THE HERBICIDAL EFFECTS OF THE SODIUM SALTS OF TRICHLOROACETIC ACID AND 2,2-DICHLOROPROPIONIC ACID ON FLAX GROWN UNDER WEED-FREE CONDITIONS

by

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ABSTRACT

The reaction of three commercial flax varieties, Redwood, Raja and Marine, to treatments with the sodium salts of trichloroacetic acid (TCA) and 2,2-dichloropropionic acid (dalapon) was studied in 1958 and 1959. An additional experiment was conducted in 1959 to study the effect of combining TCA or dalapon with 2,4-D (2,4-dichlorophenoxyacetic acid) on Marine flax. Morphological characteristics, crop yield and seed quality were used to measure the response of flax to these herbicidal treatments.

In 1958, TCA applied at 4 pounds per acre and dalapon applied at 1 pound per acre did not damage the flax crop, but in 1959, comparable treatments reduced yields and, in some cases, lowered seed quality. TCA treatments were less injurious to flax than were comparable dalapon treatments. TCA applied at 8 pounds per acre and dalapon applied at 3 pounds per acre resulted in crop injury in both years. The stage of growth at the time of treatment, i.e. 4-6 leaf stage or early bud stage, was not a factor influencing flax response to the herbicides. No variety appeared to be consistently more resistant or susceptible to TCA or dalapon with respect to the factors studied.

The effects of combinations of 2,4-D with TCA or dalapon were not significantly different from the separate effects of each of these herbicides. There was, however, a consistent trend toward lower yields and lower seed quality when more than one chemical was used.

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INTRODUCTION

Flax is one of the major oil seed crops grown in Manitoba, with approximately 600,000 acres devoted to its production annually. Because this crop does 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 used for many years to control susceptible broad-leaved weeds in flax fields, but annual grass-type weeds have continued to be a problem. Of the many weed species infesting flax fields, green foxtail (Setaria viridis L.) is becoming increasingly serious in Manitoba on land which is being cropped continuously without the benefit of competitive or intertilled crops in the rotation.

Cultural methods for weed control such as (1) early spring seeding for green foxtail control, (2) delayed seeding for wild oat (Avena fatua L.) control and (3) post-seeding tillage to control small annual weeds, have been successful. However, these practices have their limitations. Early spring seeding or delayed seeding of flax increases the possibility of damage due to early spring or late fall frosts. Similarly, post-seeding tillage is not recommended because of the relatively poor root development in this crop. Because cultural practices have not been entirely satisfactory the farmer has turned to chemical methods for control of weeds in flax.

TCA (sodium salt of trichloroacetic acid) has been recommended as a selective herbicide for the control of green foxtail in flax since 1952. TCA is absorbed through the root system of plants and therefore its effectiveness is dependent on an adequate supply of moisture in the soil to leach the chemical to the root zone. A closely related herbicide, dalapon (sodium salt of 2,2-dichloropropionic acid), also is effective in controlling green foxtail. This herbicide appears to have several advantages over TCA. It is less irritable to the skin, more soluble in water, easier to handle, absorbed through the foliage of plants as well as by the roots and less expensive in terms of cost of chemical per acre. Although dalapon appears to be more efficient as well as more economical its use has been reported to result in some injury to flax crops.

A more thorough knowledge of the herbicidal effects of these two chemicals on flax would aid in determining whether dalapon can be used as an alternative to TCA for the control of green foxtail in flax under Manitoba conditions. A study was carried out at the University of Manitoba during 1958 and 1959 to compare the effects of TCA and dalapon on the morphology, seed yield and quality (oil content, iodine number of the oil and seed viability) of three flax varieties, Redwood, Raja and Marine. The effect on Marine flax of applications of each of these herbicides combined with a recommended rate of 2,4-D was determined in an additional experiment in 1959.

LITERATURE REVIEW

Weed competition studies by several workers have demonstrated the inability of flax to compete successfully with weeds. Density studies with wild mustard, (*Brassica arvensis* (L.) Rabenh.) conducted by Burrows and Olson (17), showed that as few as 10 mustard plants per square yard reduced yields of flax by over 50 percent. Pavlychenko (7) showed that moderate infestations of wild oats in flax reduced yields by 84.2 percent. Stoa (57) reported that competition from green foxtail seeded at 40 pounds per acre in flax plots resulted in a 38 percent loss in flax yields.

Results of these competition studies explain why, prior to the advent of selective herbicides, this crop was generally restricted to summerfallow land or new-breaking. With the aid of selective herbicides, flax can now be grown successfully on land previously considered too weedy for this crop.

One of the first herbicides to be used successfully for controlling annual broad-leaved weeds in flax was 2,4-D. Subsequently, another chemical, MCPA, proved to be less damaging to flax crops. Both herbicides controlled many broad-leaved weeds but left grass-type weeds undamaged. In 1950 TCA was found to control green foxtail in flax. This development was followed almost immediately by the introduction of dalapon for the same purpose.

The Effect of 2,4-D on Flax

Flax originally was considered too sensitive to treat with 2,4-D. Subsequently, extensive research in the United

States and Canada proved that with minor precautions flax could be treated without adversely affecting the yield of this crop.

Considerable research has been carried out to study the effects of 2,4-D on the seed quality of flax. Burrows and Olson (17), Chubb and MacKey (19), Friesen (32) and Robinson _et al._ (51) treated flax with 2,4-D at rates ranging from 3 to 16 ounces acid equivalent per acre and found that the oil content and iodine values were not affected. Dunham (27), however, reported that the yield of oil from some varieties of flax was seriously reduced by the 4 ounce rate of the sodium salt and ester formulations of 2,4-D, and that in some trials the iodine number of linseed oil also was reduced.

