THE SELECTIVITY OF DICAMBA AND RELATED HERBICIDES IN BARLEY AND FLAX

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INTRODUCTION

Barley, a cereal crop, and flax, an oilseed crop, are crops of economic importance grown in Manitoba with approximately 2,400,000 acres devoted to their production annually. Because these crops do not compete successfully with weeds, considerable yield reductions occur each year in weed infested fields. The herbicides 2,4-D (2,4-dichlorophenoxyacetic acid) and MCPA (2-methyl-4-chlorophenoxyacetic acid) have been recommended for many years to control susceptible broad-leaved weeds in these crops, but resistant broad-leaved weeds such as wild buckwheat (*Polygonum convolvulus* L.) and green smartweed (*Polygonum scabrum* Moench.) have continued to be a problem.

Recently dicamba (2-methoxy-3,6-dichlorobenzoic acid) has been recommended for selective control of wild buckwheat and green smartweed in barley and flax. Dicamba is a hormone type herbicide which is absorbed by the roots and aerial parts of the plant. The herbicide is translocated in the growing plant to areas of high meristematic activity where it results in malformation of the plant tissue. Within a period of several weeks the plant will begin to dessicate and eventually die.

Because of limited information on the herbicidal effects of dicamba on barley and flax a study was initiated at the University of Manitoba in 1964 to determine whether this herbicide could be used to control wild buckwheat and green smartweed in barley and flax under Manitoba conditions.

Experiments were conducted to study the effect of dicamba and herbicidal mixtures containing dicamba on crop yield, crop injury, and seed quality (protein content and bushel weight) in Keystone and Parkland barley. Further studies to determine the effect of dicamba and herbicidal mixtures containing dicamba on flax yields, plant injury and oilseed quality (oil content and iodine number) were carried out. Experiments were conducted over a two-year period, 1964 and 1965.

In 1965, the study was supplemented with a project to determine the response of flax to dicamba and commercial mixtures of dicamba at different growth stages. A greenhouse project designed to study the response of flax to dicamba under varying soil and moisture conditions, was conducted in 1965.

The effectiveness of dicamba and various herbicidal mixtures containing dicamba for the control of "hard to kill" weeds was also studied. Emphasis was placed on measuring the additive effects, if any, of 2,4-D and 2-(MCPP) in commercial dicamba mixtures.

REVIEW OF LITERATURE

Wild buckwheat (Polygonum convolvulus L.), tartary buckwheat (Fagopyrum tataricum L.), and green smartweed (Polygonum scabrum Moench.) constitute major weed problems over a large portion of the cultivated acreage of Western Canada. Surveys have shown that 30,000,000 acres are infested with wild buckwheat, and 6,440,000 acres with green and pale smartweed (1). Studies conducted by Friesen and Shebeski (19) showed that 98 percent of farm fields in Manitoba had wild buckwheat as part of the weed population with 41 percent of the fields having a serious infestation.

Numerous weed competition studies have demonstrated the inability of agricultural crops to compete successfully with the above weeds. Nalewaja (47) conducted competition studies with wild buckwheat in wheat and flax. It was found that 5 wild buckwheat plants per square foot reduced wheat yields by 11.6 percent, while 20 plants per square foot reduced the yield by 27.5 percent. Similarly, 4 wild buckwheat plants per square foot in flax reduced the yield 9.5 percent and 16 plants reduced the yield by 20.1 percent. Competition studies in Manitoba showed that 43 wild buckwheat plants per square yard reduced barley yields by 6.2 percent, and 172 wild buckwheat plants per square yard reduced wheat yields by 25.7 percent (19). Dosland and Arnold (11) showed that wild buckwheat depleted soil moisture and significantly reduced the yield of spring wheat. Marten and Rademacher (40) reported that lady's thumb (Polygonum persicaria L.) reduced the shoot growth of flax and potatoes by approximately 45 percent. Vanden Born and Corns (57) studying the competition effect of tartary buckwheat on barley found that tartary buckwheat densities of 25, 50 and 100 plants per square yard reduced barley yields 7, 28 and 59 percent, respectively.

Phenoxy Herbicides

Considerable research has been conducted to study the effect of phenoxy herbicides, such as 2,4-D (2,4-dichlorophenoxyacetic acid), MCPA (2-methyl-4-chlorophenoxyacetic acid), 2-(2,4-DP) (2-(2,4 dichlorophenoxy) propionic acid), 4-(2,4-DB)(4-(2,4 dichlorophenoxy) butyric acid) and 2-(MCPP) (2-(2-methyl-4-chlorophenoxy) propionic acid) for the control of wild buckwheat, tartary buckwheat and green smartweed. It is well known that a single application of 2,4-D at 6 to 8 ounces per acre will not provide adequate control of wild buckwheat. Forsberg (15, 16) reported that fair control of wild buckwheat was achieved by a 12 to 16 ounces per acre application rate of 2,4-D. However, in the same study, it was found that two applications of 2,4-D at 5 ounces per acre, spaced one week apart, resulted in 87 percent control of wild buckwheat. The control was somewhat better than a single 10 ounce per acre rate. However, other workers found that a double application of 2,4-D was not more effective than a single application of 2,4-D for the control of wild buckwheat (8, 10, 35).

MCPA has also been evaluated as a possible herbicide for wild buckwheat control. Corns and Vanden Born (10) found that the control of wild buckwheat was less when MCPA was used as compared with 2,4-D at similar rates. Forsberg (15) reported that in comparison to 2,4-D ester formulations, MCPA ester formulations did not give satisfactory control of wild buckwheat.

Results from studies conducted on the control of green smartweed and tartary buckwheat with 2,4-D and MCPA are similar to those reported on the control of wild buckwheat. It was found that MCPA amine at 8 ounces per acre resulted in only 19 percent control while 2,4-D amine at 12 ounces per acre was only slightly more effective; however, a reduction in wheat yields was also reported (53, 54).

Ester formulations of 2,4-D applied at 8 ounces per acre to tartary buckwheat showed some stunting but otherwise had little effect on the plants, while a 2,4-D amine formulation at 8 ounces per acre in the same experiment had no appreciable effect (24). Ester formulations of MCPA were less effective than the ester formulations of 2,4-D. Vanden Born and Corns (58) concluded that 2,4 D ester at rates of 4, 8 and 12 ounces per acre reduced the stand of tartary buckwheat by 45, 65 and 70 percent respectively when treated in the early seedling stage.

Studies designed to evaluate the effect of 2-(2,4-DP), 2,4-DB, 2-(MCPP) and MCPB (4-(2-methyl-4 chlorophenoxy)butyric acid) on wild buckwheat and green smartweed have indicated that the chemicals offer no advantage over comparable rates of 2,4-D or MCPA. Forsberg (12, 17, 14) reported that in 1956, 2,4-DB at 4, 6 and 8 ounces per acre did not give any control of wild buckwheat. In 1958, two applications of 2,4-DB and 2,4-D at 5 ounces per acre resulted in equal control of wild buckwheat. In 1959, MCPB and 2,4-DB resulted in less control than did the ester of MCPA and 2,4-D.

Friesen (27) reported that 2-(2,4-DP) applied at 12 ounces per acre to green smartweed and wild buckwheat resulted in only 60 percent control of the weed species. Howden (34) stated that 2-(MCPP) at rates up to 32 ounces per acre failed to control green smartweed.

Neburon (1-n-butyl-3-(3,4-dichlorophenyl) 1-methyl urea) has been considered as a possible means of chemical control of wild buckwheat, green smartweed and tartary buckwheat. Forsberg (13) studying the effect of neburon on wild buckwheat, reported that the degree of control of wild buckwheat with neburon varied at different rates, depending on the volume of water in which the chemical was applied. However, 100 percent kill was achieved when neburon at 6 pounds per acre was applied in 100 gallons of water. At the same time, Brown (7) reported that two applications of neburon at 1-1/2 pounds per acre resulted in 68 percent kill of the wild buckwheat plants, in comparison to the 38 percent control achieved with a single application of 1-1/2 pounds per acre. Friesen (25) studying the effect of neburon on tartary buckwheat, reported that neburon applied at 2 pounds per acre and higher resulted in complete kill in the early growth stages of the plants. Treatments made after the 4 true leaf stage of the tartary buckwheat required rates of not less than 6 pounds per acre for similar results. It was found that the effectiveness of neburon in controlling these weeds varied from one year to the next, depending on the amount of precipitation during the growing season.

Substituted benzoic acids

Dinoben (3-nitro-2,5-dichlorobenzoic acid) and amiben (3-amino-2,5-dichlorobenzoic acid) both have been reported to control *Polygonum* species, but are limited in that they have to be applied pre-emergence to weed and crop growth, and have a narrow spectrum of crop tolerance which does not include cereal crops (5, 2).

TBA (2,3,6-trichlorobenzoic acid) has shown possibilities for controlling wild and tartary buckwheat. Friesen (23) reported that TBA when applied to tartary buckwheat resulted in good control. Brown (6) stated that a mixture of TBA + MCPA at 2.2 pounds per acre resulted in good control of tartary buckwheat when applied in the 2-inch growth stage.

It was also found that TBA applied at a rate of 2.5 pounds per acre resulted in 90 percent control and 5 to 8 pounds per acre resulted in 100 percent control of wild buckwheat plants (39). Also, 5.8 pounds per acre as a pre-emergent application resulted in complete control of wild buckwheat (41). Even though good weed control has been achieved with applications of TBA, crops have been found to be susceptible or moderately susceptible to the herbicide (51, 32, 9, 31, 6, 50).

Dicamba (2-methoxy-3,6-dichlorobenzoic acid), a recent addition to the benzoic acid group, has shown considerable activity in the control of wild buckwheat, tartary buckwheat, and green smartweed. Early experiments demonstrated that 5 ounces per acre of dicamba were required to effectively control wild buckwheat (3). Parker (49), in Great Britain, reported that dicamba applied at 1 ounce per acre resulted in control of certain Polygonum species. In logarithmic plots at Winnipeg Friesen (20) found that when dicamba at 1.9 ounces per acre was applied to wild buckwheat in the 4 to 6 leaf growth stage, 90 percent control was achieved. Further experiments have shown that when dicamba at 4 ounces per acre was applied to wild buckwheat or green smartweed, 90 to 95 percent control of these weeds was obtained (22, 18, 42).

Although dicamba is effective in controlling wild buckwheat, green smartweed and tartary buckwheat, species in the mustard family (Cruciferaceae) are resistant to the herbicide. Investigations were conducted into the possibility of applying dicamba and phenoxy herbicides, such as 2,4-D as mixtures. Such mixtures would provide control of a wide spectrum of weeds including wild and tartary buckwheat, green smartweed and species of the mustard family. To increase the spectrum even further 2-(MCPP) has also been added. Hall and Friesen (29) reported that a minimum dosage of 4.5 ounces per acre of dicamba:2,4-D:2-(MCPP) mixture was required for 90 percent control of wild buckwheat and green smartweed when the weeds were in the 4 to 6 leaf growth stage. Keys (36) found that dicamba:2,4-D:2-(MCPP) or dicamba:2,4-D:2-(MCPP) mixtures resulted in 94 percent control of wild buckwheat when applied in the 2 to 5 leaf growth stage at 6 ounces per acre.

The effect of dicamba on cereal and flax crops.

