Appendix Table 10 after conversion to percent of the check to $\sqrt{x + 1}$.

Source	d.f.	SS	MS	F
Replications	3	444.87	148.29	0.58
Timings	4	19691.94	4922.98	19.35**
Error a	12	3053.49	254.46	
Rates	3	57566.56	19188.85	237.19**
Error b	9	728.14	80.90	
Timings x Rates	12	7901.35	658.44	11.35**
Error c	36	2808.37	58.01	
Total	79	92194.71		

**Significant at 1% level

Appendix Table 13. Daily Precipitation Record, crop year 1974-75. Recorded at the Hyslop Agronomy Farm, Corvallis, Oregon.

Date	September	October	November	December	January	February	March	April	May	June	July	August
1			.08		.12	.13	.04	.02			.15	
2		T		.09		.05	.16	.07	.04		.15	
3				.07	.02	.06	.15	.28	1.10			
4				.30	.17	.20	.01	.10	.40			
5			.14	.10	.61	.26		.03	.03		T	T
6			.35	.48	.18	.18			T		T	
7			1.58	.09	.08	.28		.03				
8			.11	.02	.48	.18	.35	.16				.02
9	.06		.06	.22	.28	.26	.02	T				
10	.01				.32	.09						
11		.02		.67	.02	.30	.03		.22			
12				.10	.02	.55	.01					
13		T		.75	.12	.21	T					
14			.02	.78		.09		.02				
15				.24	.16		T	.02				
16				.01	.02	.37	.28	.03				
17				.12	.02		.34	.06		.02		.12
18			1.00	.04		.23	.98	.01		T		.51
19			.22	.09		.44	.54	.20				
20		.09	.15	.79		.64	.07	T	.24			
21		.16	.88	.88			.19			T		
22			.85	.29		.03	.48		.04			
23			.61		.13		.29	.47	T	.14		.23
24			.26		.31		.58	.26		.17		.03
25			.33	.03	.25		.12	.33		.46		
26			T	T	1.30	.05	T	.29	T	.09		
27		.18	.24	1.70	.05	.16		.02		.12		
28		.37				.72		T		.14		.54
29		.38								T	.32	.12
30				.29			T			T		.08
31		.20					T					.03
Avg.		1.41		8.15	4.66	5.48		2.40	2.07	1.14	.62	1.68

Appendix Table 14. Daily maximum-minimum temperatures, crop year 1974-75. Recorded at the Hyslop Agronomy Farm, Corvallis, Oregon.

Date	September	October	November	December	January	February	March	April	May	June	July	August
1	77-53	80-41	59-35	49-34	41-29	43-29	61-49	48-35	68-35	84-50	64-50	79-52
2	87-55	82-52	57-35	46-38	50-31	43-33	55-48	53-37	70-40	83-52	65-51	86-50
3	91-53	70-39	49-31	53-42	43-32	44-36	56-42	47-35	52-42	71-40	68-50	84-51
4	73-56	66-39	55-31	49-44	48-38	46-34	52-38	45-30	52-38	72-54	71-53	86-52
5	75-52	65-33	58-33	51-37	47-40	44-36	55-32	48-31	53-40	82-54	90-56	87-52
6	82-53	65-35	59-45	53-37	53-38	44-33	53-30	55-27	55-41	74-44	82-50	71-45
7	82-50	72-33	54-50	52-40	45-38	39-33	58-36	53-30	58-37	70-40	83-54	74-46
8	87-53	76-32	54-36	53-35	51-37	49-36	58-42	45-34	64-37	66-41	85-49	74-56
9	76-59	78-42	54-40	47-35	40-30	37-32	55-34	58-31	69-43	74-48	83-53	76-47
10	69-48	70-42	56-38	53-43	47-32	50-33	52-32	56-32	74-47	83-56	85-49	82-45
11	75-47	68-41	52-41	51-43	43-34	48-41	50-31	61-36	60-45	87-46	82-50	80-50
12	78-51	68-38	59-38	65-41	49-33	50-43	52-33	66-34	65-42	82-42	83-46	81-50
13	82-55	75-43	68-41	54-38	52-48	56-42	51-36	67-38	70-44	84-48	78-45	85-47
14	87-46	66-35	55-41	47-38	52-49	50-30	50-29	55-32	82-44	83-51	78-48	87-48
15	91-41	71-35	50-43	51-44	55-46	47-27	50-35	55-36	60-45	84-46	76-54	85-50
16	83-44	75-34	50-36	58-48	53-44	43-30	48-36	51-38	64-41	76-42	77-53	82-51
17	87-43	77-33	48-42	59-37	55-47	45-30	49-36	52-39	72-47	61-47	71-56	73-59
18	87-46	79-34	51-44	51-36	61-48	46-32	55-41	52-37	69-45	60-44	77-55	65-57
19	89-53	78-34	51-43	52-42	60-47	49-40	51-39	55-40	62-43	62-49	74-58	71-49
20	94-48	65-38	53-44	55-43	50-39	52-32	47-35	54-30	55-31	72-47	82-50	70-52
21	95-49	58-34	61-46	55-40	51-33	44-25	46-35	57-37	65-34	71-44	85-50	75-56
22	94-47	58-34	51-35	44-33	48-33	45-29	44-35	64-39	64-41	68-45	84-48	71-53
23	92-49	69-33	50-40	42-48	51-36	58-30	49-37	53-41	66-49	69-50	84-52	72-56
24	92-48	64-32	54-43	33-29	52-44	57-40	46-40	58-42	63-37	60-49	91-48	69-40
25	97-43	69-33	62-44	38-30	58-43	53-32	46-33	52-38	60-40	57-48	92-53	72-48
26	89-44	65-34	52-34	47-37	44-32	58-33	51-33	53-36	71-44	59-46	85-56	73-47
27	73-38	60-37	42-36	50-38	40-32	53-39	50-31	53-40	70-45	58-44	95-53	83-51
28	74-41	57-50	47-31	46-31	36-29	55-43	52-31	53-30	73-46	62-46	89-54	67-52
29	75-44	54-40	47-30	36-31	43-27		56-30	53-34	76-47	63-45	73-44	66-51
30	76-38	59-40	45-28	39-30	37-25		62-37	62-34	80-52	71-44	67-50	66-54
31		52-40		48-29	34-28		54-35		82-52		70-47	64-44
Avg	83-48	68-37	53-38	49-37	48-36	48-34		54-35	66-42	71-46	79-51	76-50