Several herbicides may be required for the adequate control of weeds in some flax fields. One herbicidal combination for the control of broad-leaved weeds and green foxtail in flax is 2,4-D plus TCA. Some controversy exists as to the advisability of combining the two herbicides and making a single application, or alternatively, applying them separately in two spray operations. Experiments in which single applications of each herbicide were compared with one combined application have given variable results. Several workers (16, 20, 28, 44) reported that the combined treatment was no more severe on flax than the separate treatments. Chubb and MacKey (21), however, reported that flax treated with TCA plus 2,4-D yielded less than similar stands treated with TCA alone. Other workers (25, 45) suggest that the lowest recommended rate of each of the herbicides be used when they are combined in a single application.

Herbicidal Uses of TCA and Dalapon

MacCall (42) called attention to the grass killing properties of the trichloroacetates in 1949, while similar properties for 2,2-dichloropropionic acid were reported in 1953 by the Dow Chemical Company, Midland, Michigan, U.S.A. (58). It has been demonstrated adequately that TCA will provide excellent control of green foxtail without lowering flax yields, (4, 18, 30, 36, 37, 40, 43, 44, 45, 55). Dalapon has been recommended as an alternative to TCA for annual grass control in flax in several States (29, 35). These recommendations state that flax plants should be at least two inches in height and green foxtail less than two inches in height for best results. In 1958, the Canadian National Weed Committee (Western Section) recommended the "trial use" of dalapon at 12 to 24 ounces per acre for the control of green foxtail in flax (5). In 1960 this committee approved the use of dalapon as an alternative to TCA for the control of green foxtail in flax (6).

TCA and dalapon have several uses in addition to the control of annual grasses in flax. TCA is used in controlling annual grass-type weeds in sugar beets and field peas. Dalapon is used to control grasses in asparagus and potato crops, in established apple and pear orchards and to control wild oats in sugar beets in some areas. It is also used to control cattails (*Typha* spp) and bull rushes (*Scirpus* spp) along roadsides and in drainage ditches. Both herbicides are used as temporary soil sterilants for controlling perennial grasses such as Johnson's grass (Sorghum halepense L.), Bermuda grass (Cynodon dactylon L.) and quack grass (Agropyron repens (L.) Beauv.), (10).

Basic Studies with TCA and Dalapon

The toxicity of TCA to mammals is very low. It is moderately corrosive to metals and therefore to sprayer equipment (3). Soil sterility resulting from treatment with TCA may last up to sixty days or more if there is little rainfall after application (2). TCA dissipation was found to be hastened by increases in temperature and soil moisture (41) but Warren (61) found that TCA was fairly resistant to breakdown in the soil.

Dalapon is less toxic than ordinary table salt to man, livestock and fish and not highly corrosive to metals (48). This herbicide is leached from the soil within two to three weeks after application (60). Although dalapon is not adsorbed by soil particles its mobility is decreased in organic matter and increased in sand (34). It is believed that part of its disappearance from the soil is due to breakdown by soil micro-organisms (34, 60).

Redeman and Hamaker (49) reported that the killing action of TCA and dalapon was related to their ability to precipitate proteins in the protoplasm of plant cells. The main difference in the action of these two chemicals was found to be in their absorption by plants. TCA was absorbed through the roots while dalapon was absorbed through the leaves as well as the root system.

Barrons and Hummer (9) found that TCA was absorbed by both susceptible and resistant plants, but it disappeared rapidly from the susceptible plants only. They postulated that TCA may be metabolised in some manner by susceptible plants with resultant growth reductions and growth abberations. However, Blanchard (11), working with radioactive TCA in corn (susceptible to TCA) and peas (resistant to TCA), confirmed that TCA was present in the sap of the roots, stems and leaves following treatment, but could not find metabolic derivatives in either plant. Switzer (59) found that TCA at concentrations of $5x10^{-2}M$ (9400 ppm) inhibited both succinate and pyruvate respiration more than 50 percent, while at higher concentrations inhibition probably was brought about by the action of TCA as a protein precipitant. Preliminary experiments with dalapon indicated that the chemical inhibited pyruvate respiration at concentrations higher than $10^{-4}M$ (16.5 ppm), but had little effect on succinate respiration. Crafts and Foy (24) found that radioactive dalapon (2,2-dichloropropionic - 2-C^{14} acid) moved rapidly from the treated leaves to the roots. There was also a transfer of dalapon from the phloem to the xylem, thereby causing an upward movement of the chemical in the transpiration stream, with an accumulation in the growing points of plants. Under their test conditions dalapon distribution, following uptake through the roots, was more rapid than after foliar absorption, and reached all parts of the plant within one hour. The authors postulated that the key to the selective growth regulatory action of dalapon seemed to be in the protoplasm. Hilton (33) has shown, both invitro and invivo, that dalapon inhibited the enzymatic synthesis of pantothenate by competing with pantoate for a site on the enzyme. He also found that the enzyme dissociation constants for TCA and other trichloro compounds were less than in corresponding dichloro compounds, i.e. they were stronger enzyme inhibitors.

Several studies have been made to examine the effect of TCA and dalapon on yield, quality and other agronomic characteristics of flax. In 1952 Chubb and MacKoy (20) used TCA as a pre-emergence treatment on fiber flax. TCA was applied at 0, 5, 10 and 20 pounds per acre to the soil on which the variety Liral Dominion was sown. Yields were decreased by the treatments, but the oil content of the seed and the iodine number of the oil was unaffected. Anderson (1) found that TCA at 8 pounds per acre or over and dalapon at 1 pound per acre or over resulted in significant yield reduction and greatly delayed flowering and maturity. He also noted that the dalapon treatments resulted in the dropping of flower buds and the formation of immature bolls in flax. Several workers (28, 52, 53) treated flax with TCA at 5 pounds per acre and dalapon at rates ranging from ½ to 1½ pounds per acre. They found that none of the treatments affected the oil content (percent) of the seed or the iodine number of the oil. In one case seed from TCA and dalapon treated flax had a lower viability than seed from untreated flax.