Field trials, published as abstracts in annual Research Reports of the National Weed Committee (Western Section) have established that dicamba can be used as a selective herbicide for the control of wild buckwheat, tartary buckwheat and green smartweed in cereal grains. Upon evaluating this data, the Research Appraisal and Recommendations Committee of the National Weed Committee (Western Section) reported that wheat and oats showed tolerance to dicamba if the herbicide was applied during the 2 to 5 leaf growth stage. Applications made during the 2 to 3 leaf growth stage will combine maximum crop tolerance and weed susceptibility. However, if dicamba:2,4-D:2-(MCPP) mixtures are applied, applications should not be made prior to the 3 leaf growth stage, because the 2,4-D present in the mixture may cause leaf and spike deformities if applied before the 3-leaf growth stage. Rate of application should not exceed 2 ounces per acre of dicamba alone or in mixtures with phenoxy herbicides.

Barley is more sensitive to dicamba than wheat or oats. Holroyd (33) reported that in comparison to other cereal crops the highest incidence of injury on application of dicamba was in barley. Experiments conducted in Western Canada, comparing the reaction of wheat, oats and barley to dicamba, yield reductions and crop injury have been reported as more pronounced in barley than in oats and wheat (21, 60). However, in certain studies concerning the reaction of dicamba to barley little or no injury to the barley was noticed. Vanden Born (59) concluded that it appeared safe to apply dicamba at rates up to 4 ounces per acre on Parkland barley. Siemens (52) showed that rates up to 4 ounces per acre were tolerated by the barley, and only when 4 ounces per acre were applied in the 6 leaf growth stage were marked differences produced.

Friesen (26) reported that applications of dicamba at rates higher than 1 ounce per acre significantly reduced the yield, and greatly significant yield reductions were obtained when 1.8 ounces per acre or more of dicamba were applied to barley at Lacombe, Alberta.

Friesen, et al. (28) studying the morphological and cytological effects of dicamba on barley, found that when dicamba was applied during periods of high meristematic activity, normal growth was disrupted and morphological and cytological abberations were induced. They found that dicamba at 4 ounces per acre in the field or 2 ounces per acre in the greenhouse, applied to barley before the 3 leaf growth stage, caused a noticeable bending of the inter-nodes of the main culms. They observed that the bending appeared to result from constricted leaf sheaths at the nodes, and in most cases the constriction was so severe that the heads had great difficulty emerging from the sheath and, as a result, were severely twisted and curled. At this time active growing points were found only in the main culms.

When the treatments were made at the 4 leaf stage, the injury in the spike of the main culms increased and a bending of the internodes of the tillers became evident. During the 5 and 6 leaf stage of application the same effects became prevalent in the tillers.

It was also found that concentrations of dicamba greater than 10 parts per million resulted in a high frequency of cells with abnormal mitotic activity. They concluded that chemical treatments should be made prior to the 4 leaf growth stage, before the appearance of the tillers which can outnumber the main culms 3 to 1 in the field.

Recommendations by the National Weed Committee (4) suggested that dicamba applications on barley should be made during the 3 leaf growth stage, and the rates of application should not exceed 2 ounces per acre of dicamba alone or in mixtures with phenoxy herbicides.

At the 1965 National Weed Conference (Western Section), an "emergency use" was granted for the control of green smartweed and wild buckwheat in flax with dicamba alone or in mixtures. However, at present, such a use has not been registered by the Canada Department of Agriculture but a "trial use" registration has been granted for the use of dicamba, 2,4-D and 2-(MCPP) mixtures in flax.

Results from experiments with dicamba and dicamba mixtures on flax indicate that flax will tolerate dicamba alone or in mixtures with phenoxy herbicides at rates up to 2 ounces per acre. Frequently, when dicamba-phenoxy mixtures were applied, growth of the flax crop was retarded (37). It was also found that herbicidal treatment would increase branching in flax plants by 35 percent, but at maturity no yield differences were recorded (46).

Reports indicate that flax at early growth stages showed more tolerance to dicamba than at later growth stages. Keys (38) reported that dicamba at 2 and 4 ounces per acre applied to flax in the 8 to 10 leaf stage and 14 to 16 leaf stage resulted in more severe crop injury in the later stage. In the second growth stage, the main stem was killed back to the crown, but intensive branching resulted in no yield differences at maturity.

Molberg (43) concluded that crop injury upon application of dicamba at 2 ounces per acre was more severe in the 2 to 4 leaf growth stage than in the 6 leaf growth stage.

At Regina, dicamba at 2 ounces per acre applied to Redwood flax 3 inches in height completely destroyed the flax crop, however, the precipitation after application of the chemical was above average (44). This suggests that precipitation following dicamba use can have a profound influence on crop tolerance.

A study conducted by Molberg (45) indicated that the means of up-take of dicamba by the plant may influence the tolerance of flax plants to dicamba. No appreciable plant injury resulted when the chemical was absorbed by the foliage only, but when the herbicide was taken up by the roots or roots and foliage, severe plant injury resulted.

From the previous review, it is apparent that considerable information was lacking on the tolerance of barley and flax to dicamba and dicamba mixtures. More specific information was required on time of spraying, rates of application, and the influence of soil and moisture conditions on the effect of the herbicides. Such information is essential to develop the full potential of dicamba as a herbicide. With this objective in mind, the study reported in this manuscript was carried out in an attempt to obtain this information.

MATERIALS AND METHODS

Six projects were carried out to determine the response of barley and flax to dicamba and herbicidal mixtures containing dicamba. The projects were as follows:

a) The effect of dicamba and dicamba mixtures on barley, 1964 and 1965.

b) The effect of dicamba and dicamba mixtures on flax, 1964 and 1965.

c) The effectiveness of dicamba and dicamba mixtures for selective weed control in flax, 1964.

d) The additive value of 2-(MCPP) and 2,4-D in commercial mixtures of dicamba, 1964 and 1965.

e) Flax tolerance to dicamba and dicamba mixtures at different growth stages, 1965.

f) Response of flax to dicamba under different soil and moisture conditions (Greenhouse, 1965).

All experiments with the exception of the greenhouse experiment were located at the Glenlea Research Station. Commercial preparations of dicamba (dimethyl amine salt of 2-methoxy-3,6-dichlorobenzoic acid) and mixtures of dicamba, amine salts of 2,4-D or MCPA, and the sodium salt of 2-(MCPP) were used in these experiments. The commercial preparations formed stable solutions with water as a carrier.

All the field plots were seeded with a 12-row pony-press seeder. Each plot was 6 by 16 feet in size and accommodated 12 rows of grain spaced 6 inches apart. All chemical applications were made with a small plot precision sprayer delivering 5.5 gallons per acre total solution at 45 psi. Visual assessments of crop injury and weed control were recorded on a 0-10 (0: no injury, 10: complete kill) basis. A small plot harvester was used to harvest 30 square feet of grain from the centre of each plot at maturity. Yield data from each project was subjected to statistical analysis as outlined by Steel and Torrie (56).

a) The effect of dicamba and dicamba mixtures on barley, 1964 and 1965.

Two barley varieties, widely grown in Manitoba, were selected for this study. Included were Parkland, a malting variety, and Keystone, a feed variety. These were sown at a rate of 100 pounds per acre on May 21, 1964 and June 1, 1965. The varieties were sprayed with dicamba and dicamba mixtures at two growth stages. The first date of spraying in 1964 was June 10, at which time both varieties were in the 2-3 leaf growth stage. The second date of spraying was June 30 at which time the barley was in the 4-5 leaf growth stage. In 1965, the spraying dates, June 21 and 29, corresponded with the 2½-3 leaf and 4 leaf growth stages. The experiments were conducted under almost weed-free conditions, and as a result only visual assessments of crop injury were recorded. The visual observations were made at two dates in both years and the final date represents an average of these two recordings. In 1964, crop injury assessments were made on July 20 and August 12. In 1965, the crop injury was assessed on July 27 and August 18.

In 1964, both barley varieties were harvested on August 21. In 1965, the varieties Parkland and Keystone were harvested on August 19, and August 24, respectively. Protein and bushel weight determinations were made on the harvested grain samples. The protein content was determined according to the procedure outlined by Harowitz et al.(30).

The experimental design was a four replicate split plot design with varieties as main plots and growth stages and chemical treatments as sub-plots.

b) <u>Effect of dicamba and dicamba mixtures on flax, 1964 and 1965</u>.

The varieties Raja and Bolley flax were sown on May 22, 1964 and June 1, 1965 at 35 pounds per acre. In 1964, dicamba and dicamba mixtures were applied to the flax on June 10 and June 30, at which time the flax was 1½ and 3½-4 inches in height. In 1965, the chemicals were applied on June 21 (1½-2 inches) and June 29 (4 inches). Visual assessments of crop injury were made as described in the previous experiment. The visual assessments were made on July 14 and August 12, 1964 and July 27 and August 18, 1965. Both varieties were harvested on September 4, 1964 while in 1965, Raja was harvested on September 8 and Bolley on September 21. The difference in harvest dates in 1965 was not due to a delay in maturity of the variety Bolley, but a result of adverse weather conditions.

The percent oil content and iodine values of the oil were determined on harvested seed samples. The oil content (percent dry weight) determinations were carried out according to a method outlined by Sixten (55). The oil collected from the seed samples was placed in an oil refactometer, and the scale readings were taken at 35° Centigrade. Each reading was converted to the refractive index at 25° Centigrade by the use of tables included in the instruction booklet of the refractometer. The refractive index was then converted to the iodine value by the following formula:

Iodine Number (Wij): $8{,}584.97_D^{25} - 12{,}513.83$ where $_D^{25}$ is the refractive index at 25° Centigrade (48). The experimental design was identical to that described in the barley experiment.

c) <u>The effectiveness of dicamba and dicamba mixtures for selective weed control in flax, 1964</u>.

Dicamba and dicamba mixtures were applied to Raja flax which was sown on May 22 at 35 pounds per acre. Green smartweed (*Polygonum scabrum* moench.) was broadcast seeded and harrowed the same day, to ensure a uniform weed infestation. The experimental design was a randomized block replicated four times. The experiment was sprinkler irrigated on June 10 with an equivalent of one inch of rainfall. The herbicides were applied on July 3 when the flax was 7 to 9 inches in height and the green smartweed in the 2 to 4 leaf growth stage. Crop injury and weed control ratings were made on July 13 and August 13. The flax was harvested on September 4.

d) <u>The additive value of 2-(MCPP) and 2,4-D in commercial mixtures of dicamba, 1964 and 1965</u>.

In 1964 and 1965 the performance of dicamba with and without 2,4-D and 2-(MCPP) in ratios comparable to a commercial formulation was evaluated for green smartweed control in flax. In both years the experimental design was a randomized block replicated four times. In 1964, Raja flax was sown May 22, and in 1965 on June 1, at 35 pounds per acre. In both years the green smartweed was broadcast-seeded and harrowed the same day the flax was seeded. On July 10, 1964, the experiment was sprinkler-irrigated to an equivalent of 1 inch of rainfall. In 1965, due to poor germination, the desired green smartweed infestation was not achieved, although there was a light, natural infestation of wild buckwheat.

In 1964 the herbicides were applied July 3, at which time the flax was 7 to 9 inches in height and the green smartweed in the 2-4 leaf growth stage. In 1965 the herbicides were applied on July 5 at which time the flax was 7 to 9 inches in height, the green smartweed plants present in the 2-4 leaf stage, and the wild buckwheat in the 4-6 leaf growth stage. Visual assessment of crop injury and weed control were recorded July 14 and August 13, 1964 and July 27 and September 1, 1965. The flax crop was harvested September 4, 1964 and September 8, 1965.

e) Flax tolerance to dicamba at different growth stages, 1965.

