HERBICIDAL EFFECTS OF CHLORFLURAZOLE

IN CEREAL CROPS AND FLAX

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ABSTRACT

HERBICIDAL EFFECTS OF CHLORFLURAZOLE IN CEREAL CROPS AND FLAX

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A two year project was undertaken to study the potential usefulness of chlorflurazole (4,5-dichloro-2-trifluoromethylbenzimidazole) for weed control in cereal crops and flax. The weed species studied were those generally considered resistant to the phenoxyacetic acid type herbicides.

The results of this study indicate that chlorflurazole is suitable for the control of certain serious weeds, notably *Polygonum convolvulus* and *P. scabrum* in cereal crops. However, its selectivity in flax is subject to considerable variation.

Chlorflurazole appeared to have a wide margin of crop safety in cereal crops. Rates of twice the amount required for weed control were applied with little or no crop injury. In flax, crop injury occurred in the first year of this study at all rates of herbicide and was significant in reducing yield. In the second year little or no crop injury occurred to flax.

Effective weed control was achieved in cereal crops with chlorflurazole and MCPA (2-methyl-4-chlorophenoxyacetic acid) at 8+8 ounces per acre or chlorflurazole and mecoprop (2-(2-methyl-4-chlorophenoxy) propionic acid) at 5+4 ounces per acre. It appears that application should be made at the 2 to 3 leaf stage of weed growth, as beyond this

stage the species studied became somewhat resistant. Under conditions of dense weed growth it appeared that use of larger volumes of diluent would be advantageous.

Results from determinations of protein content of wheat and oil content of flax suggest that chlorflurazole has no detrimental effect on crop quality.

INTRODUCTION

During the past twenty years, the use of herbicides for the control of broadleaved annual weeds in cereal crops and flax has been a common farming practice in Western Canada. The most commonly used herbicides are 2,4-D (2,4-dichlorophenoxyacetic acid) and MCPA (2-methyl-4-chlorophenoxyacetic acid) which are useful for the control of many susceptible broadleaved weeds. However, these herbicides are not consistently effective in the control of moderately resistant weeds such as *Polygonum convolvulus* L. and *Polygonum scabrum* Moench.

Approximately thirty million acres of farmland in Western Canada are now infested with weeds not readily controlled with 2,4-D or MCPA. The increase in the relative abundance of these "hard to kill" weeds has resulted in considerable emphasis being placed on the search for more effective herbicides. This search has led to the development of such useful herbicides as dicamba (2-methoxy-3,6-dichlorobenzoic acid), picloram (4-amino-3,4,6-trichloropicolinic acid) and bromoxynil (3,5-dibromo-4-hydroxybenzonitrile). Each one of these has broadened the spectrum of weed control under actual farm conditions but limitations of some importance remain.

A systematic study of the biological behaviour of the 2-trifluoromethylbenzimidazoles, and particularly those with halogen substituents in the benzenoid ring, has been undertaken recently. When applied post-emergent to weeds, the typical symptoms induced by active members of this series are rapid loss of turgidity, necrosis and death of the plant within about four days. It has been confirmed that the biologically active 2-trifluoromethylbenzimidazoles are active uncouplers of oxidative phosphorylation with limited translocation activity. One of these compounds, chlorflurazole (4,5-dichloro-2-trifluoromethyl-benzimidazole), has shown a high contact toxicity to many broadleaved species at rates which may be safe to cereal crops and flax. A true synergistic effect has also been noted in mixtures of chlorflurazole with MCPA or mecoprop (2-(2-methyl-4-chlorophenoxy)propionic acid).

Limited information on the herbicidal effects of chlorflurazole in cereal crops and flax prompted the initiation of a project at the University of Manitoba in 1966 to determine whether chlorflurazole could be used to control *Polygonum convolvulus* and *P. scabrum* in these crops when grown under Manitoba conditions.

Experiments were designed to study the effects of chlorflurazole formulations (with or without the addition of MCPA) on crop injury, yield and oilseed quality (oil content and iodine value) of flax. In 1967, the project was altered to study the effect of volume of diluent on the toxicity of chlorflurazole as measured by crop injury and yield of flax.

A further project was carried out in 1967 to measure the effect of chlorflurazole-MCPA mixtures on crop injury and yield of wheat, oats and barley.

The effectiveness of chlorflurazole formulations (with or without the addition of MCPA or wetting agents) for the control of *Polygonum convolvulus* and *P. scabrum* was studied in both years.

REVIEW OF THE LITERATURE

Recent surveys have shown that a large percentage of the cultivated acreage in Western Canada is infested with *Polygonum convolvulus* and *P. scabrum*. The former constitutes the most severe problem in terms of extent of infestation with more than 30,000,000 acres affected, while the latter infests some 6,440,000 acres (1). Friesen and Shebeski (6), in a survey conducted from 1956 to 1958, found that 98 percent of farm fields in Manitoba contained *P. convolvulus* and 42 percent contained *P. scabrum*. It is possible that the extent of these weeds will increase because of their relative resistance to the commonly used herbicides, 2,4-D and MCPA.

The extent of competition between *P. convolvulus* and cereal crops has been shown in several studies. Friesen and Shebeski (6) found that an infestation of 47 *P. convolvulus* plants per square yard reduced wheat yields by 14.8 percent while 172 plants per square yard reduced wheat yields by 25.7 percent. Forsberg (5) found that 15 plants per square foot reduced oat yields by 55 percent. Similar results were reported by Nalewaja (16) in North Dakota.

Competition between *P. convolvulus* and flax appears to be very severe. Nalewaja (16) found that 4 *P.convolvulus* plants per square foot reduced flax yields by 22.5 percent while Forsberg (5) reported a 66 percent loss in flax yields with an infestation of only 3 plants per square foot. Martin and Rademacher (14) studied the effect of *P. persicaria* on flax and found a 43 percent reduction in shoot growth of flax due to allelopathic influences of the weed.

Based upon information presented over many years in the annual

Research Reports of the National Weed Committee (Western Section), the following recommendations were made for the control of P. convolvulus and P. scabrum in cereal crops and flax for 1966 and 1967 (3):

(1) Control of *Polygonum convolvulus* in cereal crops.

One application of 2,4-D alone at 8 to 12 ounces per acre acid equivalent or two applications at 5 ounces per acre spaced one week apart will suppress *P. convolvulus* and reduce seed production. However, some crop injury may result from the single application, and there may be considerable inconvenience involved in using the split application.

Dicamba may be applied to wheat and oats at 2 to 3 ounces per acre acid equivalent alone or at 1.5 to 2 ounces per acre when mixed with the amine salts of 2,4-D or MCPA at 4.5 to 6 ounces per acre. In barley, the rate of dicamba should not exceed 1.5 ounces per acre. Applications must be made at the 2 to 3 leaf stage to be safe on the crops, and this may involve difficulty in some situations depending upon weather conditions at this stage of growth, or susceptibility of the crop to the 2,4-D formulation used in the mixture.

Picloram may be used in barley and oats at 0.38 to 0.5 ounces per acre acid equivalent in combination with 2,4-D or MCPA at 4 to 6 ounces per acre, or in wheat at 0.25 ounces per acre mixed with 2,4-D at 4 ounces per acre. However, difficulties may arise with this herbicide because of very narrow tolerance limits for safe application to the crop and appreciable residue activity associated with its use.

Bromoxynil ester may be used at 4 to 6 ounces active ingredient per acre in all cereal crops with little or no crop injury. Treatment may be made any time from the 2 leaf stage to the early flag leaf stage of the crop but the most effective treatment would be made when the weeds are in the seedling stage.

(2) Control of *Polygonum scabrum* in cereal crops.

In wheat and barley, 2,4-D ester at 8 to 12 ounces per acre or 2,4-D amine at 12 ounces per acre may be used to control *P. scabrum*. In oats, 10 to 14 ounces per acre of MCPA amine or ester may be used when the weeds are in the seedling stage.

Good to excellent results may also be obtained with dicamba and 2,4-D in a 1:3 ratio at 6 to 8 ounces per acre; bromoxynil octanoate at 4 to 6 ounces per acre; or picloram at 0.38 ounces per acre mixed with 2,4-D at 6 ounces per acre. The latter should only be used on oats and barley.

(3) Control of *Polygonum convolvulus* and *P. scabrum* in flax.

The control of these weeds in flax is more difficult than in cereals because of the high sensitivity of flax to most of the commonly used herbicides. Both 2,4-D and MCPA may be used to suppress growth of these weeds but only at rates which are injurious to the flax. A mixture of dicamba and 2,4-D at 1.5 ounces per acre or dicamba alone at 2 ounces per acre may be used as an emergency measure, but severe delay in maturity will result. The crop should not be treated later than 20 days after emergence.

Bromoxynil and MCPA in a 1:1 ratio may be used at 8 ounces per acre but it should be recognized that severe injury to the flax has been observed, particularly under conditions of stress to the plant, e.g. hot, humid weather.

Picloram at 0.25 to 0.375 ounces per acre in mixture with 2,4-D at 4 to 6 ounces per acre may also be used, but some delay in maturity should be expected. The use of picloram also entails the possibility of herbicide residues in the soil or plant debris which may result in injury to sensitive plants in the following years.

Dichloroprop (2-(2,4-dichlorophenoxy)propionic acid), 2,4-DB (4(2,4-dichlorophenoxy)butyric acid), MCPB (4-(2-methyl-4-chlorophenoxy) butyric acid), and mecoprop have also been evaluated for the control of Polygonum convolvulus and P. scabrum. Results have indicated that these herbicides offer no advantage over 2,4-D and MCPA when applied at similar rates.