Appendix Table 15. Ratings of percent control of wild oats and barnyardgrass in the HOE 23408-broadleaf herbicide combination trial, Schmidt Farm.[a]

Treatment	Rate lb/A	R1 Wld Oat Control	R1 Barnydgr. Control	R2 Wld Oat Control	R2 Barnydgr. Control	R3 Wld Oat Control	R3 Barnydgr. Control	R4 Wld Oat Control	R4 Barnydgr. Control	Average Wld Oat	Average Barnydgr.
HOE 23408	1	40	20	45	77.5	37.5	40	47.5	80	42.5	54.4
HOE 23408	2	77.5	77.5	75	90	77.5	92.5	70	99	75	89.7
2, 4-D L.V. ester	.75	0	0	0	0	12.5	17.5	5	7.5	4.4	6.2
MCPA L.V. ester	.75	15	40	5	0	10	10	0	25	7.5	18.7
dicamba amine	.25	0	0	0	0	0	2.5	5	7.5	1.2	2.5
bromoxynil ester	.50	5	0	7.5	10	0	0	0	0	3.1	2.5
HOE 23408 + 2, 4-D	1 + .75	10	25	25	45	7.5	45	0	12.5	10.6	31.9
HOE 23408 + 2, 4-D	2 + .75	37.5	67.5	25	35	27.5	50	50	50	35	50.6
HOE 23408 + 2, 4-D one day delay	1 + .75	20	42.5	17.5	62.5	27.5	75	20	52.5	21.2	58.1
HOE 23408 + 2, 4-D three days delay	1 + .75	22.5	32.5	25	65	32.5	47.5	80	45	40	47.5
HOE 23408 + 2, 4-D seven days delay	1 + .75	50	62.5	67.5	50	55	82.5	62.5	70	58.7	66.2
HOE 23408 + MCPA	1 + .75	22.5	60	10	0	10	35	17.5	62.5	15	39.4
HOE 23408 + MCPA	2 + .75	50	75	45	70	50	75	37.5	75	45.6	73.7
HOE 23408 + dicamba	1 + .25	10	65	15	35	10	5	12.5	87.5	11.9	48.1
HOE 23408 + dicamba	2 + .25	15	85	15	10	7.5	75	17.5	90	13.7	65
HOE 23408 + bromoxynil	1 + .50	52.5	10	75	32.5	63.5	5	62.5	20	63.1	16.9
HOE 23408 + bromoxynil	2 + .50	80	65	75	27.5	80	80	82.5	22.5	79.4	48.7
Check	0	0	0	0	0	0	0	0	0	0	0

[a] Average of two independent evaluators.

Appendix Table 16. HOE 23408-broadleaf herbicide combination study in spring wheat, Schmidt Farm.