This project was designed to permit spraying at 3-day intervals for 30 days after emergence. However, due to adverse weather conditions the prescribed schedule was frequently disrupted. Flax (variety Bolley) was seeded on June 1 and herbicidal applications were made on June 16 to July 26. Visual estimates of crop injury were assessed on July 27 and August 18. The flax was harvested on September 21 and yields were determined on the harvested seed samples. The experimental design was a split plot design with spraying dates as main plots and chemical treatments as sub-plots.

f) Response of flax to dicamba under different soil and moisture conditions (Greenhouse, 1965).

This experiment was conducted in the greenhouse in 1965. The experimental design was a split plot design, with soil types as main plots and moisture conditions as sub-plots. On January 23, Redwood flax was sown in three soil types, sand, clay, and potting soil (1:2 mixture of peat and clay). The pots were maintained at three moisture levels, field capacity, saturated conditions, and a moisture level near the wilting point. Herbicidal treatments were applied to the field capacity and to the saturated pots on February 18 when the flax was 5-6 inches in height, and to the wilting point treatments on February 25, at which time the flax was 5-6 inches in height.

RESULTS AND DISCUSSION

a) Effect of dicamba and dicamba mixtures on barley, 1964 and 1965.

Several trends were evident in the visual assessment of crop injury in 1964 (Table 1). Injury ratings in the 4-leaf growth stage of Parkland barley were somewhat higher than the earlier treatment stage. It appeared as if the variety Keystone was slightly more susceptible to chemical treatment in the 2½-3 leaf growth stage, but differences in response of the growth stages were small. The chemical treatments in general had little effect on the morphology of the plants, with one exception, there was a slight reduction in plant height when dicamba was applied to Parkland barley at the 4 ounces per acre rate.

In 1965 the visual injury ratings (Table 2) were lower than in 1964, except for the dicamba treatment at 4 ounces per acre, which showed similar response in the Parkland variety in both years. In 1965 the crop injury from the 4 ounces per acre dicamba treatment was more pronounced than the other chemical treatments.

Yield data for 1964 and 1965 are presented in Tables 3 and 4. The analyses of variance for yield data for 1964 and 1965 (Appendices 1 and 2) show that varietal differences were significant. This significant difference could be expected because of inherent characteristics. There were slight differences in yield responses to time of herbicidal application but these differences were insignificant. The non-significant interaction between varieties and stage of growth, indicates that the varieties responded similarly at different growth stages. The interaction of treatments by growth stages, with varieties, was not significant,

Table 1 The effect of dicamba and dicamba mixtures on barley injury, 1964.

Treatment		Crop Injury* (0-10)			
		Parkland		Keystone	
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2
Check	Weedy	0	0	0	0
Check	hand-weeded	0	0	0	0
Dicamba + MCPA	2 + 6	1.9	2.1	1.9	1.9
Dicamba	4	1.8	3.4	1.9	1.9
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	1.8	2.1	1.6	2.1
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	2.0	3.4	1.6	1.4
Dicamba + 2,4-D + 2-(2,4-DP)	1.35 + 3.75 + 0.9	1.8	2.8	1.8	1.5
Dicamba + 2,4-D + 2-(2,4-DP)	1.8 + 5.0 + 1.2	1.5	2.4	1.9	1.6
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	1.5	2.0	2.4	1.1
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	1.8	2.0	2.5	1.8
Average		1.8	2.5	1.9	1.7

* 0 = no injury; 10 = complete kill.

Table 2 The effect of dicamba and dicamba mixtures on barley injury, 1965.

Treatment		Crop Injury* (0-10)			
		Parkland		Keystone	
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2
Check	Weedy	0	0	0	0
Check	Hand-weeded	0	0	0	0
Dicamba + MCPA	2 + 6	0.3	1.0	0	0.3
Dicamba	4	2.5	4.0	1.0	1.5
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	0.3	1.2	0	0.3
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	0.7	2.0	0.5	0.5
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	0	1.0	0	0
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	0.3	1.3	0	0.3
MCPA	10	0	0.3	0	0
2,4-D	8	0	0	0	0
Average		0.5	1.4	0.2	0.4

* 0 = no injury; 10 = complete kill.

Table 3 The effect of dicamba and dicamba mixtures on the yield of barley, 1964.

Treatment		Crop Yield (bu/ac)					Duncan's
		Parkland		Keystone			Multiple
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average	Range Test*
Check	Weedy	37.2	33.1	54.0	51.6	43.9	a b c
Check	Hand-weeded	40.8	35.5	52.9	56.1	46.2	a b
Dicamba + MCPA	2 + 6	34.2	33.2	52.2	53.4	43.2	a b c
Dicamba	4	34.0	27.4	55.5	47.5	41.1	c
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	33.5	38.9	59.8	52.7	46.2	a b
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	29.4	25.3	53.1	59.0	41.6	b c
Dicamba + 2,4-D + 2-(2,4-DP)	1.35 + 3.75 + 0.9	32.1	31.4	55.4	55.8	43.6	a b c
Dicamba + 2,4-D + 2-(2,4-DP)	1.8 + 5.0 + 1.2	34.6	28.0	54.4	57.4	43.5	a b c
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	41.6	36.9	55.8	57.8	48.0	a
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	37.6	32.5	52.0	59.0	45.2	a b c
Average		35.5	32.2	54.5	55.0		

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

Table 4 The effect of dicamba and dicamba mixtures on the yield of barley, 1965.

Treatment		Crop Yield (bu/ac)				
		Parkland		Keystone		
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average
Check	Weedy	50.1	46.8	50.4	57.5	51.2
Check	Hand-weeded	53.5	48.8	43.8	57.9	51.0
Dicamba + MCPA	2 + 6	45.7	42.6	48.9	58.9	49.0
Dicamba	4	37.7	42.6	46.8	51.9	44.7
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	47.9	41.2	43.0	50.6	45.7
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	45.5	40.5	47.8	50.5	46.1
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	48.4	40.8	47.0	54.6	47.7
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	49.5	46.6	51.5	52.1	49.9
MCPA	10	44.7	49.0	45.6	52.9	48.0
2,4-D	8	47.9	48.6	51.9	52.1	50.1
Average		47.1	44.7	47.7	53.9	

indicating that treatment responses were the same in both varieties and stages of growth. In 1964, treatment with dicamba at 4 ounces per acre significantly reduced the yield of both varieties when compared with the yield of the hand-weeded check plots, dicamba:2,4-D:2-(MCPP) and dicamba: MCPA:2-(MCPP) mixtures at 6 ounces per acre. However, dicamba at 4 ounces per acre did not significantly reduce the barley yields from those obtained when mixtures of dicamba were applied at the 8 ounces per acre rate. All other chemical treatments did not reduce the yield significantly as compared to the weedy, and hand-weeded check plots.

In 1965, there were no significant barley yield reductions due to herbicide applications. Several trends, similar to 1964 results, were apparent. There was some response in yields to time of chemical application. Both varieties, Parkland and Keystone, showed a small reduction in yield when the herbicides were applied in the 4-leaf growth stage, but these reductions were not significant. Dicamba at 4 ounces per acre applied to the barley resulted in a yield reduction of 6.3 bushels per acre when compared with the hand-weeded check plots, but this reduction was not statistically significant.

Protein data from the 1964 project is presented in Table 5. The analysis of variance (Appendix 3) indicated that significant differences resulted in protein content of harvested barley samples. Varietal differences were significant, as was expected. Protein content of grain samples treated with dicamba or dicamba mixtures was higher or equal to the protein content of grain samples obtained from weedy and hand-weeded check plots. The protein content of grain samples which had received treatments of dicamba at 4 ounces per acre and dicamba MCPA mixture at 8 ounces (total active ingredient) per acre, was significantly

Table 5 The effect of dicamba and dicamba mixtures on protein content in barley, 1964.

Treatment		Protein Content (%)					Duncan's
		Parkland		Keystone			Multiple
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average	Range Test*
Check	Weedy	13.2	12.8	13.1	13.7	13.2	b c
Check	Hand-weeded	13.2	12.3	12.8	13.4	12.9	c
Dicamba + MCPA	2 + 6	14.4	13.4	13.0	14.2	13.7	a
Dicamba	4	14.5	13.4	12.8	13.9	13.7	a
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	14.3	12.9	12.4	14.0	13.4	a b
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	14.3	13.5	13.2	13.5	13.6	a b
Dicamba + 2,4-D + 2-(2,4-DP)	1.35 + 3.75 + 0.9	13.4	13.3	12.9	13.5	13.3	a b c
Dicamba + 2,4-D + 2-(2,4-DP)	1.8 + 5.0 + 1.2	14.1	13.2	12.8	14.0	13.5	a b
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	13.4	13.0	12.6	13.9	13.2	b c
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	13.8	13.1	12.5	13.7	13.2	b c
Average		13.8	13.1	12.8	13.8		

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

higher than the protein content of grain samples obtained from check plots and plots treated with the dicamba:MCPA:2-(MCPP) mixture at rates totalling 6 and 8 ounces per acre.

Protein content data from 1965 grain samples are presented in Table 6 and Appendix 4. Herbicidal treatments resulted in protein content of the grain samples similar to that obtained in 1964. All chemical treatments resulted in protein values equal to, or higher than, those obtained from untreated samples.

Bushel weights were determined on harvested grain samples in 1964 and 1965, and the data is presented in Tables 7 and 8. Analyses of variance (Appendices 5 and 6) show that in both years there was a significant difference in the bushel weight of the two varieties, but the application of herbicides did not result in significant responses in bushel weight of the grain.

The results indicate that the barley varieties used in this project were quite tolerant to treatment with dicamba mixtures, in which the rate of dicamba did not exceed 1.8 ounces per acre. However, in 1964, dicamba applied alone at 4 ounces per acre reduced barley yields and plant height, but did not adversely affect the protein content or bushel weight of the grain. It would appear from the significant yield reduction, as a result of a 4 ounces per acre treatment of dicamba in 1964 and not in 1965, that environment may be an influencing factor in determining the tolerance of barley to dicamba. The high rate was used in this project to determine the effect of dicamba when applied in amounts exceeding the recommended rate of 1.5 ounces per acre. Similar rates may be applied on farm fields as a result of overlapping when spraying, improper boom height, miscalculations of chemical concentration

Table 6 The effect of dicamba and dicamba mixtures on protein content in barley, 1965.

Treatment		Protein Content (%)					Duncan's Multiple Range Test*
		Parkland		Keystone			
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average	
Check	Weedy	10.2	10.0	10.3	11.5	10.5	d
Check	Hand-weeded	10.0	10.3	10.3	10.4	10.2	e
Dicamba + MCPA	2 + 6	10.6	10.5	10.7	10.9	10.7	b c
Dicamba	4	10.5	10.2	10.8	11.5	10.8	a b
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	10.7	10.6	10.5	10.8	10.7	
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	10.8	11.7	10.9	10.9	10.9	a
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	10.5	10.5	10.3	11.0	10.6	c d
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	10.4	10.9	11.0	10.7	10.7	b c
MCPA	10	10.0	10.0	10.5	10.8	10.3	e
2,4-D	8	10.1	10.6	10.4	11.0	10.5	d
Average		10.4	10.4	10.6	10.8		

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

Table 7 The effect of dicamba and dicamba mixtures on barley bushel weights, 1964.