It is evident that there are limitations of considerable importance associated with the use of all of the recommended herbicides in controlling semi-resistant weeds in cereal crops and flax.

THE 2-TRIFLUOROMETHYLBENZIMIDAZOLES

A systematic study of the synthesis and biological activity of the 2-trifluoromethylbenzimidazoles, and particularly those with halogen substituents in the benzenoid ring, was undertaken by workers at Fisons Pest Control Ltd. in 1962. The typical symptoms induced by compounds of this series, when applied to plants post-emergent, are rapid loss of turgidity, necrosis, and death of the plant within 2 to 6 days (4). They were shown to be very active uncouplers of oxidative phosphorylation (11). Damage on sprayed leaves was localized with no significant systemic transfer, indicating that these compounds had an activity pattern resembling that of many other contact herbicides. Repeated screening trials in the field and the greenhouse have shown one of these compounds - Chlorflurazole - to be superior in selectivity for broad-leaved weed control in cereal crops and flax (17).

Pfeiffer (17) has shown that under European conditions no annual broadleaved plant has been found resistant to an application of chlorflurazole in the seedling stage. He reports an average reduction in growth of 89 percent for seven common European weeds when sprayed with chlorflurazole at 16 ounces per acre active ingredient. Several trials in Canada have shown that chlorflurazole at 16 ounces per acre or in combination with MCPA at 8 + 8 ounces per acre can result in up to 100 percent control of the "hard to kill" weeds most often found in cereal crops (7, 8, 13, 21). However, there has been a wide variation in degree of control of some species including Polygonum scabrum and P. convolvulus. Some reports indicate only fair control while others indicate good to excellent control of these weeds (2, 7, 12, 13, 15, 20, 21).

Preliminary screening trials reported by Pfeiffer (17) showed little injury to gramineous species. Rates of chlorflurazole in excess of those required for weed control have shown little injury to cereal crops in trials in Western Canada (8). When crop injury was reported, however, it was found that no reduction in yields occurred (2, 9, 10). One report showed very little injury to flax treated with chlorflurazole at 8 ounces per acre (15).

It has been reported that chlorflurazole in combination with hormone type herbicides (MCPA, mecoprop), displays a synergistic increase in activity (17). Results indicate that the degree of weed control shown by 16 ounces of chlorflurazole alone may be duplicated by 8 ounces of chlorflurazole in combination with 8 ounces of MCPA (2, 8, 21).

Preliminary trials reported by Pfeiffer (17) suggested that volumes of 15 to 20 gallons per acre total solution were necessary for adequate coverage of the plants. However, Friesen (9) has achieved good weed control without crop injury using as low as 5.0 gallons per acre.

MATERIALS AND METHODS

Six projects were carried out to determine the effect of chlorflurazole, and mixtures containing chlorflurazole, on cereal crops and flax and the efficiency of these compounds for the control of *Polygonum convolvulus* and *P. scabrum*. The projects were as follows:

(a) The effect of chlorflurazole and chlorflurazole-MCPA mixtures applied to flax at various growth stages.

(b) The efficiency of three formulations of chlorflurazole for selective weed control in flax.

(c) The influence of a wetting agent and/or MCPA on the efficiency of chlorflurazole for weed control.

(d) The effect of chlorflurazole and chlorflurazole-MCPA mixtures applied to flax and wheat in various volumes of diluent.

(e) The effect of mixtures of chlorflurazole with MCPA or mecoprop on oats and barley.

(f) The effect of chlorflurazole and chlorflurazole-MCPA mixtures on protein content of wheat and oil content of flax.

All experiments with flax were conducted at the Glenlea Research Station on summerfallow land (Osborne clay soil). The experiments with cereal crops were conducted at the University of Manitoba (Riverdale clay loam) on land which had previously been sown to flax. To ensure an adequate infestation of weeds at the Glenlea location, a mixture of weed seeds consisting mainly of *Polygonum convolvulus* and *P. scabrum* was broadcast over the area and harrowed twice prior to seeding. The University of Manitoba site had been given similar treatment in late

1965 and a uniformly heavy infestation of weeds occurred in 1967.

Field plots were seeded with a 6-foot press drill, each plot being 6 by 16 feet in size and accommodating 12 rows of crop. All herbicide applications were made with a small plot sprayer delivering the appropriate volume of application at 45 p.s.i. Sprayer nozzles were varied to achieve the desired volume of application.

Visual estimates of crop injury and weed control were made on a 0-10 basis (0 = no damage, 10 = complete kill). At maturity, a 30 square foot sample from the center of each plot was harvested with a small plot harvester. Crop yields and the percent of weed seeds found in the threshed sample were recorded. Data from each project were subjected to statistical analysis as outlined by Steel and Torrie (18).

(a) The effect of chlorflurazole and chlorflurazole-MCPA mixtures applied to flax at various growth stages.

Flax (variety Bolley) was seeded May 28, 1966 at the rate of 35 pounds per acre. The following treatments were applied in 5.5 gallons per acre total solution at three stages of crop growth (dosage is expressed as acid equivalent or active ingredient): chlorflurazole S* at 4, 8, 12 and 16 ounces per acre; chlorflurazole S at 4, 8, 12 and 16 ounces per acre in combination with MCPA** at 3 ounces per acre; and MCPA at 6 ounces per acre was included as a standard treatment. The first stage was treated June 20 when the flax was 1 to 2 inches in height; the second stage was treated June 30 when the flax was 6 inches

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* Sodium salt formulation. Formulated by Fisons Pest Control Ltd.

** MCPA (Sodium and Potassium salt).

in height; and the third stage was treated June 13 when the flax was in the bud stage. Weed control and crop injury were assessed visually on July 11 and July 19 and the crop was harvested September 14. Percent dockage was obtained for all treatments by screening the threshed sample to remove the weed seeds. To reduce variability, all samples were screened in a similar manner. The experimental design used in this project was a split-plot with 4 replicates. Stages of growth constituted the main plots and chemical treatments the sub-plots.

(b) The efficiency of three formulations of chlorflurazole for selective weed control in flax.

Flax (variety Bolley) was seeded May 28, 1966 at 35 pounds per acre. The following treatments were applied in 5.5 gallons per acre total solution at two stages of crop growth (dosage is expressed as acid equivalent or active ingredient): chlorflurazole S at 4, 8, 12 and 16 ounces per acre; chlorflurazole NH_4* at 4, 8, 12 and 16 ounces per acre and chlorflurazole S at 4, 8, 12 and 16 ounces per acre in combination with MCPA at 3 ounces per acre. The first stage was treated June 17 when the flax was 2 inches in height and the second stage was treated June 30 when the flax was 6 inches in height. Weed control and crop injury were assessed visually on July 11 and July 19 and the crop was harvested September 14. Percent dockage was determined as outlined in the previous experiment. The experimental design used in this project was a split-plot with 4 replicates. Stages of growth constituted the main plots and chemical treatments the sub-plots.

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* Ammonium salt formulation. Formulated by Fisons Pest Control Ltd.

(c) The influence of a wetting agent and/or MCPA on the efficiency of chlorflurazole for weed control.

A mixture of Polygonum convolvulus and P. scabrum was broadcast seeded on May 26, 1966 and soil incorporated by cultivating and harrowing. Amaranthus retroflexus also grew in abundance in the plot area. The following treatments were applied to the pure stand of weeds in 5.5 gallons per acre total solution at two stages of weed growth (dosage is expressed as acid equivalent or active ingredient): chlorflurazole S at 4, 8, 12 and 16 ounces per acre; chlorflurazole W* at 4, 8, 12 and 16 ounces per acre and chlorflurazole W at 4, 8, 12 and 16 ounces per acre in combination with MCPA at 6 ounces per acre. The first stage was treated June 24 when the weeds had 2 to 4 true leaves and the second stage was treated July 13 when the weeds varied from 6 inches in height to flowering. Weed control was assessed visually July 19 and samples of Polygonum scabrum, P. convolvulus and Amaranthus retroflexus were harvested by hand from square-yard areas in each plot on August 25. The samples were threshed and yield of weed seeds was recorded as a means of assessing control. The experimental design used in this project was a split-plot with 4 replicates. Stages of growth constituted the main plots and chemical treatments the sub-plots.

(d) The effect of chlorflurazole and chlorflurazole-MCPA mixtures applied to wheat and flax in various volumes of diluent.

Flax (variety Noralta) was seeded May 17, 1967 at the rate of

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* Chlorflurazole with wetting agents added. Formulated by Fisons Pest Control Ltd.

35 pounds per acre. The following treatments were applied June 14 in three volumes of application (5.2, 7.8, 15.0 gallons of water per acre) when the flax was 2 inches in height (dosage is expressed as acid equivalent or active ingredient): chlorflurazole S at 12, 18 and 24 ounces per acre; chlorflurazole S at 8, 10 and 12 ounces per acre in combination with MCPA at 6 ounces per acre, and MCPA at 8 ounces per acre was included as a standard treatment. Weed control and crop injury were assessed visually on June 15 and June 28 and the crop was harvested August 30. The experimental design used in this project was a split-plot with 4 replicates. Volumes of application constituted the main plots and chemical treatments the sub-plots.