Burnside (15), in 1958, wrote that: "several reports have arisen in the past season where dalapon has been thought to be more injurious to the flax than TCA. The injury has shown up as leaf-tip burn and greater boll droppage. One experiment in particular at Morris, Minnesota, showed the symptoms quite markedly; however, no visible differences were evident at harvest time and there was not a significant difference in yield between treated and untreated plots. A similar situation occurred in our flax plots at Rosemount, Minnesota. This was the first year that such injury was noted in Minnesota at the 1 pound per acre rate of dalapon. Also, since this injury does not appear to reduce yields, the recommendation for using TCA or dalapon will be continued". Several reports indicate that the tolerance of flax to dalapon is near the 1 pound per acre rate, and that treatment beyond this rate will result in very serious damage to the flax (1, 8, 12, 13, 14, 31, 37, 38, 54).

MATERIALS AND METHODS

Four separate experiments were used to determine the response of flax to treatments with TCA and dalapon. In 1958 each herbicide was studied in a separate experiment. In order to make a more accurate comparison of the two herbicides both were included in one experiment in 1959. Because it would be desirable to control both broad-leaved and grass-type weeds with one spray application an additional experiment was set up to determine the effect on flax of combinations of 2,4-D with either TCA or dalapon.

Commercial preparations of TCA (the sodium salt of trichloroacetic acid) and dalapon (the sodium salt of 2,2-dichloropropionic acid) were used in these experiments. The commercial preparations formed a stable solution when dissolved in water. The project was conducted on land situated at the University of Manitoba.

(a) The Effect of TCA on Flax, 1958

Three flax varieties, widely grown in Manitoba, were selected for this study. Included were Marine, an early maturing, relatively low yielding variety, Redwood, a late maturing, relatively high yielding variety and Raja, an early maturing, intermediate yielding variety. These varieties were sown at a rate of 40 pounds per acre on June 3. The design of the experiment was a five replicate split-plot with varieties as main plots and rates and dates of treatments as subplots. Each subplot was

5 foot by 10½ foot in size and accommodated 8 rows of flax spaced 6 inches apart. This provided a 1 foot space between plots for the wheels of the sprayer to pass over. When the flax reached maturity 4 rod-rows were harvested from the center of each plot.

There had been no precipitation in May, so on June 1 the experimental area was sprinkle irrigated with an equivalent of 1 inch of rainfall. The experiment was conducted under weed-free conditions. The varieties were sprayed with TCA at rates of 4 and 8 pounds active ingredient per acre, at two stages of growth. These rates were chosen to include an officially recommended rate plus a rate much in excess of the recommended dosage. The first date of spraying was June 21, at which time all flax varieties were in the 4 to 6 leaf stage and from 2 to 3 inches in height. The second date of spraying coincided with the early bud stage of development. The dates were July 9 for Raja, July 12 for Marine and July 16 for Redwood. The herbicides were applied in 90 gallons of total solution per acre. The varieties Raja and Marine were harvested on September 11, and the variety Redwood was harvested on September 20.

The percent oil content, iodine number of the oil and percent germination were determined on seed samples obtained from each plot. The oil content determinations were carried out according to a press method outlined by Comstock and Culbertson (23), with the following modifications: each sample was subjected to a pressure of 20,000 pounds per square inch for a period of one minute. The length of time that the pressure should be maintained is not stated in Comstock's paper. After the third decantation with "Skellysolve" F (a petroleum ether), the vials containing the extracted flax meal were placed in a drying oven at 100 degrees C. for a period of 24 hours instead of the 48 hours at 90 degrees C. suggested by the authors. The oil percentages that were obtained by this procedure were approximately 0.3 higher than those obtained from the conventional Soxhlet method, and were consistent with results reported by Comstock. Comstock made each iodine number determination from an oil sample placed in a hand refractometer immediately after each flax sample had been pressed. This is an efficient method where two individuals work together, but for one individual it was found more convenient to collect the oil from the first decantation for this use. The "Skellysolve" F was evaporated in a standard drying oven for one hour at 100 degrees C. and then for one hour in a vacuum oven at 60 degrees C. The oil thus collected was placed in an oil refractometer[1] and the scale readings were taken at 35 degrees C. Each reading was converted to the refractive index at 25 degrees C. by the use of tables[2], and the refractive index into the iodine number by the following formula;

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

where n_D^{25} is the refractive index at 25 degrees C. (46).

Germination tests were carried out on seed samples from each plot by placing 100 seeds on moistened filter paper in petri dishes, and these were maintained at room temperature for 5 days.

1. Sugar and Oil Refractometer, 1953, model, Bellingham and Stanley, Ltd. London.
2. Tables are included in the instruction booklet of the refractometer.

(b) <u>The Effect of Dalapon on Flax, 1958</u>

The dalapon experiment was located in a similar area 75 yards from the TCA experiment. The experimental design, flax varieties and stages of growth at the time of treatment were the same as in the previous experiment. The land was sprinkler irrigated on June 12 with an equivalent of one inch of rainfall. Seeding of the three varieties was completed on June 14. The first treatment of dalapon at 1 and 3 pounds per acre was applied on June 28 when the flax was 2 to 3 inches in height and had from 4 to 6 true leaves. The second treatment was made at the early bud stage i.e. July 21 for Raja, July 23 for Marine and July 27 for Redwood. Quality studies on the seed were carried out as described in section (a).