Treatment		Bushel Weights (lb/bu)				
	Rate	Parkland		Keystone		
Herbicide	oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average
Check	Weedy	50.2	48.7	45.2	46.5	47.6
Check	Hand-weeded	50.2	48.2	44.0	46.7	47.3
Dicamba + MCPA	2 + 6	48.0	48.0	45.5	44.2	46.4
Dicamba	4	47.2	47.0	44.7	46.7	46.4
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	49.2	49.0	46.2	46.2	47.6
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	49.5	47.7	48.0	48.2	48.3
Dicamba + 2,4-D + 2-(2,4-DP)	1.35 + 3.75 + 0.9	48.0	48.2	45.2	47.2	47.4
Dicamba + 2,4-D + 2-(2,4-DP)	1.8 + 5.0 + 1.2	47.5	48.7	43.0	45.2	46.1
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	49.2	49.5	44.2	46.2	47.3
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	48.7	48.5	47.7	45.5	47.6
Average		48.8	48.5	45.4	46.3	

Table 8 The effect of dicamba and dicamba mixtures on barley bushel weights, 1965.

Treatment		Bushel Weight (lb/bu)				
		Parkland		Keystone		
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average
Check	Weedy	49.2	48.2	46.7	46.0	47.6
Check	Hand-weeded	49.0	50.0	46.7	46.0	47.9
Dicamba + MCPA	2 + 6	49.2	48.7	45.2	45.0	47.0
Dicamba	4	48.0	48.0	45.0	44.5	46.4
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	49.2	48.5	43.2	47.0	47.0
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	49.0	49.2	45.7	44.2	47.0
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	49.7	48.2	44.2	45.7	47.0
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	48.5	48.2	46.0	46.5	47.3
MCPA	10	49.2	49.0	45.2	44.2	46.9
2,4-D	8	48.0	49.2	44.2	45.0	46.6
Average		48.9	48.7	45.2	45.4	

and sprayer output or spray drift. The results indicate that dicamba should be applied carefully to avoid decreases in yield resulting from too high a rate of application.

b) <u>The effect of dicamba and dicamba mixtures on flax, 1964 and 1965</u>.

Visual estimates of flax injury in 1964 (Table 9) suggest that both varieties were about equal in tolerance to dicamba and dicamba mixtures. The ratings also suggest that both varieties responded in a similar manner as to time of chemical application. Injury appeared to be more pronounced when the herbicides were applied in the 4-inch growth stage. Commercial mixtures of dicamba:2,4-D:2-(MCPP), dicamba:MCPA: 2-(MCPP) and dicamba:2,4-D:2-(2,4-DP), when applied to the flax in the 4-inch growth stage resulted in the most severe injury.

Crop injury on flax in 1965 (Table 10) was not as severe as the previous year. The herbicidal effects were similar to those observed the previous year. Chemical applications of dicamba:2,4-D:2-(MCPP) and dicamba:MCPA:2-(MCPP) mixtures resulted in the highest injury ratings when applied to the flax in the 4-inch growth stage.

Yield data for the 1964 experiment are presented in Table 11. Both flax varieties responded similarly to herbicidal treatments at the 1½-inch and 3½-4 inch growth stages. Varietal differences were not significant (Appendix 7). Chemical applications of dicamba:2,4-D:2-(2,4-DP) and dicamba:MCPA:2-(MCPP) mixtures at the highest rates, resulted in the greatest reduction of flax yields, but none of the yield reductions were significant.

In 1965, flax yields (Table 12) were higher than in 1964. The analysis of variance (Appendix 8) shows that there were no significant responses of the flax varieties to chemical application, at either growth stage.

Oil content values for the 1964 and 1965 experiments are presented in Tables 13 and 14. In 1964, all chemical treatments with

Table 9 The effect of dicamba and dicamba mixtures on flax injury, 1964.

Treatment		Crop Injury*			
		Raja		Bolley	
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2
Check	Weedy	0	0	0	0
Check	Hand-weeded	0	0	0	0
Dicamba	4	3.0	3.9	3.4	3.8
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	2.7	5.3	2.2	4.2
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	2.6	5.3	2.8	6.3
Dicamba + 2,4-D +2-(2,4-DP)	1.35 + 3.75 + 0.9	1.8	4.2	2.3	3.3
Dicamba + 2,4-D + 2-(2,4-DP)	1.8 + 5.0 + 1.2	4.3	6.2	2.9	4.8
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	2.0	3.9	2.6	2.9
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	2.6	5.0	2.9	4.7
Average		2.7	4.8	2.8	4.3

* 0 = no injury; 10 = complete kill.

Table 10 The effect of dicamba and dicamba mixtures on flax injury, 1965.

Treatment		Crop Injury*			
		Raja		Bolley	
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2
Check	Weedy	0	0	0	0
Check	Hand-weeded	0	0	0	0
Dicamba + MCPA	2 + 6	.4	.9	.8	.9
Dicamba	4	.8	2.1	.9	1.6
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	.9	2.1	1.0	1.2
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	1.1	2.5	1.7	2.1
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	.7	2.0	.9	1.3
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	.9	2.3	1.3	1.9
MCPA	10	.3	.8	.7	.9
2,4-D	8	.7	1.6	.8	.6
Average		.7	1.8	1.0	1.3

* 0 = no injury; 10 = complete kill.

Table 11 The effect of dicamba and dicamba mixtures on flax yields, 1964.

Treatment		Crop Yield (bu/ac)				
		Raja		Bolley		
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average
Check	Weedy	16.3	16.3	16.5	16.1	16.3
Check	Hand-weeded	17.3	17.9	17.0	16.6	17.2
Dicamba	4	16.4	17.3	15.5	19.2	17.1
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	16.8	15.8	17.1	19.2	17.2
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	17.1	15.9	15.4	15.4	15.9
Dicamba + 2,4-D + 2-(2,4-DP)	1.35 + 3.74 + 0.9	14.0	17.0	19.0	16.8	16.7
Dicamba + 2,4-D +2-(2,4-DP)	1.8 + 5.0 + 1.2	16.3	16.3	15.5	17.6	16.9
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	15.5	15.1	17.9	16.6	16.2
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	13.4	16.6	16.7	15.7	15.6
Average		16.0	16.5	16.8	17.0	

Table 12 The effect of dicamba and dicamba mixtures on flax yields, 1965.

Treatment		Crop Yield (bu/ac)				
		Raja		Bolley		
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average
Check	Weedy	22.9	22.8	24.7	20.7	22.7
Check	Hand-weeded	22.8	24.5	25.9	22.2	23.9
Dicamba + MCPA	2 + 6	23.9	21.5	24.9	20.9	22.8
Dicamba	4	24.0	24.2	23.5	24.8	23.5
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	22.4	25.1	23.5	22.9	23.4
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	23.8	21.9	24.3	20.9	22.7
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	21.9	25.1	26.6	23.8	24.3
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	23.9	23.9	24.7	21.5	23.4
MCPA	10	23.8	23.3	27.7	24.9	24.9
2,4-D	8	25.7	24.1	24.8	21.2	23.3
Average		23.5	23.6	25.1	22.4	

Table 13 The effect of dicamba and dicamba mixtures on the oil content of flax, 1964.

Treatment		Oil Content (%)				
		Raja		Bolley		
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average
Check	Weedy	41.8	41.7	44.3	44.2	43.0
Check	Hand-weeded	42.3	41.7	44.5	44.4	43.0
Dicamba	4	42.2	41.7	44.5	44.6	43.2
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	42.1	41.6	44.7	44.7	43.3
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	42.0	41.7	44.7	44.5	43.2
Dicamba + 2,4-D + 2-(2,4-DP)	1.35 + 3.75 + 0.9	42.3	41.7	44.5	44.6	43.3
Dicamba + 2,4-D + 2-(2,4-DP)	1.8 + 5.0 + 1.2	41.9	41.6	44.3	44.6	43.1
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	42.2	41.0	44.4	44.3	43.0
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	42.2	41.7	44.5	44.7	43.3
Average		42.1	41.6	44.5	44.5	

Table 14 The effect of dicamba and dicamba mixtures on the oil content of flax, 1965.

Treatment		Oil Content (%)					Duncan's
	Rate	Raja		Bolley			Multiple
Herbicide	oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average	Range Test*
Check	Weedy	43.2	42.0	45.2	45.3	43.9	b c
Check	hand-weeded	43.7	42.7	45.3	45.8	44.4	a
Dicamba + MCPA	2 + 6	43.0	42.1	45.1	45.4	43.9	b c d
Dicamba	4	42.7	42.2	45.0	45.4	43.8	b c d
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	41.9	42.9	45.0	45.2	43.8	b c d
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	42.9	42.0	45.1	45.5	43.9	b c d
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	42.9	41.5	45.2	44.9	43.6	c d e
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	42.9	41.8	45.6	45.8	44.0	b
MCPA	10	41.9	42.6	44.6	44.8	43.5	e
2,4-D	8	42.8	41.6	45.0	44.9	43.6	d e
Average		42.8	42.1	45.1	45.3		

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

the exception of the dicamba:MCPA:2-(MCPP) mixture at 6 ounces (total active ingredient) per acre resulted in slight increases in oil content. In 1965, herbicidal applications resulted in slight reductions in the oil content of the flax seed. Of interest to flax processors would be the significantly higher oil content in the variety Bolley as compared with the Raja variety (Appendices 9 and 10).

The iodine values presented in Tables 15 and 16 are a measure of the degree of unsaturation of the double bonds in the long chain fatty acids found in the oil of flaxseed. A high number of unsaturated double bonds indicates a rapidly drying oil. Consequently, a high iodine number means high quality.

In 1964, herbicide applications of dicamba and dicamba mixtures resulted in slight increases in the iodine values of the flax seed oil as compared with the check plots. Both varieties Raja and Bolley showed increases in the iodine values when the herbicides were applied in the later growth stage. Iodine values in the two varieties were significantly different (Appendix 11).

In 1965, all chemical treatments with the exception of the dicamba:2,4-D:2-(MCPP) mixture at 8 ounces (total active ingredient) per acre and 2,4-D at 8 ounces per acre significantly reduced the iodine values of the flax seed oil, as compared with the check plots. The variety Bolley showed a somewhat greater response to time of herbicidal application.

The results of these experiments indicate that the two flax varieties studied were similar in their response to dicamba and dicamba mixtures. Dicamba and mixtures containing dicamba had no adverse effect on flax yields when the herbicides were applied in the 1½-inch and

Table 15 The effect of dicamba and dicamba mixtures on the iodine number of flax oil, 1964.

Treatment		Iodine Number					Duncan's
	Rate	Raja		Bolley			Multiple
Herbicide	oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average	Range Test*
Check	Weedy	183.76	182.48	194.06	194.28	188.64	c
Check	Hand-weeded	184.40	184.19	193.63	193.85	189.02	c
Dicamba	4	185.05	186.77	196.85	197.28	191.49	a b
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	183.98	189.77	194.71	196.85	191.33	a b
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	184.83	189.06	196.92	199.00	192.33	a
Dicamba + 2,4-D + 2-(2,4-DP)	1.35 + 3.75 + 0.9	183.55	187.41	194.92	197.07	190.73	b
Dicamba + 2,4-D + 2-(2,4-DP)	1.8 + 5.0 + 1.2	184.19	187.49	194.06	197.71	190.86	b
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	184.83	186.77	195.56	196.64	190.95	b
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	183.21	187.63	195.35	198.14	190.08	b
Average		184.20	186.84	195.06	196.76		

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

Table 16 The effect of dicamba and dicamba mixtures on the iodine number of flax oil, 1965.