Wheat (variety Manitou) was seeded on May 11, 1967 at the rate of 60 pounds per acre. The following treatments were applied May 29 in four volumes of application (2.2, 5.2, 7.8, 15.0 gallons of water per acre) when the wheat was in the 2 leaf stage of growth (all treatments are expressed as chlorflurazole + MCPA* acid equivalent or active ingredient): 4 + 4, 6 + 4, 8 + 4, 8 + 8, 12 + 8, 16 + 8, 16 + 16, 32 + 16 ounces per acre, and MCPA at 8 ounces per acre was included as a standard treatment. Weed control and crop injury were assessed visually on May 31, June 9 and June 28 and the crop was harvested on August 22. The experimental design used in this project was a split-plot with 4 replicates. Volumes of application constituted the main plots and chemical treatments the sub-plots.

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* Mixture formulated by Fisons Pest Control Ltd.

(e) The effect of mixtures of chlorflurazole with MCPA or mecoprop on oats and barley.

Oats (variety Harmon) at 56 pounds per acre and barley (variety Conquest) at 76 pounds per acre were seeded May 11, 1967. The following treatments were applied May 29 in 7.8 gallons per acre total solution when the crops were in the 3 leaf stage of growth (all treatments are expressed as chlorflurazole + MCPA* acid equivalent or active ingredient): 4 + 4, 6 + 4, 8 + 4, 12 + 8, 16 + 8, 16 + 16, 24 + 16, 32 + 16 ounces per acre; (expressed as chlorflurazole + mecoprop* acid equivalent or active ingredient): 5 + 4, 10 + 8, 20 + 16 ounces per acre; and MCPA at 8 ounces per acre was included as a standard treatment. Weed control and crop injury were assessed visually on June 1 and June 9 and the crops were harvested August 23. The experimental design used in this project was a randomized block with 4 replicates.

(f) The effect of chlorflurazole and chlorflurazole-MCPA mixtures on protein content of wheat and oil content of flax.

Samples of wheat (variety Manitou) were taken from the experiment described in project (d) for protein analysis. Samples were bulked according to treatment and crude protein was determined by the standard Kjeldahl method.

The oil content and iodine values of the oil were determined on samples of flax (variety Bolley) obtained from the experiment described in project (a). The oil content (percent dry weight) determinations were

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* Mixtures formulated by Fisons Pest Control Ltd.

carried out by extraction with ether and weighing of the extracted oil according to a method outlined by Troëng (19). The oil collected from the seed samples was placed in an oil refractometer and readings were taken at 35° Centigrade. Each reading was converted to a refractive index at 25° Centigrade by use of tables included in the instruction booklet of the refractometer. The refractive index was then converted to the iodine value by means of the following formula (22):

$$\text{Iodine Number (Wijs)} = 8584.97\, n_D^{25} - 12{,}513.83$$

where n_D^{25} is the refractive index at 25° Centigrade.

RESULTS AND DISCUSSIONS

(a) The effect of chlorflurazole and chlorflurazole-MCPA mixtures applied to flax at various growth stages.

This experiment was conducted to determine the most suitable herbicidal dosage and stage of application of chlorflurazole and mixtures of chlorflurazole and MCPA for use in flax. Data on crop yields, weed control scores and the percentage of weed seeds found in the threshed samples (percent dockage) are presented in Tables 1 and 2.

There is evidence of highly significant differences in the yield of flax (Appendix 2). At stage 1 and stage 2 it is noted that, in general, the lower rates of application (4 and 8 ounces per acre and 4 + 3 and 8 + 3 ounces per acre) are not significantly different from the weed free check while the higher rates are different from the check. However, there is some variation in this trend. At stage 3 all treatments were significantly different from the weed free check but there were no differences between the treatments which may indicate that at this stage of growth the weeds and crop were too far advanced to appreciate any reduction in competition. The results appear too variable to determine an optimum chemical rate and stage of application from this experiment. However, it appears that fairly high rates (12 to 16 ounces per acre) are necessary to ensure adequate control of weeds and that the herbicide should be applied as early as possible to ensure adequate coverage of the plants.

It became evident within two days after spraying that crop injury would be severe. Partial defoliation of the basal leaves and stunting of the flax plants was noted at all rates and at each date of application.

Figure 1 compares injury to flax when sprayed at 6 inches in height with 4, 8, 12 and 16 ounces per acre of chlorflurazole. At the lower rates (4 and 8 ounces per acre) most of the flax had recovered within a few weeks and, in fact, was not delayed in maturity when compared to the check plots. At the higher rates, however, many plants did not recover although those that did recover were not delayed in maturity. Increased branching of stems was noticed in all flax plants which recovered after having been severely damaged. It is thought that the disruption of apical dominance led to the release of inhibition and subsequent growth of two new stems from the buds at the base of the cotyledons in the flax plants. This growth of new stems resulted in the yield in plots treated with the highest rates of herbicide being greater than was expected on the basis of the number of individual flax plants surviving in each plot.

Figure 2 correlates graphically the rate of application with yield of flax. It is obvious that there is almost a linear decrease in yield of flax as the rate of both chlorflurazole and chlorflurazole in combination with MCPA is increased. This graph also shows that the yield of flax was at best approximately equal to that of the unweeded check, indicating that herbicidal damage to the crop was probably the most important factor in determining the yield of flax.

There was no general trend in either weed control assessments or percent of dockage when compared to rate of herbicide. The extent of damage to weeds was very similar to that of flax and it was noted that within a few weeks after spraying most of the weeds had also recovered. At the higher rates, weeds which did recover were able to take advantage of a decrease in competition and this probably resulted in the percent of dockage in these plots being equal to that found in plots treated with lower rates of herbicide.

No attempt was made to determine the cause of injury to the flax although two possible explanations are presented:

(1) It is known that the herbicidal properties of chlorflurazole are dependent in part on the conditions of temperature and relative humidity at the time of spraying (17). It is possible that the relatively high temperatures and humidities encountered at all stages of application (Appendix 1), combined with the somewhat decreased resistance of flax to this herbicide, could account for more severe injury to the flax than was expected.

(2) Chlorflurazole is a contact herbicide and as such it is desirable that very uniform coverage of the foliage be attained. These applications were made in 5.5 gallons per acre total solution and it is possible that at this relatively low volume uniform coverage of the foliage was not attained with the result that small areas of the leaves were subjected to relatively high concentrations of herbicide. This could result in the severe necrosis noted in both flax and weeds. The competitive ability of flax would be decreased as a result of injury and plants which were severely injured would not recover. Plants which were injured only moderately, however, would recover and grow in a normal manner because of the lack of systemic transfer of the herbicide. This could explain, in part, the inadequate control of weeds and the trend toward decreasing yield of flax with increasing rate of herbicide.

On the basis of these results it was decided that in a subsequent year the experiment be altered to determine the effect of volume of application on the type of injury noted in 1966 (Project c).

Table 1. The effect of chlorflurazole and chlorflurazole-MCPA mixtures on yield of flax when applied at three stages of growth.

Treatment	Dosage oz./ac.	Yield of flax bu./ac.			
		Stage 1	Stage 2	Stage 3	Average
Weed Free Check		20.8 a	19.4 a	22.8 a	21.0
Chlorflurazole	4	16.4 cd	17.0 ab	15.3 b	16.2
Chlorflurazole	8	19.2 abc	16.1 abc	14.6 b	16.6
Chlorflurazole	12	15.2 d	11.6 d	15.5 b	14.1
Chlorflurazole	16	14.4 de	10.8 d	14.1 b	13.1
Chlorflurazole + MCPA	4 + 3	17.5 abcd	16.1 abc	14.7 b	16.1
Chlorflurazole + MCPA	8 + 3	11.4 ef	15.0 bc	13.9 b	13.4
Chlorflurazole + MCPA	12 + 3	8.8 f	13.0 cd	13.0 b	11.6
Chlorflurazole + MCPA	16 + 3	11.5 ef	11.1 d	12.0 b	11.5
Weedy Check		16.7 bcd	17.3 ab	13.6 b	15.8
MCPA	6	20.2 ab	18.0 ab	12.0 b	16.7

* In any one stage of treatment, yields followed by the same letter are not significantly different at the 5% level of probability.

Table 2. The effect of chlorflurazole and chlorflurazole-MCPA mixtures on weed control and percent dockage in flax when applied at three stages of growth.

Treatment	Dosage oz./ac.	Weed Control (0-10) *			Percent Dockage **		
		Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
Weed Free Check	--	10	10	10	0	0	0
Chlorflurazole	4	2	3	2	14.2	17.3	21.4
Chlorflurazole	8	4.5	2	2	12.4	22.5	17.3
Chlorflurazole	12	4.5	5	2	16.7	17.0	18.2
Chlorflurazole	16	4	3	3	20.1	29.9	22.5
Chlorflurazole + MCPA	4 + 3	3	2	2	14.1	20.7	15.7
Chlorflurazole + MCPA	8 + 3	5	5	2	13.0	12.0	18.5
Chlorflurazole + MCPA	12 + 3	3	5	4	30.9	22.1	15.7
Chlorflurazole + MCPA	16 + 3	5	6	4	21.8	15.6	20.1
Weedy Check	--	0	0	0	13.1	14.0	19.9
MCPA	6	4	3	0	15.6	16.2	21.1

* Weed Control (0 = no injury 10 = complete kill)

** Weed Seeds in threshed sample as a percent of sample weight.

Figure 1. The effect of various rates of chlorflurazole applied to flax at the 6 inch stage of growth, 1966.