(c) <u>The Effect of TCA and Dalapon on Flax, 1959</u>

In order to make a more accurate comparison of the two herbicides both were included in one experiment in 1959. The flax varieties, rates of application and stages of growth at the time of treatment used in this experiment were identical to those used in "a" and "b" in 1958. The design of the experiment was that of a modified split-plot, a strip-plot (22) with six replicates. This design improved the efficiency of the first date of spraying and made the dimensions of a replicate closer to a square.

The flax was sown on June 1 and emerged on June 7. The moisture supply was adequate and irrigation was not necessary. The first treatment of TCA at 4 and 8 pounds per acre and dalapon at 1 and 3 pounds per acre was applied on June 18 when all three varieties were approximately 3 inches tall and had developed from 4 to 6 true leaves. The second treatment was made when the flax was in the early bud stage; on July 3 for variety Raja, on July 7 for Marine and on July 13 for Redwood. The harvest date for most of the Marine and Raja plots were August 25 and September 10 respectively. The plots of Redwood and those plots of Marine and Raja which were treated with dalapon at 3 pounds per acre were harvested on September 25. Quality tests on the flax seed were carried out in the same manner as in 1958.

(d) <u>The Effect of TCA and Dalapon in Combination with 2,4-D, 1959</u>

Treatments in this experiment included TCA and dalapon at 4 and 1 pounds per acre respectively, and 2,4-D (amine) at 5 ounces per acre. These rates of TCA and dalapon in combination with the 5 ounce rate of 2,4-D also were applied. The test area was sown to Marine flax on May 21. Treatments were made at the same two stages of growth as in the previous experiments, the dates of spraying being June 13 and June 29. The flax was harvested on August 19. The experimental design was a completely randomized block, with 5 replicates and 11 plots per replicate. Plot size was 5 feet by 18½ feet. The effect of treatments on seed quality was determined as outlined in previous experiments.

RESULTS AND DISCUSSION

(a) The Effect of TCA on Flax, 1958

Treatment with TCA at 4 and 8 pounds per acre had no visible effect on the morphology of the flax plants.

The analyses of variance for yield and oil content data (Appendices 1 and 2) show that the differences between varieties were not significant. The non-significant treatment by variety interaction indicates that all varieties responded to all treatments in the same manner. This justifies the presentation of this data (Table 1) as averages of all varieties.

Treatment with TCA at 4 pounds per acre at either treatment stage had no marked effect on yield. The higher rate of 8 pounds of TCA per acre resulted in significant decreases in yield for both dates of application.

Application of TCA to flax plants in this experiment did not alter the percent oil content of the seed. The slight deviations of the treatment percentages from the check value are not significant. The data is included in Table 1.

Table 1. The effect of TCA on the yield and oil content (percent) of flax, 1958.

Treatment Stage	Rate of TCA lbs./ac.	Yield bu./ac.	Oil Content %
Check		26.6	40.31
1. 4-6 leaf stage	4	26.4	40.35
	8	24.6 *	40.29
2. early bud stage	4	24.8	40.12
	8	23.8 **	39.99

** significant at 1 percent
* significant at 5 percent

The iodine numbers presented in Table 2 are a measure of the degree of unsaturation of the double bonds in the long chain fatty acids found in the oil of the seed harvested in this experiment. A high number of unsaturated double bonds indicates a rapidly drying oil. Consequently, high iodine number means high quality. The analysis of variance (Appendix 3) detected significant differences among varieties but not among treatments. The variety Raja had a significantly lower iodine number than Marine or Redwood. Treatment with TCA had no effect on the iodine number of any of the varieties, (Table 2).

Table 2. The effect of TCA on the iodine number of flax oil, 1958.

Treatment Stage	Rate of TCA lbs./ac.	Iodine Number		
		Marine	Raja	Redwood
Check		191.64	183.00	197.70
1. 4-6 leaf stage	4	190.27	184.01	197.22
	8	191.20	183.47	198.12
2. early bud stage	4	190.71	185.12	197.26
	8	190.06	184.76	197.75
		N.S.	N.S.	N.S.

The effect of TCA treatments on seed viability may be noted in Table 3. The results were collected originally as percentages, but the distribution obtained was skewed and lacked continuity. Subsequently, the original results were converted using the inverse sine transformation (55). The resulting distribution was sufficiently symmetrical to be treated as normal. Transformed values are used throughout this discussion.

The variety Redwood contained significantly fewer viable seeds than Marine or Raja (Appendix 4 and Table 3). However the germinability of these varieties was not affected by application of either rate of TCA at either stage of development (Table 3).

Table 3. The effect of TCA on the viability (percent germination) of flax, 1958.

Treatment Stage	Rate of TCA lbs./ac.	Percent Germination (Transformed Data)		
		Marine	Raja	Redwood
Check		73.1	75.9	57.8
1. 4-6 leaf stage	4	79.6	74.0	54.7
	8	76.9	78.0	60.8
2. early bud stage	4	71.0	76.9	54.4
	8	74.8	75.7	58.1
		N.S.	N.S.	N.S.

The results of this experiment indicate that the flax varieties used were quite tolerant to treatment with TCA. Application at 4 pounds per acre had no appreciable effect on any of the characteristics studied. Treatment with 8 pounds of TCA per acre decreased seed yield, but did not adversely affect plant morphology, percent oil content, iodine number or seed viability. The high rate was used to determine the effect of TCA when applied in amounts exceeding the recommended rate of 6 pounds per acre. Similar rates may be applied on farm fields as a result of overlapping when spraying, improper boom height, miscalculation of chemical concentration and sprayer output or spray drift. The results indicate that TCA should be applied carefully to avoid decreases in yield resulting from too high a rate of application.