Treatment		Iodine Number					Duncan's Multiple Range Test*
		Raja		Bolley			
Herbicide	Rate oz/ac	Stage 1	Stage 2	Stage 1	Stage 2	Average	
Check	Weedy	185.27	184.19	192.35	193.92	188.93	a
Check	Hand-weeded	184.83	184.41	192.13	192.99	188.59	a b
Dicamba + MCPA	2 + 6	183.76	182.51	191.06	192.99	187.58	c d
Dicamba	4	182.08	182.26	191.49	192.56	187.10	d
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	182.90	182.33	191.70	192.35	187.35	c d
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	182.90	184.40	192.56	192.78	188.16	b c
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 + 0.9	183.15	182.90	191.49	192.56	187.52	c d
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	182.30	183.55	191.27	192.78	187.48	c d
MCPA	10	183.98	183.98	190.84	192.13	187.73	c d
2,4-D	8	184.84	182.51	191.27	192.78	187.85	b c d
Average		183.60	183.30	191.61	192.78		

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

4-inch growth stages. Differences in the oil content and quality were detected but it is unlikely that these differences would be of economic importance at the farm level.

c) <u>The effectiveness of dicamba and dicamba mixtures for selective weed control in flax, 1964</u>.

Dicamba and various combinations of dicamba and phenoxy herbicides were applied to weed infested flax for the purpose of evaluating the selective properties of such herbicidal mixtures. The experimental area was infested with wild buckwheat and green smartweed. Weed control, crop injury and yield data are presented in Table 17.

Chemical treatments of dicamba at 1.5 ounces per acre did not result in satisfactory weed control. However, slight increases in weed control were observed when dicamba was applied at 2 ounces per acre. Herbicide applications of dicamba:2,4-D mixtures greatly increased weed control. Chemical applications of dicamba:2,4-D:2-(MCPP), dicamba:2,4-D:2-(2,4-DP) and dicamba:MCPA:2-(MCPP) mixtures at the highest rates resulted in satisfactory weed control. The phenoxy herbicide, 2,4-D, applied at 10 ounces per acre did not result in satisfactory weed control. Chemical applications of 2-(MCPP) at 24 and 32 ounces per acre resulted in very little weed control. Satisfactory weed control was achieved when 2-(2,4-DP) was applied at 32 ounces per acre, but at the same time was highly injurious to the flax crop.

Most of the herbicidal mixtures resulted in moderate to severe crop injury. Dicamba alone applied at 1.5 and 2 ounces per acre resulted in comparatively little crop injury. Severe crop injury resulted when treatments of 2-(MCPP) at 32 ounces per acre, and 2-(2,4-DP) at 24 and 32 ounces per acre were applied to the flax.

All chemical treatments with the exception of the dicamba:2,4-D mixture at 5.5 ounces (total active ingredient) and the dicamba:MCPA:2-(MCPP) mixture at 5 ounces (total active ingredient) per acre resulted in significant yield reductions as compared with the hand-weeded check plots.

Table 17 The effect of dicamba and dicamba mixtures on selective weed control, crop injury, and yields in flax, 1964.

Treatment	Herbicide	Weed Control***	Crop Injury***	Flax Yields
		0-10	0-10	bu/ac
Check	Weedy	0	0	15.9*
Check	Hand-weeded	10.0	0	18.9
Dicamba	1.5	4.0	2.4	15.9*
Dicamba	2.0	5.8	2.5	15.2**
Dicamba + 2,4-D	1.5 + 4.0	7.0	5.0	16.9
Dicamba + 2,4-D	1.5 + 6.0	7.0	5.4	15.6*
Dicamba + 2,4-D	2 + 6.0	7.5	6.3	15.2**
Dicamba + 2,4-D + 2-(MCPP)	1.125 + 3.125 + 0.75	6.4	4.6	14.7**
Dicamba + 2,4-D + 2-(MCPP)	1.35 + 3.75 + 0.9	6.9	5.4	14.7**
Dicamba + 2,4-D + 2-(MCPP)	1.8 + 5.0 + 1.2	7.6	6.8	13.9**
Dicamba + 2,4-D + 2-(2,4-DP)	0.9 + 2.5 + 0.6	5.6	2.6	15.8*
Dicamba + 2,4-D + 2-(2,4-DP)	1.35 + 3.75 + 0.9	7.8	5.3	14.6**
Dicamba + 2,4-D + 2-(2,4-DP)	1.8 + 5.0 + 1.2	7.9	5.3	14.5**
Dicamba + MCPA + 2-(MCPP)	1.125 + 3.125 + 0.75	4.5	2.6	16.6
Dicamba + MCPA + 2-(MCPP)	1.35 + 3.75 _ 0.9	6.8	4.4	16.1*
Dicamba + MCPA + 2-(MCPP)	1.8 + 5.0 + 1.2	7.4	5.1	15.7*
2,4-D	10	4.4	4.9	13.5**
2-(MCPP)	24	2.4	5.6	13.4**
2-(MCPP)	32	3.0	7.6	10.1**
2-(2,4-DP)	24	4.9	8.9	6.6**
2-(2,4-DP)	32	7.3	9.0	3.5**

** Significant at 1 percent level of probability.

* Significant at 5 percent level of probability.

*** 0 = no control or injury; 10 = complete kill.

The results of this experiment indicate that dicamba added to phenoxy herbicides increased the control of green smartweed. The serious crop injury and significant yield reductions following herbicidal applications may have been reduced or avoided if spraying had been carried out earlier.

d) The additive value of 2-(MCPP) and 2,4-D in commercial mixtures of dicamba, 1964 and 1965.

The effect of dicamba with and without 2,4-D and 2-(MCPP) in ratios comparable to the commercial formulation was evaluated for green smartweed control in flax.

In 1964, weed control ratings (Table 18) were based on green smartweed control. Treatments with dicamba alone offered the highest control, and 2,4-D at 3.75 ounces per acre (Plate 1) resulted in intermediate control of the three single components of the mixture. However, when 2-(MCPP) was added to the 2,4-D treatment, a slight increase in green smartweed control resulted (Plate 2). Also, the herbicidal properties of dicamba, regarding green smartweed control, were slightly increased with the addition of 2-(MCPP) to the dicamba. However, when dicamba at 1.35 ounces per acre in combination with 2,4-D at 3.75 ounces per acre was applied to the weeds much better weed control was achieved (Plate 3). The addition of 2-(MCPP) to dicamba and 2,4-D appeared to result in slightly higher weed control than the previous treatment of dicamba and 2,4-D (Plate 4).

In 1965, weed control readings were recorded on a light infestation of wild buckwheat. Weed control ratings (Table 19) showed similar trends to those discussed in the 1964 experiment on green smartweed control. Again, as in the previous year, dicamba was essential in the mixture for satisfactory weed control, and 2-(MCPP) when added to dicamba, 2,4-D or a mixture of dicamba and 2,4-D resulted in slight increased weed control.

Flax injury ratings in 1964 and 1965 (Tables 18 and 19) were somewhat higher than expected for these herbicidal applications, probably because the flax was in an advanced growth stage at time of chemical

Table 18 The effect of 2-(MCPP), 2,4-D and dicamba in commercial herbicide mixtures on weed control, flax injury, and flax yields, 1964.

Treatment			Weed	Flax	Flax
Dicamba	2,4-D	2-(MCPP)	Control*	Injury*	Yield
oz/ac	oz/ac	oz/ac	0-10	0-10	bu/ac
0	0	0	0.0	0.0	14.5
1.35	3.75	0.9	7.6	3.6	15.7
1.35	3.75	0	7.0	4.4	12.4
1.35	0	0.9	6.4	3.4	13.9
0	3.75	0.9	4.3	2.3	15.7
1.35	0	0	5.3	2.3	13.8
0	3.75	0	3.1	2.8	15.4
0	0	0.9	2.8	1.3	16.1

* 0 = no injury; 10 = complete kill.

Plate I.

Plate 1. Plot treated with 2,4-D at 3.75 ounces per acre.

Plate 2.

Plate 2. Plot treated with 2,4-D at 3.75 ounces per acre plus 2-(MCPP) at 0.9 ounces per acre.

Plate 3.

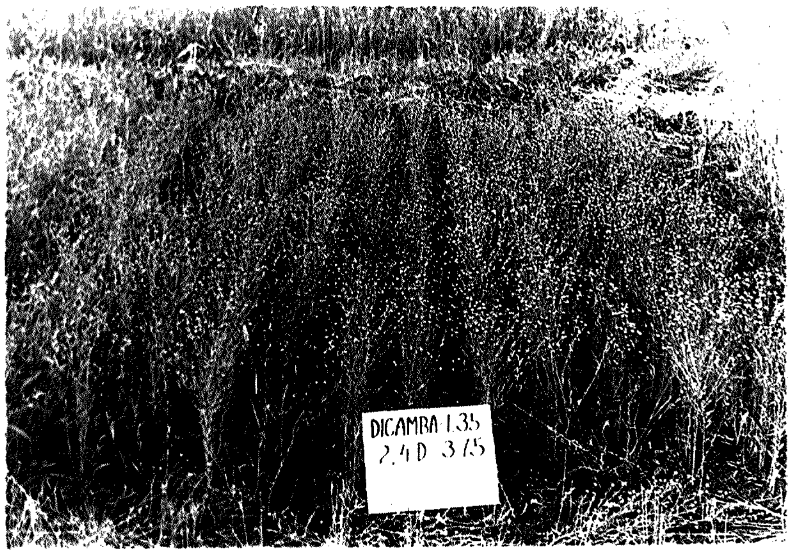

Plate 3. Plot treated with dicamba at 1.35 ounces per acre plus 2,4-D at 3.75 ounces per acre.

Plate 4.

Plate 4. Plot treated with dicamba at 1.35 ounces per acre plus 2,4-D at 3.75 ounces per acre plus 2-(MCPP) at 0.9 ounced per acre.

Table 19 The effect of 2-(MCPP), 2,4-D and dicamba in commercial herbicide mixtures on weed control, flax injury, and flax yields, 1965.

Treatment			Weed	Flax	Flax	Duncan's Multiple
Dicamba	2,4-D	2-(MCPP)	Control*	Injury*	Yield	Range Test**
oz/ac	oz/ac	oz/ac	0-10	0-10	bu/ac	
0	0	0	0	0	12.9	b c
1.35	3.75	0.9	7.5	1.8	16.5	a b
1.35	3.75	0	7.2	1.2	15.7	a b c
1.35	0	0.9	5.8	0.6	18.3	a
0	3.75	0.9	4.5	0.4	11.2	c
1.35	0	0	5.5	0.2	17.0	a b
0	3.75	0	4.4	0.7	14.4	a b c
0	0	0.9	3.0	0	16.8	a

* 0 = no injury or no control; 10 = complete kill.

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

treatment. However, in both years, chemical treatments containing both dicamba and 2,4-D or the addition of 2-(MCPP) resulted in the highest crop injury. 2-(MCPP) alone resulted in the least injury to the flax crop.