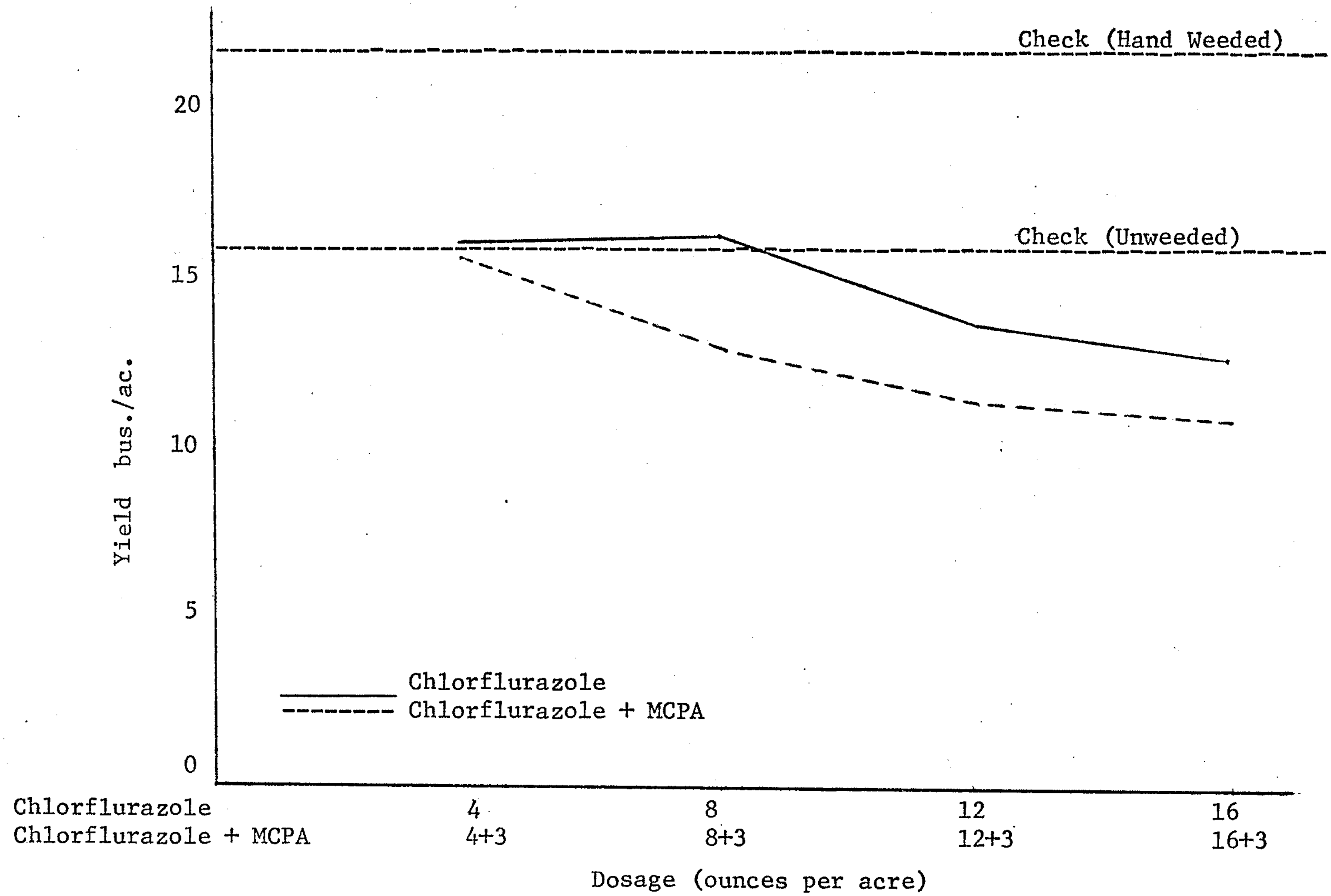

Figure 2. A comparison of the average yield of flax with dosage of chlorflurazole and chlorflurazole-MCPA mixtures.

(b) The efficiency of three formulations of chlorflurazole for selective weed control in flax.

This project was conducted to compare the sodium salt (S) formulation of chlorflurazole, with or without the addition of MCPA, with the ammonium salt (NH_4) formulation of chlorflurazole when applied to flax. Data on crop yields, weed control assessments and percent of weed seeds in the threshed samples are presented in Tables 3 and 4.

There was no evidence of any significant differences between either the dates of spraying or the treatments (Appendix 3). The only check plot included was unweeded so it must be concluded that none of the treatments resulted in yields which were significantly greater than would have been obtained under untreated conditions. There are two possible reasons for this: (1) Weed control was not adequate to result in increased yields, or (2) crop injury was sufficiently severe to offset any gain in weed control. Injury to both the flax and the weeds followed a pattern similar to that obtained in Project (a). Based upon assessments of weed control and crop injury, the low yields of flax in this experiment were a result of a combination of both inadequate weed control and excessive crop injury.

It is interesting to compare the performance of chlorflurazole alone with the chlorflurazole-MCPA mixtures as found in both Projects (a) and (b). Projects (a) and (b) both contain the same rates of chlorflurazole and chlorflurazole-MCPA mixtures applied under similar or nearly similar conditions, the only difference being that stage 1 of Project (b) was sprayed June 17 when the relative humidity was 90 percent and stage 1 of Project (a) was sprayed June 20 when the relative humidity was 49 percent (Appendix 1). The average weed control assessments and crop yields for both dates of spraying are presented in Figures 3 to 6. It is interesting to note that in almost all cases the chlorflurazole-MCPA mixtures result in higher weed control assessments and lower crop yields. This is also noted in Figure 2. This is thought to be a reflection of increased activity provided by the addition of MCPA to chlorflurazole. However, as this is neither a consistent nor significant trend it cannot be concluded that the addition of a hormone type herbicide, in fact, results in a synergistic increase in the activity of chlorflurazole.

Weed control assessments and crop yields for the ammonium salt (NH_4) formulation of chlorflurazole are also presented in Figures 3 to 6. Flax yields are quite variable at the second stage of spraying with no general trend observable, while at the first stage higher herbicidal rates resulted in higher yields. Weed control was generally poorer than that shown by the other two formulations at all rates and stages of application. There were no significant differences in yields, so it cannot be concluded that the ammonium salt formulation of chlorflurazole is less suited for use on flax.

Table 3. The effect of various formulations of chlorflurazole on yield of flax, 1966.

Treatment	Dosage oz./ac.	Yield of flax bu./ac. **	
		Date 1	Date 2
Weedy Check	--	16.2	11.9
Chlorflurazole S *	4	13.9	16.9
Chlorflurazole NH_4 *	4	13.1	15.8
Chlorflurazole S + MCPA	4 + 3	16.4	16.4
Chlorflurazole S	8	14.6	19.0
Chlorflurazole NH_4	8	16.4	21.0
Chlorflurazole S + MCPA	8 + 3	16.8	16.3
Chlorflurazole S	12	15.8	17.2
Chlorflurazole NH_4	12	15.6	15.7
Chlorflurazole S + MCPA	12 + 3	14.6	11.6
Chlorflurazole S	16	16.2	15.6
Chlorflurazole NH_4	16	17.2	17.9
Chlorflurazole S + MCPA	16 + 3	18.1	11.1

* Formulated by Fisons Pest Control Ltd.

** No significant differences

Table 4. The effect of various formulations of chlorflurazole on weed control and percent dockage in flax, 1966.

Treatment	Dosage oz./ac.	Weed Control (0-10) *		Percent Dockage **	
		Date 1	Date 2	Date 1	Date 2
Weedy Check	--	0	0	16.8	31.2
Chlorflurazole S	4	2.5	3	28.8	22.6
Chlorflurazole NH_4	4	2	3	31.8	24.1
Chlorflurazole S + MCPA	4 + 3	2.5	4	23.9	19.7
Chlorflurazole S	8	3	4.5	26.8	15.0
Chlorflurazole NH_4	8	4	3.5	24.6	15.0
Chlorflurazole S + MCPA	8 + 3	3	3.5	18.9	16.3
Chlorflurazole S	12	3	4.5	35.6	18.1
Chlorflurazole NH_4	12	2	2.5	27.3	23.8
Chlorflurazole S + MCPA	12 + 3	3	5	24.7	24.4
Chlorflurazole S	16	4	3	20.5	28.3
Chlorflurazole NH_4	16	4	2.5	16.1	24.0
Chlorflurazole S + MCPA	16 + 3	4.5	4	16.3	28.5

* Weed control (0 = no injury 10 = complete kill)

** Weed seeds in threshed sample as a percent of sample weight.

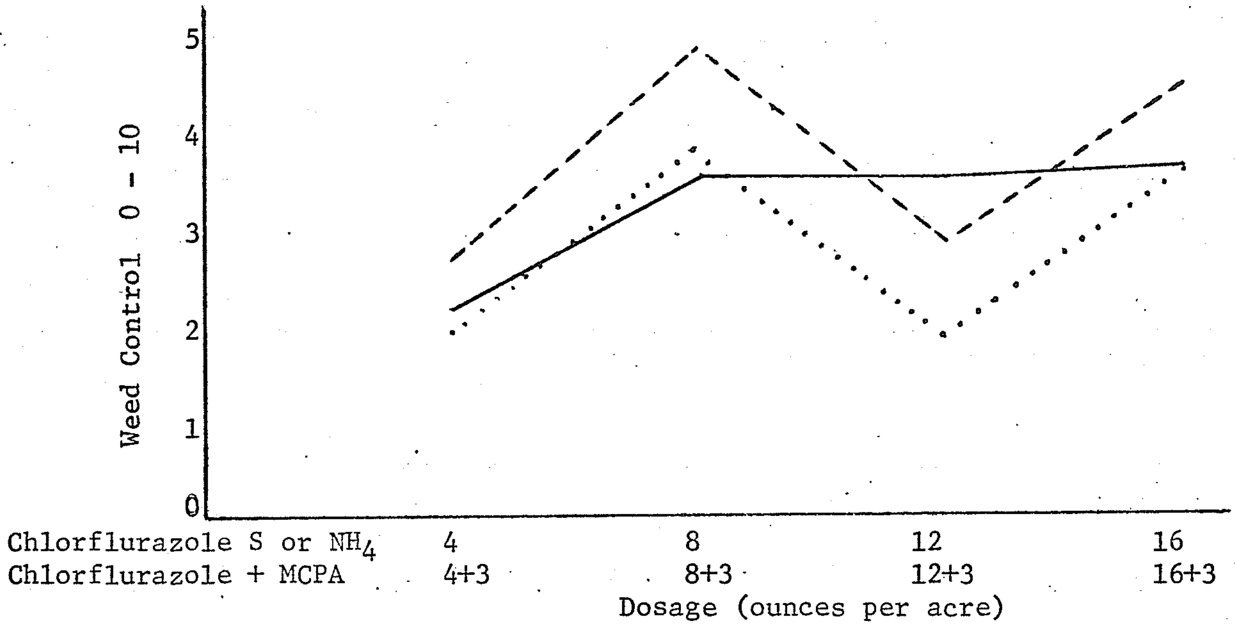

Figure 3. A comparison of average weed control assessments with rates of chlorflurazole formulations applied to flax at the 2 inch stage of growth.