Treatment	Rate lb/A	Bu/A R1	R2	R3	R4	Average
HOE 23408	1	32.21	28.14	32.21	25.18	29.44
HOE 23408	2	28.88	33.32	29.99	30.36	30.64
2, 4-D L.V. ester	.75	24.81	28.14	27.03	25.55	26.38
MCPA L.V. ester	.75	26.29	29.99	28.51	27.77	28.14
dicamba amine	.25	27.40	32.58	29.62	25.18	28.70
bromoxynil ester	.50	28.51	24.81	32.21	29.62	28.79
HOE 23408 + 2, 4-D	1 + .75	26.66	28.40	31.84	32.21	29.78
HOE 23408 + 2, 4-D	2 + .75	24.44	31.10	28.88	25.92	27.56
HOE 23408 + 2, 4-D one day delay	1 + .75	25.18	28.88	26.29	28.14	27.12
HOE 23408 + 2, 4-D three days delay	1 + .75	25.92	26.66	29.62	27.83	27.51
HOE 23408 + 2, 4-D seven days delay	1 + .75	25.55	26.29	29.25	24.02	26.28
HOE 23408 + MCPA	1 + .75	22.22	31.84	30.36	28.51	28.25
HOE 23408 + MCPA	2 + .75	24.81	29.62	29.62	29.62	28.42
HOE 23408 + dicamba	1 + .25	29.25	24.07	28.14	27.03	27.12
HOE 23408 + dicamba	2 + .25	25.18	27.03	34.06	24.44	27.68
HOE 23408 + bromoxynil	1 + .50	27.40	28.51	21.47	31.84	29.81
HOE 23408 + bromoxynil	2 + .50	25.18	27.40	30.73	27.77	27.77
Check		25.18	29.99	32.58	29.99	29.44

Application Data

Date:	June 1, 1975
	Postemergence
Conditions:	
Air temperature	84°
Soil temperature	90°
Humidity	65
% Cloud cover	10
Wind speed	0-4 mph

Method of application:	Broadcast
Carrier volume	25 gal/A
Nozzle size	8002
Pressure	27-30 psi
Weeds:	Barnyardgrass
	Wild oats
Harvest date:	September 9, 1975

Appendix Table 17. Analysis of variance for data in Appendix Table 16.

Source	d.f.	SS	MS	F
Replications	3	132.89	44.30	8.46**
Mix	17	101.02	5.94	1.13
Replications x Mix	51	266.97	5.23	
Total	71	500.87		

**Significant at 1% level

Appendix Table 18. Yield response of three spring wheat cultivars to different rates of HOE 23408.

Treatment	Rate lb/A	Bu/A R1	R2	R3	R4	Average
Cv. Waldron						
HOE 23408	1	23.13	22.02	22.02	23.86	22.76
HOE 23408	2	22.78	22.78	18.72	24.23	22.13
HOE 23408	4	22.78	21.29	19.82	21.66	21.39
Check	0	20.56	20.56	18.35	23.13	20.65
Cv. Twin						
HOE 23408	1	16.89	17.62	23.13	22.02	19.92
HOE 23408	2	17.99	18.72	20.92	21.66	19.82
HOE 23408	4	13.95	16.89	23.13	19.09	18.27
Check	0	19.46	10.65	22.02	21.66	18.45
Cv. WS-1						
HOE 23408	1	23.49	29.37	24.59	27.16	26.15
HOE 23408	2	29.00	25.33	28.27	23.86	26.62
HOE 23408	4	27.53	24.23	25.23	23.13	24.78
Check	0	25.33	27.90	23.13	28.27	26.16

Application Data

Date: May 22, 1975
Postemergence

Conditions:
- Air temperature 70°
- Soil temperature 72°
- Humidity 52%
- % Cloud cover 100
- Wind speed 0-5 mph

Method of application: Broadcast
- Carrier volume 50 gal/A
- Nozzle size 8002
- Pressure 27-30 psi

Harvest date: September 3, 1975

Stage of growth at the time of treatment:
- Waldron - 3 1/2 leaf, 30% tiller
- Twin - 3-3 1/2 leaf, 25% tiller
- WS-1 - 3 1/2 leaf, 30% tiller

Appendix Table 19. Analysis of variance for data in Appendix Table 18.

Source	d.f.	SS	MS	F
Replications	3	22.80	7.60	0.37
Varieties	2	378.05	189.03	9.24*
Error a	6	122.77	20.46	
Rates	3	20.27	6.76	1.46
Varieties x Rates	6	6.52	1.09	0.24
Error b	27	124.60	4.61	
Total	47	675.02		

L.S.D. .05 = 3.91 bu/A for comparison between varieties
*Significant at 5% level