Yield data for 1964 and 1965 are also presented in Tables 18 and 19. In 1964, there were no significant differences among chemical treatments in their effect on crop yield (Appendix 14).

In 1965, significant differences among the treatments were detected by the analysis of variance (Appendix 15). Chemical treatments with 2,4-D and 2-(MCPP) resulted in significant yield reductions from the following treatments: dicamba:2,4-D:2-(MCPP) mixtures, dicamba:2-(MCPP) mixture, dicamba alone, and 2-(MCPP) alone. A serious infestation of Canada thistle (Cirsium arvense L.) in certain areas of the experiment may have amplified the differences which did occur and account for the significant yield differences.

Results from these experiments indicate that when 2,4-D was added to dicamba and applied to flax there was a marked increase in the weed control. The addition of 2-(MCPP) to 2,4-D or to dicamba resulted in only slightly increased weed control.

e) Flax tolerance to dicamba and dicamba mixtures at different growth stages, 1965.

Dicamba alone, two mixtures containing dicamba, and MCPA, were applied to flax at ten different growth stages to determine and compare flax tolerance to the herbicides.

Visual assessments of crop injury are presented in Table 20. All chemical treatments resulted in very little injury to the flax crop up to a period when the flax was 8 inches in height. It appeared that flax 8 inches in height had less tolerance to the dicamba:2,4-D:2-(MCPP) mixture than to other herbicide treatments. However, chamical applications beyond the 8-inch growth stage resulted in more severe crop injury. The crop injury from chemical treatments was not as severe once the flax had reached the flowering and late flowering stage. The injury resulting on the flax crop when treated with dicamba at 2 ounces per acre was similar to the injury following application of MCPA at 10 ounces per acre, which is recommended for weed control in flax. The flax appeared to be somewhat less tolerant to the mixtures containing dicamba, phenoxy herbicides, and 2-(MCPP).

Data on the effect of the four chemical treatments on flax yield at ten different growth stages is presented in Table 21 and Figures 1 and 2. The analysis of variance (Appendix 16) detected significant differences among treatment dates. The average yields for treatment dates were higher than those of the hand-weeded check plots at the earlier growth stages. A definite reduction in yield resulted when chemicals were applied to flax after the 8-inch growth stage. Chemical treatments applied to the flax when the flax was 12 inches in height and at the flowering stage, resulted in significant yield reductions over yields obtained when the chemicals were applied in the early growth stages (1 inch and 2 inches).

Table 20 The effect of dicamba and dicamba mixtures on flax when applied at different growth stages, 1965.

Growth Stage	Time (Days post-emergence)	CROP INJURY* Dicamba 2-oz/ac	Dicamba + 2,4-D +2-(MCPP) 1.8-oz/ac 5.0-oz/ac 1.2-oz/ac	Dicamba + MCPA +2-(MCPP) 1.8-oz/ac 5.0-oz/ac 1.2-oz/ac	MCPA 10-oz/ac
Hand-weeded check		0	0	0	0
Weedy check		0	0	0	0
1/2 in.	9	0	0.3	0.3	0.1
1 in.	14	0.2	0.8	0.8	0.3
2 in.	19	0	1.1	0.9	0
4 in.	24	0.4	1.1	1.2	0
8 in.	29	1.1	4.2	2.0	0.3
10 in.	32	2.0	4.6	4.2	2.5
12 in.	36	2.8	4.2	3.4	2.2
Early flowering	39	1.5	3.0	2.2	1.4
Flowering	46	1.8	2.5	2.8	1.8
Late flowering	50	1.1	1.8	1.8	1.8
Average		1.1	2.4	2.0	1.0

* 0 = no injury; 10 = complete kill.

Table 21 The effect of dicamba and dicamba mixtures on flax yield when applied at different growth stages, 1965.

Growth Stage	Time Days post-emergence)	CROP YIELD (bu/ac) Dicamba 2-oz/ac	Dicamba + 2,4-D +2-(MCPP) 1.8-0z/ac 5.0-oz/ac 1.2-oz/ac	Dicamba + MCPA +2-(MCPP) 1.8-oz/ac 5.0-oz/ac 1.2-oz/ac	MCPA 10-oz/ac	Average	Duncan's Multiple Range Test*
Hand-weeded check		18.1	18.7	17.4	16.1	17.6	a b
Weedy check		15.8	13.5	14.9	15.0	14.8	a b
1/2 inc.	9	17.5	18.8	18.5	19.0	18.4	a b
1 in.	14	18.9	18.7	19.0	19.1	18.9	a
2 in.	19	18.3	19.0	19.0	19.9	19.0	a
4 in.	24	16.7	17.9	18.9	17.8	17.8	a b
8 in.	29	16.3	15.3	17.1	17.1	16.4	a b
10 in.	32	13.6	12.8	12.8	13.2	13.1	a b
12 in.	36	11.3	11.3	12.3	12.3	11.8	b
Early flowering	39	14.0	12.8	14.7	15.6	14.3	a b
Flowering	46	12.8	9.6	9.9	14.2	11.6	b
Late flowering	50	15.9	10.5	11.0	12.9	12.6	a b
Average		15.7	14.9	15.4	16.0		
Duncan's Multiple Range Test*		a	b	ab	a		

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

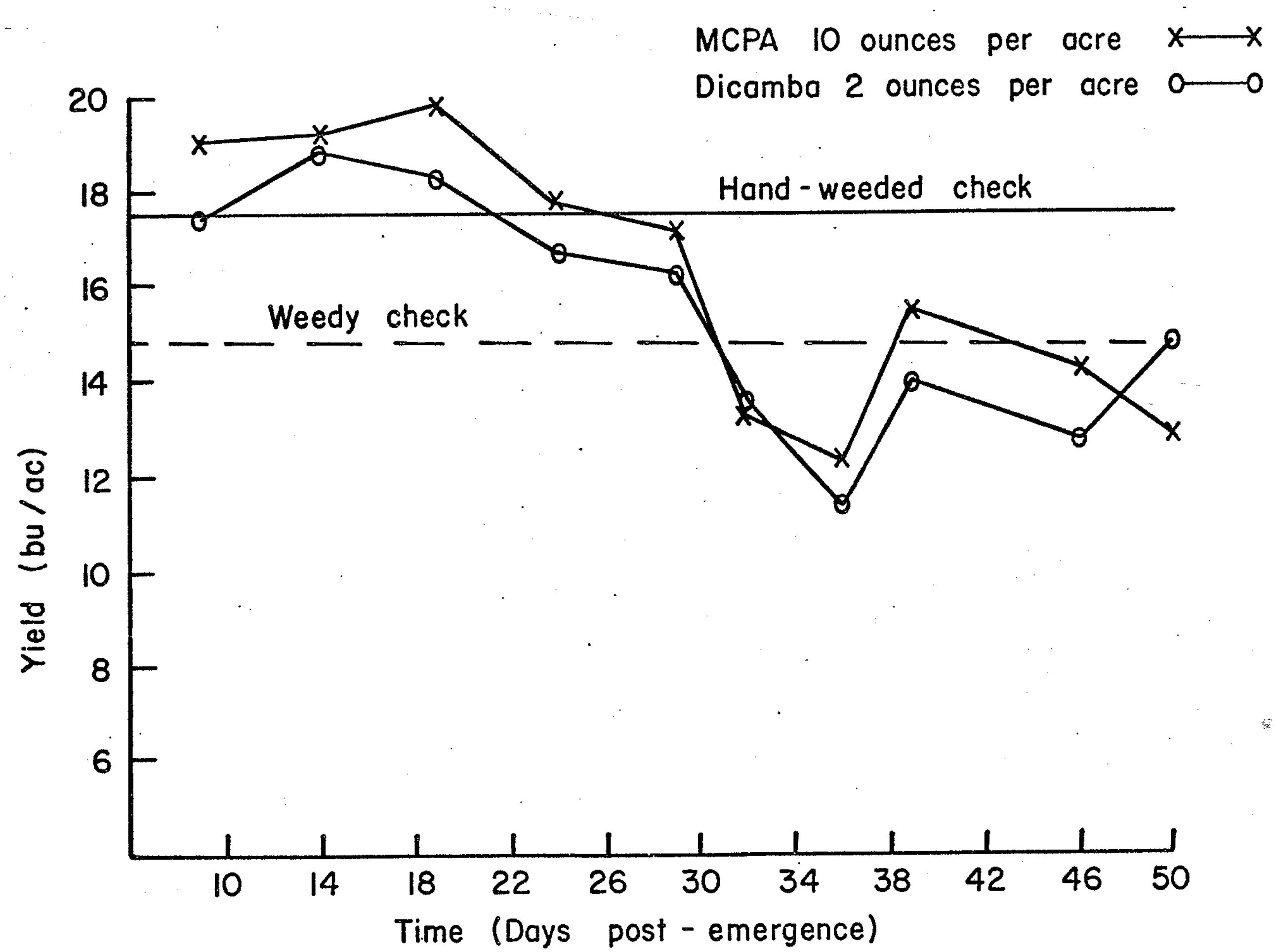

Figure 1 The effect of dicamba at 2 ounces per acre and MCPA at 10 ounces per acre on flax yield applied at different growth stages.