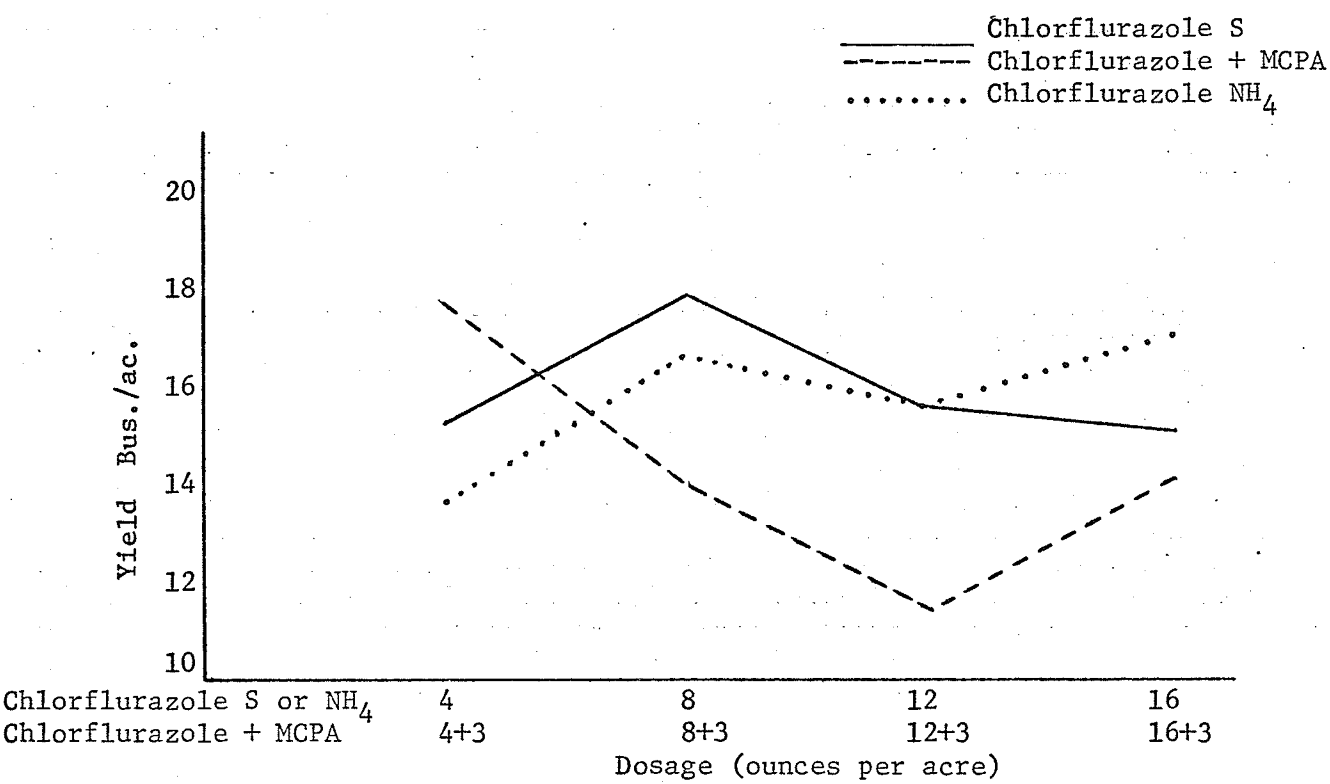

Figure 4. A comparison of average yields of flax with rates of chlorflurazole formulations applied to flax at the 2 inch stage of growth.

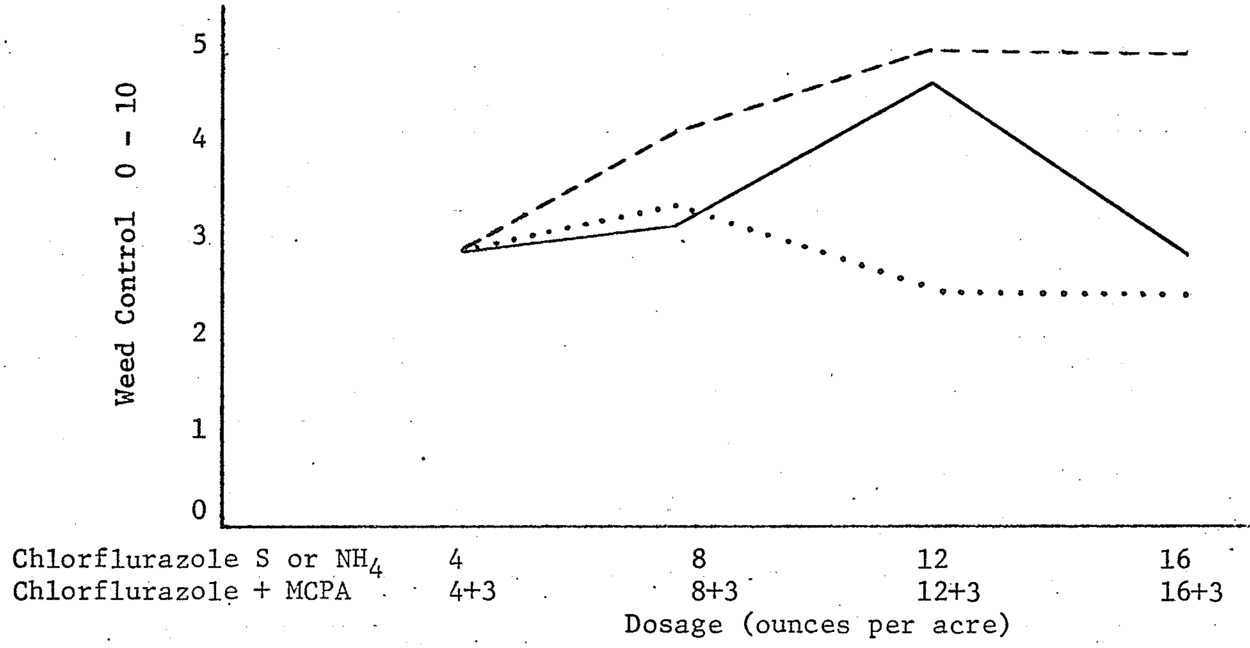

Figure 5. A comparison of average weed control assessments with rates of chlorflurazole formulations applied to flax at the 6 inch stage of growth.