(b) The Effect of Dalapon on Flax, 1958

Treatment with dalapon at 1 pound per acre did not result in visible injury to the plants, but treatment with 3 pounds per acre caused extensive damage in all varieties. The first signs of injury were browning of the leaf margins and stunting of the plants (Plate 1). This effect became quite evident nine days after the first date of spraying and continued throughout the growing season (Plate 2). Leaf-tip burn was most severe on the variety Raja.

Floral deformities were observed in all three varieties as a result of the 3 pound per acre treatment (Plate 3). The petals of deformed flowers were wrinkled and curled and remained tightly rolled. These flowers failed to open normally and the petals were retained by the plant long after petals of the untreated plants had dropped to the ground. Although the flowers of these treated plants contained stamens and pistils, seed development was restricted to thin small white seeds which failed to reach maturity. Subsequent observations showed that the majority of the bolls that were formed did not contain seeds. The variety Raja appeared more susceptible to this type of damage than the other two varieties. Treatment with 3 pounds of dalapon also delayed maturity of all three flax varieties (Plate 4).

PLATE 1.

Plate 1. Check plot (left) and plot treated with dalapon at 3 pounds per acre (right).

PLATE 2.

Plate 2. Plots treated with dalapon at 3 pounds per acre (left) and at 1 pound per acre (right)

PLATE 3.

Plate 3. Flowers from untreated plots (above) and from plots treated with dalapon at 3 pounds per acre (below).

PLATE 4.

Plate 4. Differential maturity of check (right) and dalapon treated plots (centre and left).

Yield data for this experiment are presented in Table 4. Variety differences were not significant (Appendix 5). Treatment with 1 pound of dalapon per acre did not affect yield of the variety Raja. However, significant reductions in yield resulted from applications of this rate to Marine at the 4 to 6 leaf stage and to Redwood at the early bud stage. Treatment with 3 pounds of dalapon per acre lowered the yield of all varieties significantly. The decrease in yield was much greater for Marine and Raja than for Redwood.

Table 4. The effect of dalapon on flax yields, 1958.

Treatment Stage	Rate of Dalapon lbs./ac.	Yield (bus./ac.) Marine	Raja	Redwood
Check		21.82	21.52	23.42
1. 4-6 leaf stage	1	20.36	21.56	18.94 **
	3	15.98 **	11.20 **	13.76 **
2. early bud stage	1	19.00 *	22.10	24.94
	3	3.24 **	2.10 **	17.94 **

** significant at 1 percent
* significant at 5 percent

The average oil content (percent) for each treatment in this experiment is presented in Table 5. Varieties were significantly different but all varieties responded in the same manner to treatment with dalapon (Appendix 6). The application of 1 pound of dalapon per acre to flax plants at either stage of growth did not alter the percentage of oil formed in the seeds. A significant reduction in oil content in all varieties followed application of the 3 pound rate at the early bud stage.

Table 5. The effect of dalapon on the oil content (percent) of flax, 1958[1].

Treatment Stage	Rate of Dalapon lbs./ac.	Oil Content %
Check		40.86
1. 4-6 leaf stage	1	40.91
	3	40.44
2. early bud stage	1	40.67
	3	39.24 **

** significant at 1 percent

The iodine number determinations on the linseed oil revealed that treatment with 3 pounds of dalapon per acre consistently reduced oil quality (Table 6). Although this treatment resulted in significant reduction in quality, it is not known whether this reduction (8 or 9 units) would be of economic importance. The variety Raja produced lower quality oil and was more sensitive to treatment than the other two varieties. (Appendix 7 and Table 6). The oil quality of Redwood was least affected by these treatments.

1. This data represents the average of the three flax varieties.

Table 6. The effect of dalapon on the oil quality (iodine number) of flax, 1958.

Treatment Stage	Rate of Dalapon lbs./ac.	Iodine Number		
		Marine	Raja	Redwood
Check		202.95	195.40	202.74
1. 4-6 leaf stage	1	202.15	193.90	202.36
	3	198.99 **	191.58 **	199.88 *
2. early bud stage	1	200.73	192.75 *	200.29
	3	194.94 **	186.06 **	199.42 *

** significant at 1 percent
* significant at 5 percent

The results of the germination tests to determine if treatment with dalapon had any effect on flax seed viability are presented in Table 7. The analysis of variance of the transformed (inverse sine) data detected significant differences between varieties but not between treatments (Appendix 8). Raja had significantly more viable seeds than Marine or Redwood. Treatment with dalapon had no effect on seed viability in any variety.

Table 7. The effect of dalapon on the viability (percent germination) of flax, 1958.

Treatment Stage	Rate of Dalapon lbs./ac.	Percent Germination (Transformed Data)		
		Marine	Raja	Redwood
Check		70.4	78.1	66.2
1. 4-6 leaf stage	1	62.4	69.9	68.3
	3	66.2	71.1	61.9
2. early bud stage	1	61.3	72.9	67.8
	3	62.2	69.1	66.1
		N.S.	N.S.	N.S.

The results of this experiment demonstrate that flax will tolerate a 1 pound per acre rate of dalapon, but that a 3 pound per acre rate is disastrous to the crop. Treatment with 1 pound per acre did not lower yields appreciably and did not affect oil content, oil quality or seed viability. Treatment with 3 pounds per acre resulted in severe leaf-tip burn, floral deformities and delayed maturity. Yields were reduced significantly and oil content and oil quality were lowered, but seed viability was not affected.

The National Weed Committee (5) has recommended the use of dalapon at 3/4 to 1½ pounds per acre for flax. From the results obtained in this experiment, the recommended rates appear to be sound. However, rates in excess of this may occur as a consequence of overlapping a sprayed area, spray drift, improper sprayer adjustment or incorrect calculation of chemical concentration and sprayer output. The results of this experiment help to emphasize the need for care in using dalapon and suggest that as low a rate as is practical for weed control should be used.