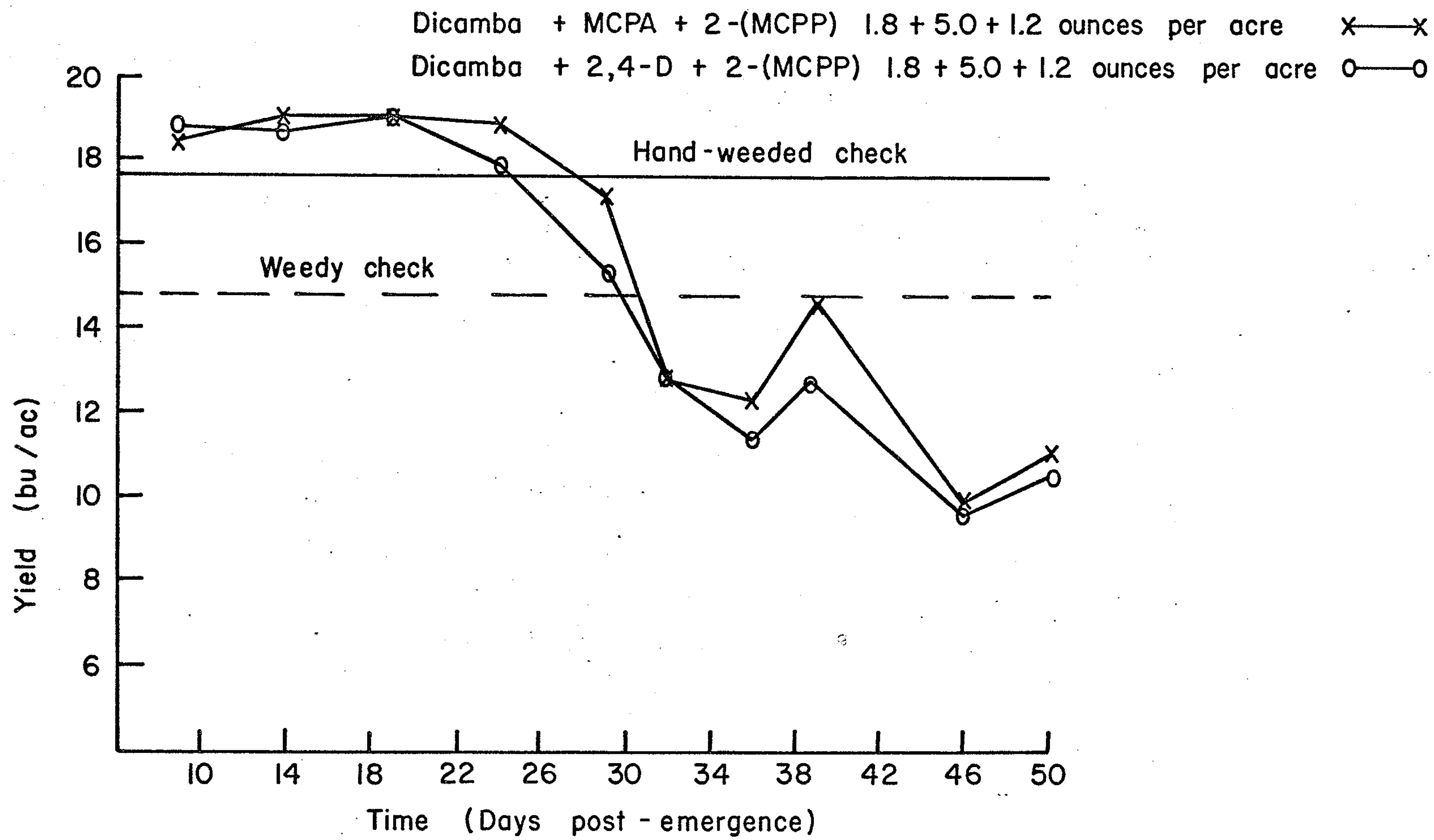

Figure 2 The effect of dicamba:2,4-D:2-(MCPP) and dicamba: MCPA:2-(MCPA) mixtures at 8 ounces per acre on flax yields applied at different growth stages.

The significant (5% level) interaction of chemicals by dates of application, detected by the analysis of variance, indicates that all the chemicals are not responding in the same manner at all treatment dates. All the chemicals appeared to affect the flax yields in the same manner at each date of application, with one exception. When dicamba was applied to flax at 2 ounces per acre in the late flowering stage, there was a marked increase in the flax yield from that of the previous date of application. There was a general increase in yields at this growth stage on application of the other chemical treatments but the increase was not as marked. The commercial mixture of dicamba:2,4-D: 2-(MCPP) resulted in significant yield reductions. The yield differed significantly from those of MCPA at 10 ounces per acre and dicamba at 2 ounces per acre, but was not significantly lower than the yield obtained when the dicamba:MCPA:2-(MCPP) mixture was applied to the flax.

The results of this project indicate that flax is quite tolerant to dicamba and herbicidal mixtures containing dicamba during the early growth stages, but the tolerance declines as the flax reaches the 10-inch growth stage. Examination of Figures 1 and 2 indicates that the response patterns of flax to these herbicides at various growth stages was quite similar.

f) The effect of dicamba on flax under different soil and moisture conditions.

Dicamba at 4 ounces per acre was applied to flax grown in sand, clay and potting soil (1:2 peat-clay mixture) at three different moisture levels to determine whether flax responded differently under varying environmental conditions.

The chemical treatment resulted in plant deformities when applied to flax plants grown in sand or clay maintained at field capacity, near the wilting point and saturated moisture conditions. But deformities were not apparent on plants grown in the potting soil at any moisture level.

Plants grown in the 3 soil types maintained at the field capacity moisture level (Plate 6) showed a differential growth response which could be attributed to the nature of the different soil types. However, plants in the sand and clay soil showed marked leaf deformities. These malformations were not apparent on plants grown in the potting soil. The injury and deformities were amplified on the plants grown in the clay soil in comparison to plants grown in the sand due to higher fertility and, as a result, more luxurious growth. The injured plants showed an initial stunting, with the formation of the deformed leaves after growth resumed.

Plants maintained near wilting point conditions showed the same injury when grown on sand and clay soil, but no deformities resulted in plants grown in potting media (Plate 7).

Plants grown in all three media maintained at saturated moisture conditions resulted in a more lush growth than any of the plants described previously under lower moisture levels. The effects of chemical treatment on the plants were similar to those when the plants were grown at lower levels of moisture (Plate 8).

Plate 5.

Plate 5. Untreated plants in potting soil at field capacity.

Plate 6.

Plate 6. Dicamba treatment at 4 ounces per acre on sand, clay, and potting soil at field capacity.

Plate 7.

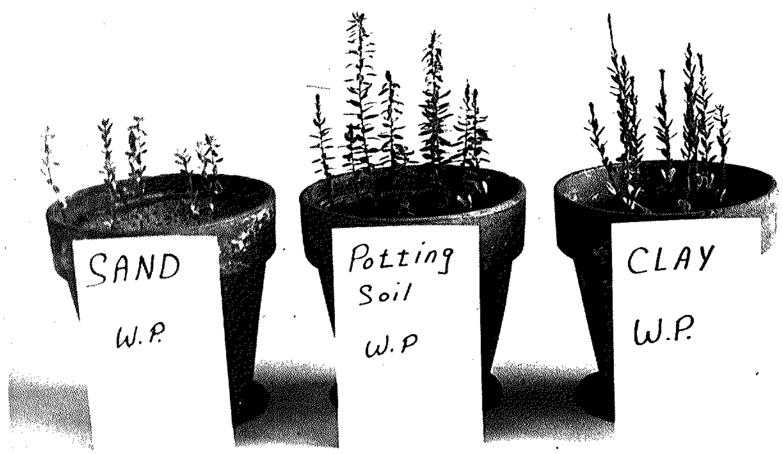

Plate 7. Dicamba treatment at 4 ounces per acre on sand, potting soil, and clay near wilting point conditions.

Plate 8.

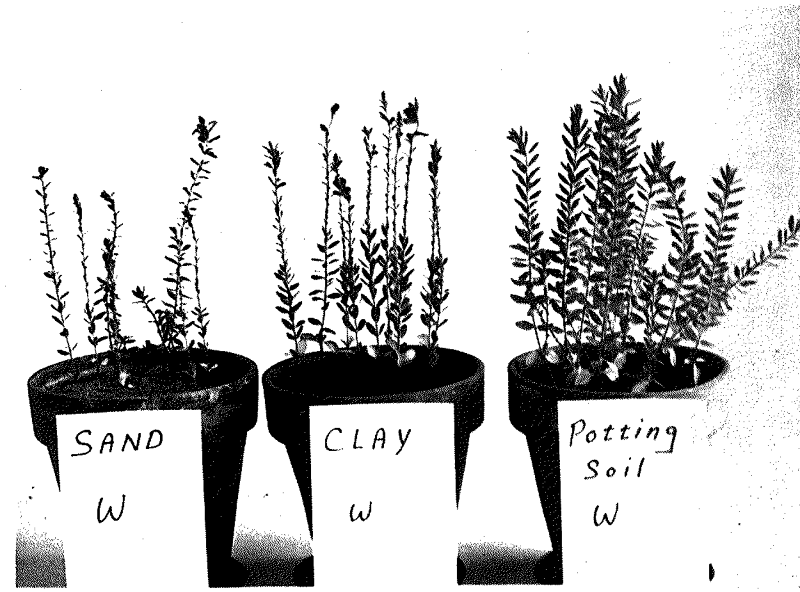

Plate 8. Dicamba treatment at 4 ounces per acre on sand, clay, and potting soil at saturated conditions.

The leaf deformities were quite apparent on plants grown in the sand and clay media, but were absent on plants grown in the potting soil.

It would appear from these preliminary studies and observations that soil type and moisture conditions, or a combination of both, could affect the response of flax plants to treatment with dicamba. The absence of plant deformities on plants grown in potting media which was high in organic matter might suggest that dicamba is inactivated or retained by the organic matter in the soil, preventing it from being absorbed by the roots. This would confirm observations by Molberg (45) that dicamba is more injurious to flax when applied to the soil than if applied to the foliage only.

SUMMARY AND CONCLUSIONS

In 1964, treatment with dicamba at 4 ounces per acre resulted in significant reductions in barley yields as compared with the hand-weeded check, and commercial mixtures of dicamba, 2,4-D or MCPA and 2-(MCPP) at 6 ounces (total active ingredient) per acre. However, dicamba at 4 ounces per acre did not result in significant yield reductions as compared with treatments of commercial mixtures containing dicamba applied at 8 ounces (total active ingredient) per acre.

In 1965, there were no significant differences in barley yields due to herbicide applications. The trends in barley yields following herbicide applications were similar to the previous year's results. The high rate of application of dicamba at 4 ounces per acre resulted in the lowest yield and treatments with the commercial mixtures of dicamba were slightly lower than the check plots. The different response in 1965 could be due to less precipitation at time of application.

Dicamba applied at 4 ounces per acre resulted in slight reductions in plant height in both experiments. Treatments with dicamba mixtures and phenoxy herbicides resulted in little visual injury.

Protein content and bushel weights of the harvested grain samples were not adversely affected by treatments of dicamba and dicamba mixtures, in both years.

The stage of growth (1½ and 4-inch) at time of treatment was not a factor influencing flax response to dicamba and mixtures containing dicamba and phenoxy herbicides. In general, flax responded in a similar manner to treatments made at these early growth stages. However, the flax tolerance was reduced at later growth stages. Applications of dicamba at 2 ounces per acre - dicamba:2,4-D:2-(MCPP), dicamba:MCPA:2-(MCPP) mixtures at 8 ounces (total active ingredient), and MCPA applied at 10 ounces per acre, resulted in yield reduction if applied when the flax was 10 inches in height (32 days post emergence). The yield reductions were highly significant when the herbicides were applied when the flax was 12 inches in height (36 days post emergence). Experimental results in 1964 and 1965 indicate that flax will tolerate treatments of dicamba up to 4 ounces per acre and in mixtures at rates up to 2 ounces per acre when applied prior to the 4-inch growth stage. All chemical treatments containing dicamba resulted in some initial injury to both flax varieties, but became negligible at maturity.

Treatments of dicamba at 4 ounces per acre and mixtures containing dicamba at 6 and 8 ounces (total active ingredient) per acre reduced oil seed quality (oil content and iodine value), but it is unlikely that this reduction is of economic importance at the farm level.

Results of these experiments indicated that dicamba is very effective for the control of green smartweed and wild buckwheat. However, the addition of phenoxy herbicides resulted in slight increases in the control of these "hard to kill" weeds.

Results from greenhouse experiments suggested that physiological factors, such as moisture and edaphic factors, such as soil type, could influence the response of flax to treatments with dicamba.

The results of these experiments indicate that even though there may not have been significant yield reductions and crop injury as a result of herbicidal treatment with dicamba and dicamba mixtures, the lowest recommended rate should be used, and care practised when applying the herbicides to barley and flax.

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- APPENDIX -

APPENDIX 1

Analysis of variance for the effect of dicamba and dicamba mixtures on the yield of barley, 1964.

Source of Variance	D.F.	M.S.	F.
Replicates	3	845.37	1.84
Varieties	1	17,484.94	37.97**
Error 1	3	460.44	
Sub-total 1	7		
Dates	1	75.90	0.25
Dates x Varieties	1	116.64	0.39
Error 2	6	302.35	
Sub-total 2	8		
Treatments	9	74.06	2.03*
Treatments x Varieties	9	57.26	1.57
Treatments x Dates	9	40.60	1.11
Treatments x Varieties x Dates	9	39.10	1.07
Error 3	108	36.57	
TOTAL	159		

** Significant at the 1% level of probability.

* Significant at the 5% level of probability.