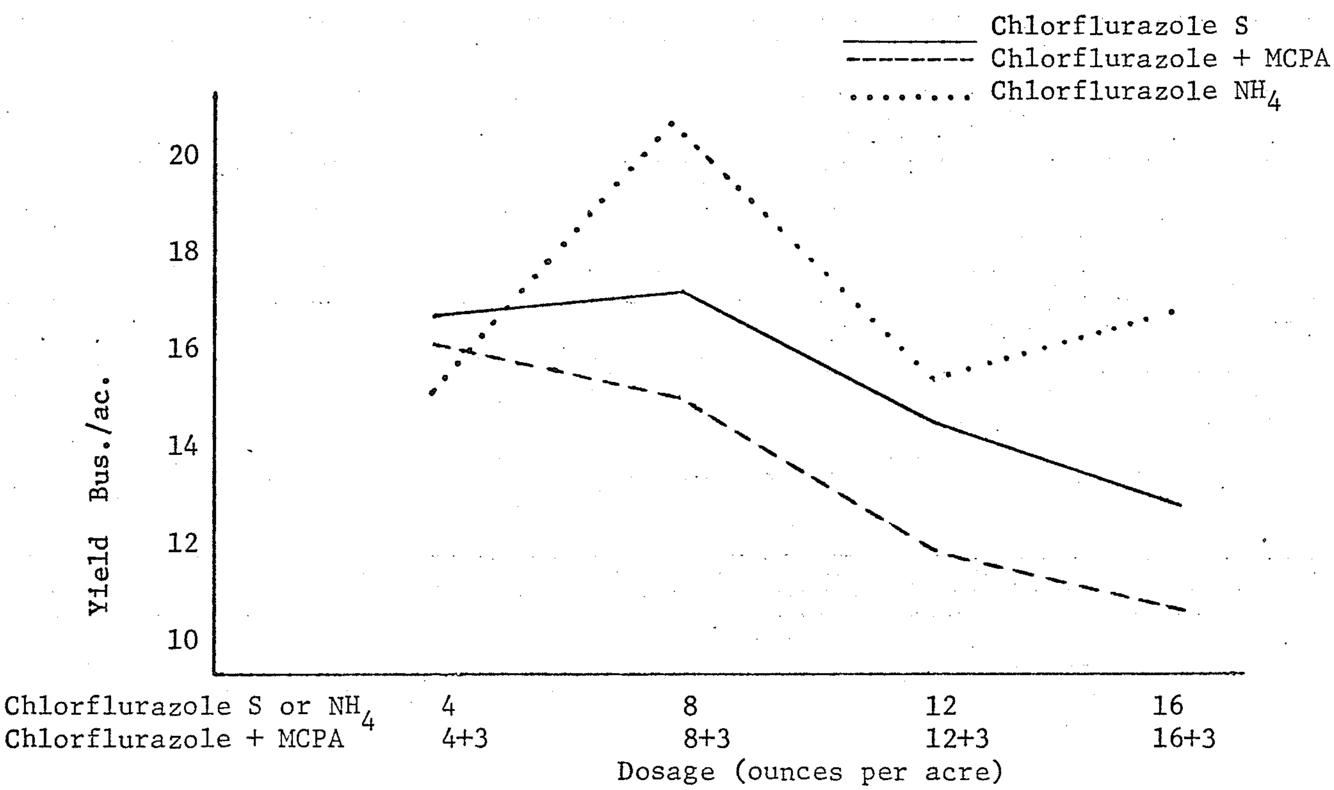

Figure 6. A comparison of average yields of flax with rates of chlorflurazole formulations applied to flax at the 6 inch stage of growth.

(c) The influence of a wetting agent and/or MCPA on the efficiency of chlorflurazole for weed control.

This experiment was conducted to determine the efficiency of a wetting agent and/or MCPA in mixture with chlorflurazole for the control of Polygonum convolvulus and P. scabrum. For this purpose, a pure stand of weeds was established (see page 11). Comparisons were based upon weed control assessments and yields of weed seeds.

Data on weed control and yield of weed seeds are presented in Table 5. There was evidence of significant differences between treatments but not between dates of application (Appendix 4). Figure 7 correlates graphically yield of weed seeds with rates of chlorflurazole mixtures. Although the results are highly variable, it appears that the higher rates of chlorflurazole W (wetting agents added) with MCPA result in better weed control than chlorflurazole alone or with just wetting agents added. It is possible, then, that the addition of wetting agents or MCPA alone will not increase the activity of chlorflurazole to a significant extent, but that the addition of both MCPA and wetting agents is significant in increasing the performance of this herbicide.

The initial effect of chlorflurazole on broadleaved weed species is very pronounced. Within three hours after spraying all broadleaved species were wilted to a considerable degree, and within two to three days after spraying severe leaf necrosis was noted. However, there was little or no translocation of the herbicide. On some plants the basal leaves, which may have been shielded from the spray application, appeared healthy and enabled these plants to eventually recover. Two weeks after treatment plots showing little or no initial control contained a dense stand of weeds while those showing a high degree of initial control contained very few weeds.

The yield of weed seeds as a measure of control was subject to some variation. Weeds which survived in plots showing a high initial degree of control were able to take advantage of the decrease in competition, and produced vigorous growth. This resulted in an increase in seed production when compared to the seed production, per plant, in plots showing little initial control.

The variability in results noted with the formulations of chlorflurazole with wetting agents and chlorflurazole with MCPA may be explained by suggesting that re-growth after treatment, with the resultant variation in degree of plant competition, gave results inconsistent with what would be expected had any one treatment resulted in nearly complete control of weeds.

Table 5. The influence of a wetting agent and/or MCPA on the efficiency of chlorflurazole for weed control.

Treatment	Dosage oz/ac.	Weed Control (0-10)**		Yield of Weed Seeds*** gms/sq.yd.	
		Date 1	Date 2	Date 1	Date 2
Chlorflurazole S	0	0	0	108.7 ab	71.6 ab
	4	4	4	69.3 abc	82.0 ab
	8	4	4	23.5 c	35.0 ab
	12	6	5	55.0 bc	48.0 ab
	16	4	4	45.8 bc	19.7 ab
Chlorflurazole W*	0	0	0	136.5 a	94.3 a
	4	4	4	34.8 bc	40.3 ab
	8	2	4	52.3 bc	45.8 ab
	12	3	4	83.5 abc	93.5 ab
	16	4	5	48.5 bc	31.7 ab
Chlorflurazole W* + MCPA	0 + 6	-	-	66.0 abc	66.3 ab
	4 + 6	4	4	64.5 abc	49.3 ab
	8 + 6	4	4	22.1 c	42.5 ab
	12 + 6	6	6	16.3 c	18.0 ab
	16 + 6	6	6	29.3 c	15.5 b

* Chlorflurazole (wetting agents added)

** Weed Control (0 = no injury 10 = complete kill)

*** Predominantly <u>Polygonum scabrum</u>, <u>P. convolvulus</u> and <u>Amaranthus retroflexus</u>.

Yields followed by the same letter are not significantly different at the 5% level of probability.

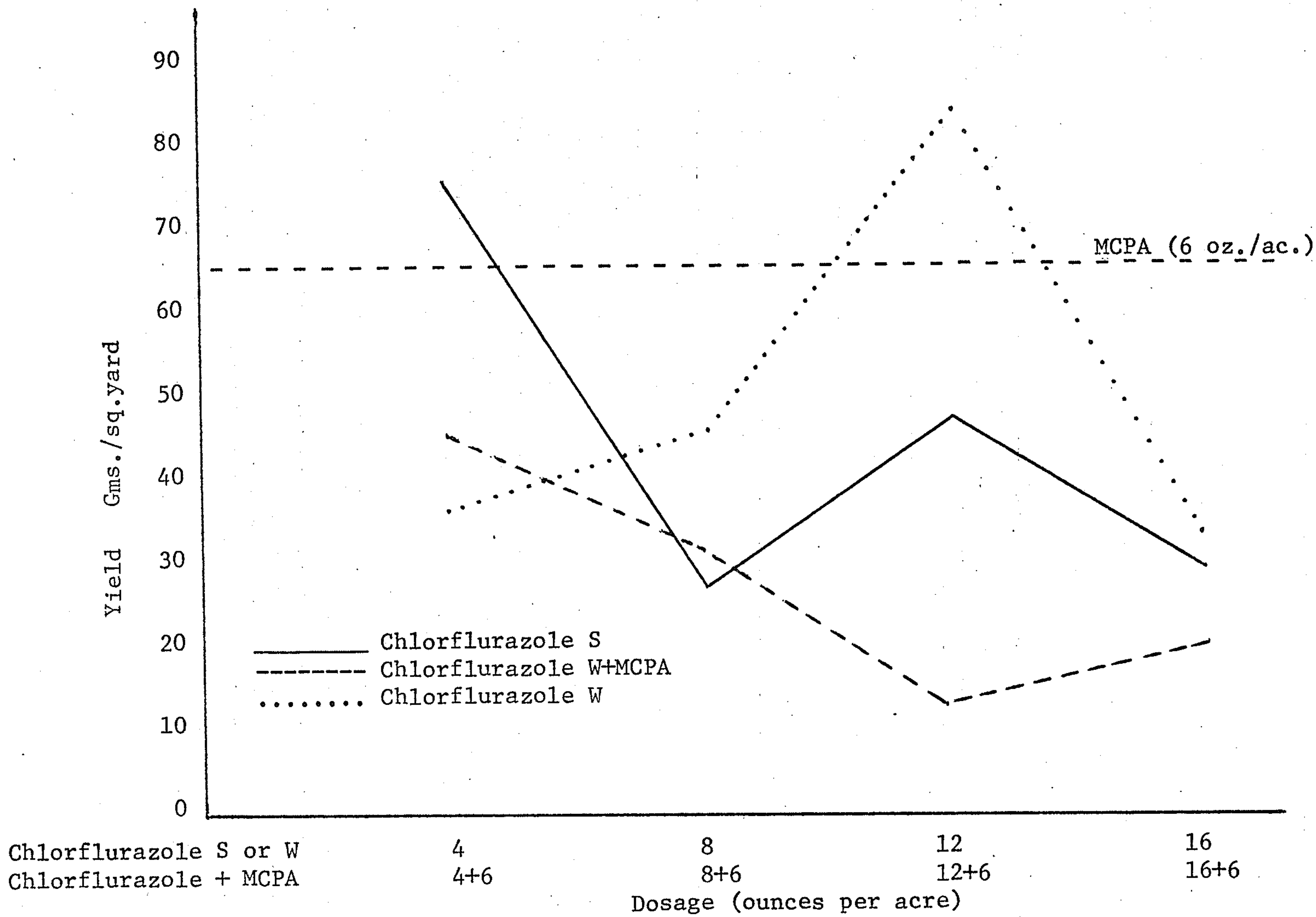

Figure 7. A comparison of average yield of weed seeds with dosage of chlorflurazole.

(d) The effect of chlorflurazole and chlorflurazole-MCPA mixtures applied to wheat and flax in various volumes of diluent.

This project was conducted to determine the most suitable herbicidal dosage and volume of application of chlorflurazole and mixtures of chlorflurazole and MCPA in wheat and flax with the possibility of explaining more fully the results obtained in the 1966 project (Project a). Data on crop yields, crop injury and weed control assessments are presented in Tables 6, 7 and 8.