(c) The Effect of TCA and Dalapon on Flax, 1959.

In this experiment treatment with 4 pounds of TCA per acre did not result in visible damage to the flax plants. The 8 pound per acre treatment caused leaf-tip burn in all three varieties. In addition, this high rate stunted slightly the varieties Raja and Marine, but did not delay maturity.

Treatment with dalapon in 1959 resulted in morphological damage to flax similar to that observed in 1958. The incidence of leaf-tip burn was slight when flax was treated with 1 pound per acre rate of dalapon (Plate 5). Flowers on a few plants in these plots were deformed. Maturity was delayed two or three days in the varieties Raja and Marine.

Severe leaf-tip burn was noted in all plots treated with dalapon at 3 pounds per acre (Plate 6). The amount of this type of injury was greater in 1959 than 1958. Deformed flowers were common, and it was observed that aborted bolls that formed dropped from the plants before harvest. This is in agreement with the findings of Anderson (1). This treatment also stunted the variety Redwood slightly. Flower petals of Marine flax treated with dalapon at 3 pounds per acre were bleached from dark blue to a very pale blue color, making them appear white when compared with other treatments in adjacent plots. This phenomena has been reported previously by Eboll and Corns (31).

PLATE 5.

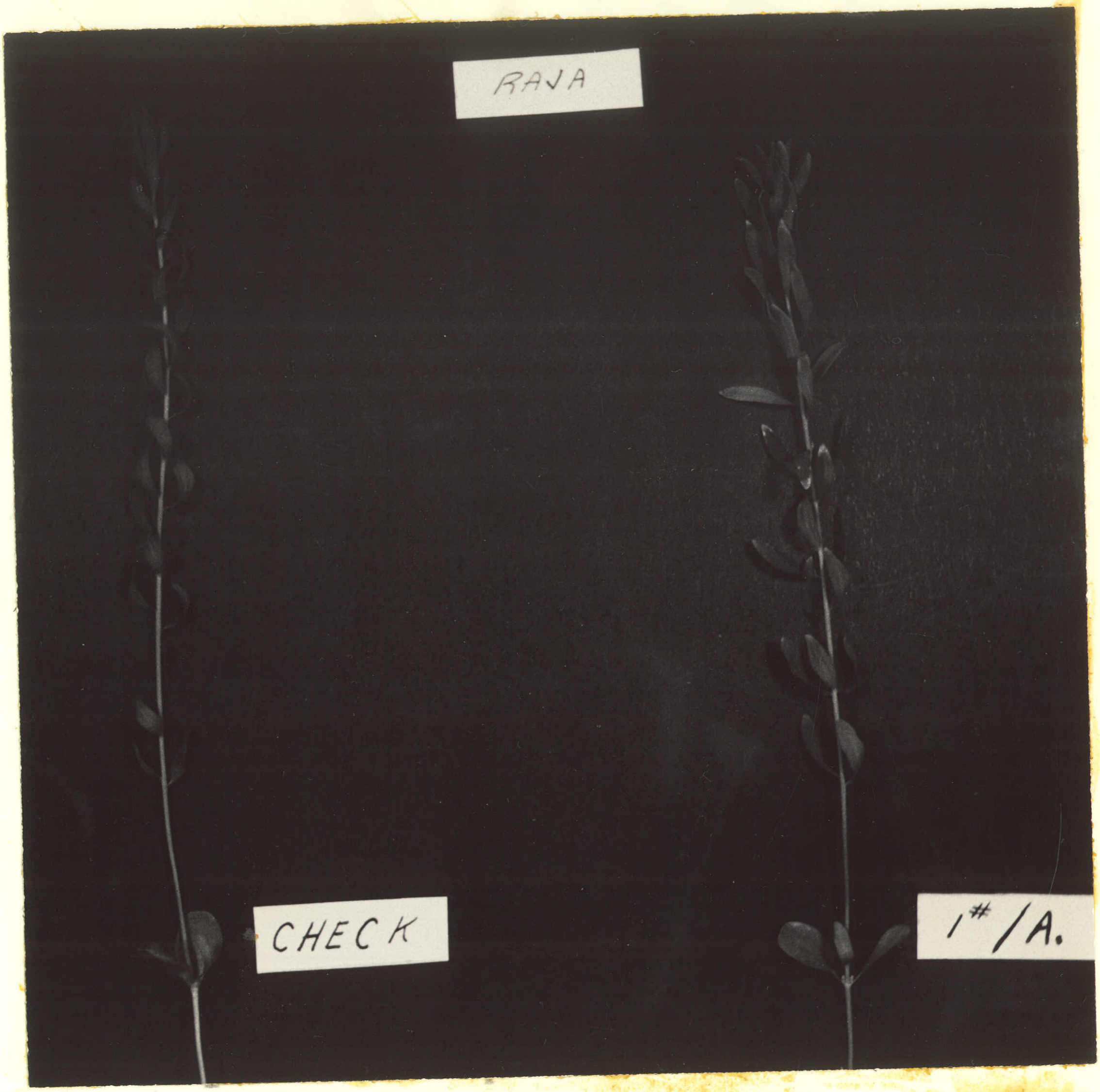

Plate 5. Normal check plant (left) and dalapon treated plant showing slight leaf-tip burn resulting from the 1 pound per acre rate of application (right).

PLATE 6.