C.V. (Varieties) 48.3%

C.V. (Dates) 39.0%

C.V. (Treatments) 13.6%

APPENDIX 2

Analysis of variance for the effect of dicamba and dicamba mixtures on the yield of barley, 1965.

Source of Variance	D.F.	M.S.	F.
Replicates	3	1,542.64	21.24*
Varieties	1	947.21	13.04*
Error 1	3	72.63	
Sub-total 1	7		
Dates	1	152.68	0.90
Dates x Varieties	1	734.03	4.34
Error 2	6	16.91	
Sub-total 2	8		
Treatments	9	83.52	1.74
Treatments x Varieties	9	39.08	0.81
Treatments x Dates	9	27.39	0.57
Treatments x Dates x Varieties	9	46.08	0.96
Error 3	108	48.04	
TOTAL	159		

* Significant at the 5% level of probability.

C.V. (Varieties) 17.6%

C.V. (Dates) 26.8%

C.V. (Treatments) 14.2%

APPENDIX 3

Analysis of variance for the effect of dicamba and dicamba mixtures on the protein content in barley, 1964.

Source of Variance	D.F.	M.S.	F.
Replicates	3	2.75	2.89
Varieties	1	1.17	1.23
Error 1	3	0.95	
Sub-total 1	7		
Dates	1	0.43	0.16
Dates x Varieties	1	30.19	11.70*
Error 2	6	2.58	
Sub-total 2	8		
Treatments	9	1.04	2.87**
Treatments x Varieties	9	0.50	1.39
Treatments x Dates	9	0.16	0.44
Treatments x Varieties x Dates	9	0.48	1.33
Error 3	108	0.36	
TOTAL	159		

** Significant at the 1% level of probability.

* Significant at the 5% level of probability.

C.V. (Varieties) 7.3%

C.V. (Dates) 11.9%

C.V. (Treatments) 4.5%

APPENDIX 4

Analysis of variance for the effect of dicamba and dicamba mixtures on protein content in barley, 1965.

Source of Variance	D.F.	M.S.	F.
Replicates	3	0.30	30.00**
Varieties	1	5.29	529.00**
Error 1	3	0.01	
Sub-total 1	7		
Dates	1	2.28	114.00**
Dates x Varieties	1	1.24	62.00**
Error 2	6	0.02	
Sub-total 2	8		
Treatments	9	0.74	37.00**
Treatments x Varieties	9	0.37	16.50**
Treatments x Dates	9	0.13	6.50**
Treatments x Varieties x Dates	9	0.37	18.50**
Error 3	108	0.02	
TOTAL	159		

** Significant at the 1% level of probability.

C.V. (Varieties) 1.1%

C.V. (Dates) 1.2%

C.V. (Treatments) 1.4%

APPENDIX 5

Analysis of variance for the effect of dicamba and dicamba mixtures on bushel weights in barley, 1964.

Source of Variance	D.F.	M.S.	F.
Replicates	3	0.79	0.51
Varieties	1	310.80	204.47**
Error 1	3	1.52	
Sub-total 1	7		
Dates	1	3.31	0.83
Dates x Varieties	1	15.01	3.77
Error 2	6	3.98	
Sub-total 2	8		
Treatments	9	7.85	1.65
Treatments x Varieties	9	5.90	1.24
Treatments x Dates	9	4.26	0.89
Treatments x Varieties x Dates	9	3.82	0.80
Error 3	108	4.74	
TOTAL	159		

** Significant at the 1% level of probability.

C.V. (Varieties) 2.6%

C.V. (Dates) 4.2%

C.V. (Treatments) 4.5%

APPENDIX 6

Analysis of variance for the effect of dicamba and dicamba mixtures on the bushel weight, in barley, 1965.

Source of Variance	D.F.	M.S.	F.
Replicates	3	1.00	2.00
Varieties	1	490.00	980.00**
Error 1	3	0.50	
Sub-total 1	7		
Dates	1	0.22	0.06
Dates x Varieties	1	1.23	0.32
Error 2	6	3.87	
Sub-total 2	8		
Treatments	9	3.15	1.26
Treatments x Varieties	9	2.32	0.93
Treatments x Dates	9	2.21	0.89
Treatments x Varieties x Dates	9	4.07	1.63
Error 3	108	2.49	
TOTAL	159		

** Significant at the 1% level of probability.

C.V. (Varieties) 1.5%

C.V. (Dates) 4.1%

C.V. (Treatments) 3.3%

APPENDIX 7

Analysis of variance for the effect of dicamba and dicamba mixtures on the yield of flax, 1964.

Source of Variance	D.F.	M.S.	F.
Replicates	3	28.21	2.98
Varieties	1	21.94	2.32
Error 1	3	9.45	
Sub-total 1	7		
Dates	1	3.24	0.08
Dates x Varieties	1	2.78	0.07
Error 2	6	40.33	
Sub-total 2	8		
Treatments	8	5.72	1.17
Treatments x Varieties	8	6.22	1.28
Treatments x Dates	8	3.62	0.74
Treatments x Varieties x Dates	8	8.08	1.66
Error 3	96	4.85	
TOTAL	143		

C.V. (Varieties) 18.5%

C.V. (Dates) 38.2%

C.V. (Treatments) 13.2%

APPENDIX 8

Analysis of variance for the effect of dicamba and dicamba mixtures on the yield of flax, 1965.

Sources of Variance	D.F.	M.S.	F.
Replicates	3	53.35	0.63
Varieties	1	0.86	0.01
Error 1	3	84.14	
Sub-total 1	7		
Dates	1	64.65	1.39
Dates x Varieties	1	111.05	2.38
Error 2	6	46.65	
Sub-total 2	8		
Treatments	9	7.99	1.06
Treatments x Varieties	9	5.79	0.77
Treatments x Dates	9	6.66	0.88
Treatments x Varieties x Dates	9	2.72	0.36
Error 3	108	7.54	
TOTAL	159		

C.V. (Varieties) 39.0%

C.V. (Dates) 29.0%

C.V. (Treatments) 11.6%

APPENDIX 9

Analysis of variance for the effect of dicamba and dicamba mixtures on oil content in flax, 1964.

Source of Variance	D.F.	M.S.	F.
Replicates	3	0.14	1.92
Varieties	1	248.61	3,359.59**
Error 1	3	0.07	
Sub total 1	7		
Dates	1	1.66	10.00*
Dates x Varieties	1	2.03	12.22*
Error 2	6	0.16	
Sub total 2	8		
Treatments	8	0.24	2.00
Treatments x Varieties	8	0.09	0.75
Treatments x Dates	8	0.13	1.08
Treatments x Varieties x Dates	8	0.15	1.25
Error 3	96	0.12	
TOTAL	143		

** Significant at the 1% level of probability.

* Significant at the 5% level of probability.

C.V. (Varieties) 0.6%

C.V. (Dates) 0.9%

C.V. (Treatments) 0.8%

APPENDIX 10

Analysis of variance for the effect of dicamba and dicamba mixtures on oil content in flax, 1965.

Source of Variance	D.F.	M.S.	F.
Replicates	3	3.16	1.14
Varieties	1	297.73	107.78**
Error 1	3	2.78	
Sub-total 1	7		
Dates	1	2.12	0.88
Dates x Varieties	1	7.02	2.91
Error 2	6	2.41	
Sub-total 2	8		
Treatments	9	0.96	6.10**
Treatments x Varieties	9	0.30	1.92
Treatments x Dates	9	0.86	5.46**
Treatments x Varieties x Dates	9	3.62	23.06**
Error 3	108	0.16	
TOTAL	159		

** Significant at the 1% level of probability.

* Significant at the 5% level of probability.

C.V. (Varieties) 3.8%

C.V. (Dates) 3.5%

C.V. (Treatments) 0.9%

APPENDIX 11

Analysis of variance for the effect of dicamba and dicamba mixtures on the iodine number of flax oil, 1964.

Source of Variance	D.F.	M.S.	F.
Replicates	3	3.93	3.47
Varieties	1	3,886.69	3,439.54**
Error 1	3	1.13	
Sub-total 1	7		
Dates	1	168.92	16.83**
Dates x Varieties	1	8.04	0.80
Error 2	6	10.03	
Sub-total 2	8		
Treatments	8	21.89	9.64**
Treatments x Varieties	8	11.44	5.02**
Treatments x Dates	8	2.64	1.16
Treatments x Varieties x Dates	8	2.31	1.01
Error 3	96	2.27	
TOTAL	143		

** Significant at the 1% level of probability.

* Significant at the 5% level of probability.

C.V. (Varieties) 0.6%

C.V. (Dates) 1.6%

C.V. (Treatments) 0.8%

APPENDIX 12

Analysis of variance for the effect of dicamba and dicamba mixtures on the iodine number of flax oil, 1965.

Source of Variance	D.F.	M.S.	F.
Replicates	3	23.80	1.93
Varieties	1	3,060.49	248.61**
Error 1	3	12.31	
Sub-total 1	7		
Dates	1	7.60	0.45
Dates x Varieties	1	21.45	1.29
Error 2	6	16.58	
Sub-total 2	8		
Treatments	9	5.32	5.06**
Treatments x Varieties	9	1.95	1.85
Treatments x Dates	9	0.94	0.89
Treatments x Varieties x Dates	9	2.16	2.05*
Error 3	108	1.05	
TOTAL			

** Significant at the 1% level of probability.

* Significant at the 5% level of probability.

C.V. (Varieties) 1.9%

C.V. (Dates) 2.1%

C.V. (Treatments) 1.7%

APPENDIX 13

Analysis of variance for the effectiveness of dicamba and dicamba mixtures for selective weed control on the yield of flax, 1964.

Source of Variance	D.F.	M.S.	F.
Replicates	3	12.53	3.61*
Treatments	20	48.86	14.08**
Error	60	3.47	
TOTAL	83		

** Significant at the 1% level of probability.

* Significant at the 5% level of probability.

C.V. 13.1%

APPENDIX 14

Analysis of variance for the effect of 2-(MCPP), 2,4-D and dicamba commercial herbicide mixtures on the yield of flax, 1964.

Source of Variance	D.F.	M.S.	F.
Replicates	3	5.80	1.42
Treatments	7	6.30	1.54
Error	21	4.08	
TOTAL	31		

C.V. 13.7%

APPENDIX 15

Analysis of variance for the effect of 2-(MCPP), 2,4-D and dicamba commercial herbicide mixtures on the yield of flax, 1965.

Source of Variance	D.F.	M.S.	F.
Replicates	3	39.04	4.58*
Treatments	7	22.07	2.59*
Error	21	8.52	
TOTAL	31		

* Significant at the 5% level of probability.

C.V. 19.1%

APPENDIX 16

Analysis of variance for the effect of dicamba and dicamba mixtures applied at different growth stages on the yield of flax, 1965.

Source of Variance	D.F.	M.S.	F.
Replicates	3	29.10	0.91
Dates	11	128.98	4.01**
Error 1	33	32.13	
Sub-total 1	47		
Herbicides	3	11.04	3.21*
Herbicides x Dates	33	5.42	1.58*
Error 2	108	3.44	
TOTAL			

** Significant at the 1% level of probability.

* Significant at the 5% level of probability.

C.V. (Dates) 36.6%

C.V. (Herbicides) 11.9%