There was no evidence of significant differences between the yields at different volumes of application in wheat (Appendix 5) although there was evidence of differences between the treatment yields. It is difficult to establish significant trends in the treatment differences although it may be seen that, in general, the lower rates (4 + 4, 6 + 4, 8 + 4 ounces per acre) gave poorer weed control and decreased yield when compared to the higher rates which gave consistently better weed control and increased yield. No crop injury was visible two days after spraying, so it appeared that increased weed control alone resulted in the higher yields. It appeared that any treatment of at least 8 + 8 ounces per acre resulted in very good weed control and crop yield in wheat and that crop injury in wheat was insignificant even at very high rates of herbicide. The fact that there were no significant differences in yields at different volumes of application indicated that volumes as low as 2.2 gallons per acre were adequate for uniform coverage of the plants and optimum selectivity of the herbicide in wheat.

In flax there was evidence of treatment differences (Appendix 6) but no evidence of yield differences at various volumes of application.

Crop injury in the form of necrotic basal leaves was noticeable to a slight extent for several days after spraying but had fully disappeared by harvest. It appeared to have no effect on crop yield.

The variation in treatment yields, especially at 15.0 gallons per acre, was probably due to uneven germination which occurred in one small section of the plot area, rather than to an effect of either the herbicide or the volume of application.

Weed control was not considered as an important part of this test as both *Polygonum convolvulus* and *P. scabrum* had reached the 4 to 5 leaf stage at the time of spraying. At this stage of growth, weed control was expected to be decreased. This is substantiated by the data on yield. There is no linear increase in yield as a result of better weed control with increased rate of herbicide as had been observed with wheat (Page 32).

A comparison of this experiment with Project (a) will serve to point out the variable results obtained with this herbicide. In 1967, although higher rates of herbicide were used, crop injury and yield were not affected; while under similar conditions in 1966 crop injury was significant in reducing yield. One possible explanation for the conflicting results could be that different flax varieties were used in the two years.

Table 6. The effect of chlorflurazole-MCPA mixtures on yield of wheat and weed control when applied in 2.2 and 5.2 gallons of water per acre.

Treatment	Dosage oz./ac.	2.2 gpa		5.2 gpa	
		Weed Control*	Yield** bu./ac.	Weed Control	Yield** bu./ac.
Weed Free Check	--	10	61.0 a	10	44.7 bc
Chlorflurazole-MCPA	4 + 4	2.0	25.2 c	4.5	51.7 abc
Chlorflurazole-MCPA	8 + 8	6.5	47.4 ab	8.0	51.4 abc
Chlorflurazole-MCPA	16 + 16	8.0	53.8 ab	8.5	64.8 a
Chlorflurazole-MCPA	6 + 4	6.5	55.3 ab	7.5	41.3 bc
Chlorflurazole-MCPA	12 + 8	6.5	50.6 ab	8.5	51.3 bc
Chlorflurazole-MCPA	24 + 16	7.0	46.7 ab	9.0	60.6 ab
Chlorflurazole-MCPA	8 + 4	5.0	36.3 bc	7.5	46.7 abc
Chlorflurazole-MCPA	16 + 8	8.0	56.6 ab	9.0	51.6 abc
Chlorflurazole-MCPA	32 + 16	9.0	59.8 a	9.0	54.7 ab
MCPA (Na Salt)	8	3.5	45.2 ab	2.5	42.8 bc
Weedy Check	--	0	39.4 bc	0	38.3 c

* Weed control (0 = no injury 10 = complete kill)

** Yields followed by the same letter are not significantly different at the 5% level of probability.

Table 7. The effect of chlorflurazole-MCPA mixtures on yield of wheat and weed control when applied in 7.8 and 15.0 gallons of water per acre.

Treatment	Dosage oz./ac.	7.8 gpa Weed Control*	7.8 gpa Yield** bu./ac.	15.0 gpa Weed Control*	15.0 gpa Yield** bu./ac.
Weed Free Check	--	10	60.6 a	10	54.7 ab**
Chlorflurazole-MCPA	4 + 4	5.5	46.9 a	6.0	43.4 ab
Chlorflurazole-MCPA	8 + 8	8.0	54.9 a	6.0	42.3 ab
Chlorflurazole-MCPA	16 + 16	8.5	55.3 a	5.0	55.2 ab
Chlorflurazole-MCPA	6 + 4	6.0	50.9 a	5.5	57.3 a
Chlorflurazole-MCPA	12 + 8	7.5	59.1 a	8.0	53.1 ab
Chlorflurazole-MCPA	24 + 16	8.0	52.9 a	8.0	56.7 a
Chlorflurazole-MCPA	8 + 4	5.5	47.9 a	6.0	53.0 ab
Chlorflurazole-MCPA	16 + 8	8.5	58.0 a	8.5	46.4 ab
Chlorflurazole-MCPA	32 + 16	9.0	51.5 a	9.0	59.7 a
MCPA (Na Salt)	8	2.0	51.5 a	3.5	55.3 ab
Weedy Check	--	0	47.7 a	0	36.4 b

* Weed control (0 = no injury 10 = complete kill)

** Yields followed by the same letter are not significantly different at the 5% level of probability.

Table 8. The effect of chlorflurazole and chlorflurazole-MCPA mixtures on yield of flax and crop injury when applied in three different volumes of water per acre.

Treatment	Dosage oz./ac.	5.2 gpa		7.8 gpa		15.0 gpa	
		Crop* Injury	Yield** bu./ac.	Crop Injury	Yield bu./ac.	Crop Injury	Yield bu./ac.
Chlorflurazole S	12	0.25	21.6 a	0.75	17.9 a	0.00	19.9 ab
Chlorflurazole S	18	0.75	19.3 ab	0.50	19.2 a	0.75	17.2 abc
Chlorflurazole S	24	1.00	21.0 ab	1.00	17.9 a	0.75	17.6 abc
Chlorflurazole S + MCPA	8 + 6	1.00	18.0 ab	0.75	17.8 a	0.25	14.8 c
Chlorflurazole S + MCPA	10 + 6	1.00	20.8 ab	1.00	19.4 a	0.50	18.0 abc
Chlorflurazole S + MCPA	12 + 6	1.00	20.6 ab	1.00	18.3 a	0.75	18.4 abc
MCPA (Na Salt)	8	1.25	17.3 b	0.75	20.2 a	0.50	16.8 bc
Weedy Check	--	0.00	19.6 ab	0.00	17.4 a	0.00	17.0 bc
Weed Free Check	--	0.00	19.2 ab	0.00	20.2 a	0.00	20.8 a

* Crop injury (0 = no injury 10 = complete kill)

** Yields followed by the same letter are not significantly different at the 5% level of probability.

(e) The effect of mixtures of chlorflurazole with MCPA or mecoprop on oats and barley.

This experiment was conducted to determine the response of oats and barley to chlorflurazole in combination with MCPA or mecoprop, on the basis of weed control and crop injury. Data on weed control assessments and yield of oats and barley are presented in Table 9.

There was no evidence of significant differences in crop yields (Appendix 7) and no general trend toward higher yield with increased dosage of herbicide as was evident in Project (d). A trend in yield was expected on the basis of the initial weed control assessments, but in the course of the growing season both the oats and barley developed vigorous stands, which probably eliminated significant weed competition. This is especially noticeable in the MCPA check in which weed control was negligible, yet yield was not reduced. The chlorflurazole and mecoprop combination resulted in some leaf necrosis in barley but this had disappeared within two weeks of treatment and did not appear to affect yield.

All of the treatments except the lowest rates of each combination resulted in excellent weed control. Weed control at the lower rates was initially poor but did not necessarily result in lower yields.

It can not be concluded, on the basis of this experiment, that the combination of chlorflurazole with MCPA is better suited than the combination of chlorflurazole with mecoprop for use in barley and oats. Rather, it appears that either combination is safe to use in these crops even at the highest rates encountered in this experiment. On the basis of initial weed control it appears that a minimum dosage of chlorflurazole with MCPA at 8 + 8 ounces per acre or chlorflurazole with mecoprop at 5 + 4 ounces per acre would be required for satisfactory results in oats and barley.

Table 9. The effect of chlorflurazole in combination with MCPA or mecoprop on weed control and yield in oats and barley.

Treatment	Dosage	Oats		Barley	
	oz./ac.	Weed* Control	Yield** bu./ac.	Weed Control	Yield bu./ac.
Weed Free Check	--	10	105.1	10	100.7
Chlorflurazole + MCPA	4 + 4	4.5	79.3	3.0	101.7
Chlorflurazole + MCPA	8 + 8	7.0	123.6	6.0	96.0
Chlorflurazole + MCPA	16 + 16	9.0	107.1	8.0	104.0
Chlorflurazole + MCPA	6 + 4	6.0	122.2	4.0	94.6
Chlorflurazole + MCPA	12 + 8	8.0	111.5	8.0	109.2
Chlorflurazole + MCPA	24 + 16	9.0	116.9	9.0	91.0
Chlorflurazole + MCPA	8 + 4	7.0	113.8	7.0	89.7
Chlorflurazole + MCPA	16 + 8	8.5	95.6	8.0	104.3
Chlorflurazole + MCPA	32 + 16	9.0	98.8	9.0	100.0
Chlorflurazole + mecoprop	5 + 4	6.5	108.3	5.0	98.7
Chlorflurazole + mecoprop	10 + 8	8.5	70.2	8.0	106.5
Chlorflurazole + mecoprop	20 + 16	9.5	82.5	9.0	93.0
MCPA	8	2.5	90.8	1.5	98.5
Weedy Check	--	0	123.7	0	93.9

* Weed control (0 = no injury 10 = complete kill)

** No significant differences

(f) The effect of chlorflurazole and chlorflurazole-MCPA mixtures on protein content of wheat and oil content of flax.