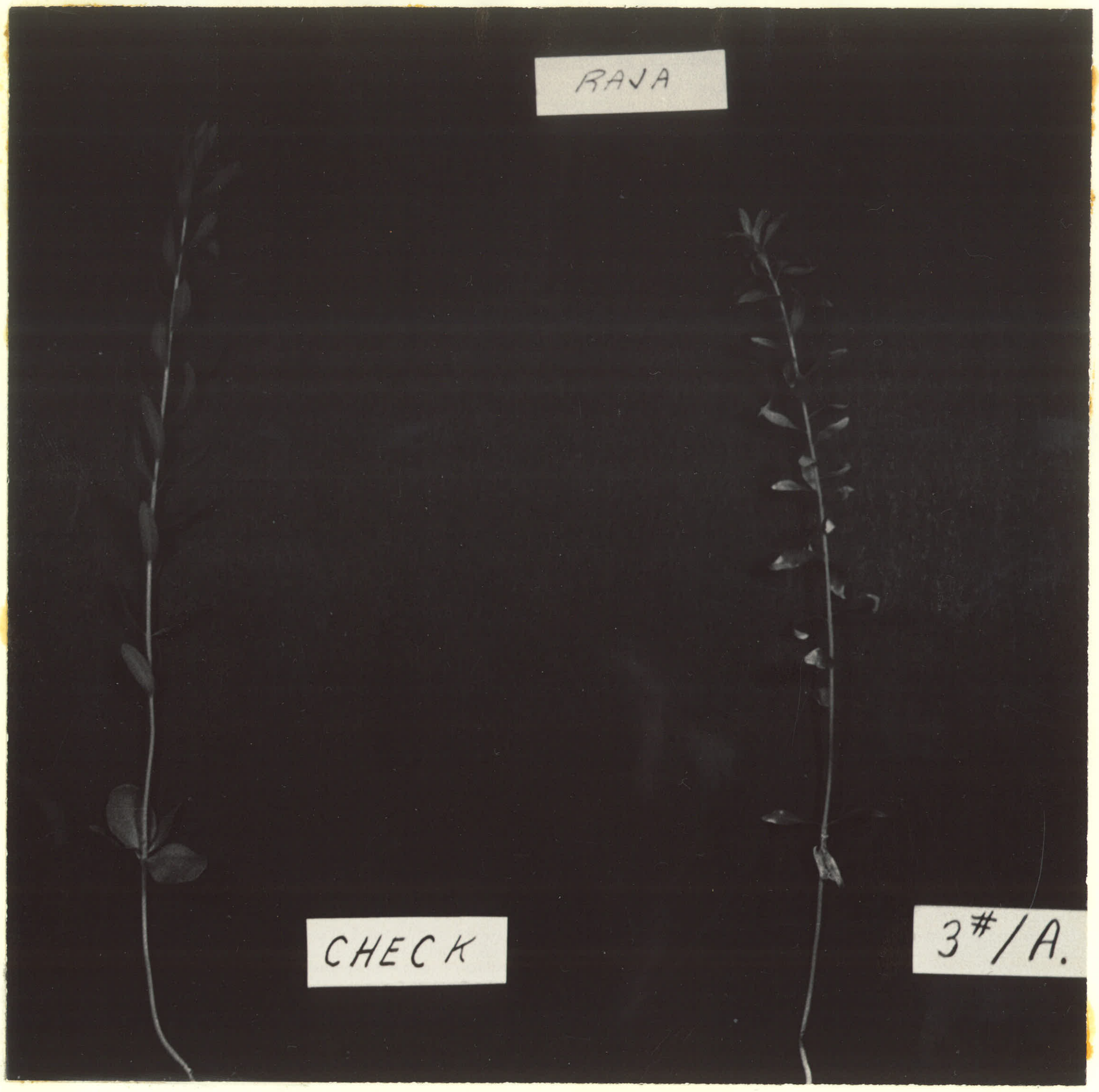

Plate 6. Normal check plant (left) and dalapon treated plant showing severe leaf-tip burn resulting from the 3 pound per acre rate of application (right).

Treatment with 3 pounds of dalapon per acre resulted in delayed maturity in all varieties. Although the plots receiving this treatment were harvested from two weeks to a month later than check plots the stems and leaves of the harvested plants were still green and immature.

Yield data for this experiment are presented in Table 8. In all but one instance treatment with TCA significantly reduced yields. In general, applications of 8 pounds per acre resulted in slightly lower yields than the 4 pound rate. Similarly, the application of dalapon to flax decreased yield, and the greatest reductions were associated with the higher rate of application.

It would appear from these results that the detrimental effects of dalapon are much greater than those of TCA. This difference is emphasized by the interaction of chemicals and rates (Appendix 9). This interaction is in large part one of magnitude. Both chemicals reduce yield at both rates and at both treatment stages, but the reduction accompanying application of the higher rate of dalapon is comparatively greater than that for the higher rate of TCA. This is not entirely unexpected. The "high" rate for TCA is twice the "low" rate (8 pounds per acre versus 4 pounds per acre), but for dalapon the "high" rate is three times as large as the "low" rate (3 pounds per acre versus 1 pound per acre). It would seem logical, therefore, to expect a comparatively greater reduction in yield from the "high" rate of dalapon.

Table 8. The effect of TCA and dalapon on the yield of flax, 1959.

Herbicide	Treatment Rate lbs./ac.	Treatment Stage	Yield (bus./ac.) Marine	Baja	Redwood
Check			25.5	27.0	26.2
TCA	4	1. 4-6 leaf	23.5 *	24.9 *	22.4 **
	8	stage	21.9 **	21.7 **	22.5 **
	4	2. early bud	22.9 **	22.0 **	24.6
	8	stage	21.8 **	22.7 **	21.6 **
Dalapon	1	1. 4-6 leaf	19.3 **	17.0 **	20.6 **
	3	stage	5.5 **	3.7 **	5.9 **
	1	2. early bud	19.7 **	19.1 **	24.7
	3	stage	3.8 **	2.1 **	11.3 **

** significant at 1 percent
* significant at 5 percent

The average oil content (percent) for the seed from each treatment is presented in Table 9. An analysis of variance of the original data (Appendix 10) indicates that varieties are not significantly different and all respond in the same manner to treatment with TCA or dalapon. It is evident from the data that treatment of flax with 4 pounds of TCA per acre at the 4-6 leaf stage, or with the 8 pound rate at either stage has reduced the oil content of flax seed. While dalapon at 1 pound per acre did not affect the oil content, the 3 pound rate at both stages of treatment decreased oil percentages.