The crude protein of wheat samples taken from Project (d) was determined by the standard Kjeldahl method. Results are presented in Table 10.

Oil content values for duplicate flax samples taken from Project (a) were determined and are presented in Table 11. The iodine values were determined from the same samples and are also presented in Table 11. The iodine values are a measure of the degree of unsaturation in the long chain fatty acids found in the oil. A high iodine value indicates a high number of unsaturated double bonds and hence a rapidly drying, high quality oil.

Statistical analysis was considered of questionable value on the data as presented. However, the results agree with what would be expected from untreated samples. It appears, therefore, that chlorflurazole has no adverse effect on protein content of wheat or oil content of flax.

Table 10. The effect of chlorflurazole-MCPA mixtures on protein content of wheat.

Treatment	Dosage oz./ac.	Protein Content of Wheat *		
		2.2 gal./ac.	7.8 gal./ac.	15.0 gal./ac.
Weed Free Check	--	18.0	18.5	17.6
Chlorflurazole + MCPA	4 + 4	18.1	18.5	17.3
Chlorflurazole + MCPA	8 + 8	18.0	17.7	18.2
Chlorflurazole + MCPA	16 + 16	18.4	18.1	17.9
Chlorflurazole + MCPA	6 + 4	18.0	18.4	17.3
Chlorflurazole + MCPA	12 + 8	17.3	18.3	18.0
Chlorflurazole + MCPA	24 + 16	17.1	17.5	18.1
Chlorflurazole + MCPA	8 + 4	17.2	18.2	17.9
Chlorflurazole + MCPA	16 + 8	18.4	18.3	18.7
Chlorflurazole + MCPA	32 + 16	18.2	18.0	18.4
MCPA	8	17.8	18.4	18.2

* Percent Dry Weight

Table 11. The effect of chlorflurazole and chlorflurazole-MCPA mixtures on oil content and iodine value of flax.

Treatment	Dosage oz./ac.	Oil Content *			Iodine Value		
		Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
Weed Free Check	--	43.5	43.3	43.7	197.9	193.8	194.2
Chlorflurazole	4	42.9	43.6	43.3	194.3	194.5	195.2
Chlorflurazole	8	43.4	43.4	43.2	197.6	195.2	195.2
Chlorflurazole	12	43.2	42.8	43.0	195.7	195.0	195.8
Chlorflurazole	16	43.4	42.8	43.1	196.1	195.5	195.8
Chlorflurazole + MCPA	4 + 3	43.5	43.2	42.6	196.8	194.0	194.0
Chlorflurazole + MCPA	8 + 3	43.3	43.3	43.1	197.6	197.1	196.6
Chlorflurazole + MCPA	12 + 3	43.0	42.7	43.0	196.8	197.3	197.0
Weedy Check	--	43.0	43.9	43.5	193.0	194.7	194.5
MCPA	6	43.4	43.8	42.2	193.5	196.6	194.2

* Percent Dry Weight

SUMMARY AND CONCLUSIONS

Weed species resistant to the phenoxyacetic herbicides have become increasingly serious in Western Canada over the past twenty years. This has resulted in considerable research aimed at developing herbicides suitable for their control. In view of this, a two-year project was undertaken at the University of Manitoba to study the effectiveness of chlorflurazole as a possible selective herbicide for the control of certain resistant weeds in cereal crops and flax under Manitoba conditions.

The results of this study indicate that chlorflurazole is suitable for the control of some serious weeds, notably *Polygonum convolvulus* and *P. scabrum*, in cereal crops. However, its selectivity in flax is subject to considerable variation.

Chlorflurazole and mixtures containing chlorflurazole appear to have a wide margin of safety to cereal crops such as wheat, oats and barley. Rates of almost three times the amount required for weed control have been applied in this study, with little or no crop injury observed.

In the first year of this study, all rates of chlorflurazole and mixtures containing chlorflurazole applied to flax resulted in crop injury which was significant in reducing yield. In the second year, little or no crop injury was observed in flax, even at rates which were higher than those applied in the first year. Further evaluation of the selectivity of chlorflurazole in flax would be desirable.

Applications of chlorflurazole in both years indicated that treatment must be made as early as possible after weed emergence, preferably at the two to three leaf stage of weed growth, to obtain adequate weed control. Treatment of weeds at this stage enabled the cereal crops to produce a vigorous stand which eliminated weed competition for the remainder of the season. Poor weed control was observed in flax treated after the weeds had reached the four to five leaf stage.

The results indicate that in cereal crops an application of chlorflurazole and MCPA at 8 + 8 ounces per acre or chlorflurazole and mecoprop at 5 + 4 ounces per acre will result in adequate weed control. In flax, it appears that applications of at least 12 to 16 ounces per acre of chlorflurazole alone or in combination with MCPA at 10 + 6 ounces per acre will result in adequate weed control. However, these rates and mixtures may result in serious crop injury.

Under conditions where the weed population has not been excessive or the weeds have not become somewhat resistant due to age, the application of chlorflurazole in as low as 2.2 gallons per acre total solution has resulted in satisfactory weed control. However, results indicate that volumes up to 15.0 gallons per acre total solution may give more satisfactory results, particularly under more adverse conditions of weed growth.

Chlorflurazole appears to have no detrimental effect on quality of wheat or flax, as evidenced by the results obtained in a determination of the protein content of wheat and the oil content and iodine value of flax which had been treated with the herbicide.

It was regretfully announced by Fisons (Canada) Limited in November, 1967, that further development of chlorflurazole for herbicidal purposes has been suspended by the Company, despite its potential usefulness in cereal crops. This decision was apparently based upon a consideration of technical, toxological and economic factors.

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APPENDIX

APPENDIX 1

Weather conditions at the time of spraying 1966.

PROJECT (a)

STAGE 1 Sprayed June 20

Wind - 6-8 mph.
Humidity - 49%
Temperature - 78°F

STAGE 2 Sprayed June 30

Wind - 0-5 mph.
Humidity - 68%
Temperature - 86°F

STAGE 3 Sprayed July 13

Wind - 7-10 mph.
Humidity - 65%
Temperature - 73°F

PROJECT (b)

STAGE 1 Sprayed June 17

Wind - NIL
R. H. - 90%
Temperature - 78°F

STAGE 2 Sprayed June 30

Wind - 0-5 mph.
R. H. - 68%
Temperature - 86°F

APPENDIX 2

Analysis of Variance for the effect of Chlorflurazole and Chlorflurazole-MCPA mixtures on flax yield when applied at three stages of growth.

Source of Variation	d.f.	M.S.	F.
Stages	2	4284.00	.27* n.s.
Replicates	3	15840.91	
Error 1	6	20443.08	
Treatments	10	26317.41	17.76**
Stages x Treatments	20	9329.39	6.29**
Error 2	86	1482.13	
Total	127		

* n.s. - not significant

** Significant at the 1% level of probability

APPENDIX 3

Analysis of Variance for the effect of three formulations of Chlorflurazole on yield in flax 1966.

Source of Variation	d.f.	M.S.	F.
Stage	1	1872.30	.1108 n.s.
Replicates	3	12017.84	
Error 1	3	16488.89	
Treatments	14	6442.63	1.515 n.s.
Stages x Treatments	14	7553.98	1.776 n.s.
Error 2	84	4251.68	
Total	119		

APPENDIX 4

Analysis of Variance for the influence of a wetting agent and/or MCPA on the efficiency of Chlorflurazole for weed control.

Source of Variation	d.f.	M.S.	F.
Stage	1	1463.01	.60 n.s.
Replicates	3	4432.36	
Error 1	3	2448.71	
Treatments	14	6359.89	2.98**
Stages x Treatments	14	704.13	.35 n.s.
Error 2	84	2128.01	
Total	119		

** Significant at the 1% level of probability.

APPENDIX 5

Analysis of Variance for the effect of Chlorflurazole-MCPA on wheat yield when applied in various volumes of water.

Source of Variation	d.f.	M.S.	F.
Volumes	3	74280.93	1.48 n.s.
Replicates	3	664448.14	
Error 1	9	50236.74	
Treatments	11	121940.7	2.32**
Volumes x Treatments	33	57205.5	1.1 n.s.
Error 2	132	52359.2	
Total	191		

** Significant at the 5% level of probability.

APPENDIX 6

Analysis of Variance for the effect of Chlorflurazole and Chlorflurazole-MCPA mixtures on Flax yield when applied in various volumes of water.

Source of Variation	d.f.	M.S.	F.
Volumes	2	9654.62	.825 n.s.
Replicates	3	21651.83	
Error 1	6	11701.96	
Treatments	8	3617.98	2.195**
Volumes x Treatments	16	2062.92	1.252 n.s.
Error 2	72	1647.69	
Total	107		

** Significant at the 5% level of probability.

APPENDIX 7

Analysis of Variance for the effect of Chlorflurazole in combination with MCPA or Mecoprop on barley.

Source of Variation	d.f.	M.S.	F.
Replications	3	98545.90	3.795**
Treatments	14	29690.39	1.143 n.s.
Error	42	25965.76	
Total	59		

** Significant at the 5% level of probability.

APPENDIX 8

Analysis of Variance for the effect of Chlorflurazole in combination with MCPA or Mecoprop on oats.

Source of Variation	d.f.	M.S.	F.
Replications	3	714322.0	5.66**
Treatments	14	126786.28	1.00 n.s.
Error	42	126179.26	
Total	59		

** Significant at the 1% level of probability.