Table 9. The effect of TCA and dalapon on the oil content (percent) of flax, 1959[1].

Herbicide	Treatment Rate lbs./ac.	Treatment Stage	Oil Content
Check			40.31
TCA	4 8	1. 4-6 leaf stage	39.69 * 39.47 **
	4 8	2. early bud stage	39.88 39.49 **
Dalapon	1 3	1. 4-6 leaf stage	39.92 38.75 **
	1 3	2. early bud stage	39.91 38.51 **

** significant at 1 percent
* significant at 5 percent

Data on the effect of herbicidal treatments on oil quality are presented in Table 10. TCA treatments reduced slightly the quality of oil from Raja and Marine, but did not affect that from the variety Redwood. The iodine number of the oil from all varieties was decreased by all dalapon treatments. The reduction was greatest for the 3 pound per acre treatment, but, considered alone, this reduction may not be of practical significance.

1. This data represents the average of the three varieties.

Table 10. The effect of TCA and dalapon on oil quality (iodine number) of flax, 1959.

Herbicide	Treatment Rate lbs./ac.	Treatment Stage	Iodine Number		
			Marine	Raja	Redwood
Check			188.40	177.27	186.62
TCA	4	1. 4-6 leaf stage	186.19 **	175.36 *	185.62
	8		186.47 *	175.25 *	185.74
	4	2. early bud stage	186.85	175.35 *	186.49
	8		186.01 **	174.48 **	185.92
Dalapon	1	1. 4-6 leaf stage	183.55 **	171.04 **	184.07 **
	3		178.75 **	169.11 **	179.23 **
	1	2. early bud stage	184.84 **	173.17 **	184.97
	3		176.75 **	167.44 **	180.87 **

** significant at 1 percent
* significant at 5 percent

The results of the germination test are presented in Table 11. An analysis of variance of the original data (Appendix 12) indicates that varieties are significantly different. Fewer viable seeds were formed on Redwood than on Marine or Raja. The absence of interaction between treatments and varieties means that all varieties were affected by treatments in the same manner. Treatment with TCA did not affect the seed viability, but dalapon at 3 pounds per acre resulted in a 15 percent reduction in germination.

Table 11. The effect of TCA and dalapon on the viability (percent germination) of flax, 1959[1].

Herbicide	Treatment Rate lbs./ac.	Treatment Stage	Percent Germination (Original Data)
Check			91.4
TCA	4 8	1. 4-6 leaf stage	89.9 90.4
	4 8	2. early bud stage	93.6 89.4
Dalapon	1 3	1. 4-6 leaf stage	90.3 75.7 **
	1 3	2. early bud stage	88.9 76.7 **

** significant at 1 percent

The data from this experiment indicate that both herbicides had an adverse effect on the flax crop. Although both chemicals were included within one test, a fair evaluation is prevented because the "high" rates of application are not comparable. It appears likely, however, that the adverse effects of TCA are less than those of dalapon. When applied at the recommended rate of 4 pounds per acre, TCA reduced yields by 2-3 bushels per acre, decreased percent oil content and iodine number slightly and had no effect on germinability. These results were obtained under weed-free conditions. It is probable that under farm field conditions these decreases might be more than offset by the benefits derived from weed control. Application of the recommended rate of

1. This data represents the average of the three flax varieties.

1 pound per acre of dalapon resulted in larger decreases in yield (6-10 bushels) and iodine number than did either the recommended or high rate of TCA. Tripling the rate of dalapon virtually tripled the reduction in yield, decreased oil content, oil quality and seed viability. This implies that flax may be more tolerant of TCA than dalapon treatments. Differences in treatment dates and varieties were of limited significance in this study.

It is of interest to note that the herbicidal effects were more severe in 1959 than in 1958. An examination of the environmental conditions for both summers may help to explain this discrepancy. Data is presented in Table 12. The spring of 1958 was extremely dry and seeding was delayed until the land could be sprinkler irrigated. In 1959, 4.63 inches of rain had fallen in May and provided an adequate supply of soil moisture. The movement of TCA into the root zone of flax in 1958 would be very slow because of the lack of water. In 1959 the chemical would move readily to the root zone, resulting in greater uptake and, consequently, more damage. In 1958 the dalapon treatment was applied when the humidity was relatively low, (44 percent) and the mean temperature for the day was 69 degrees F. In 1959 the treatment was made when the humidity was 79 percent and the temperature 69 degrees F. The higher humidity plus good growing conditions in 1959 probably resulted in a greater intake of dalapon by the plant, and, thus increased damage from the chemical. Standifer (56) observed the rate of absorption of dalapon was more efficient or more rapid in Johnson grass under conditions of high humidity.

Table 12. Temperature and rainfall data May to September, 1958 and 1959 (4).

Month	Rainfall in Inches 1958	Rainfall in Inches 1959	Mean Temperatures 1958	Mean Temperatures 1959
May	0.42	4.63	54.0	49.1
June	2.70	2.33	58.6	63.2
July	5.65	3.57	65.3	67.8
August	0.96	3.94	64.1	67.4
September	0.80	3.83	54.8	54.7
Total	10.53	18.30		

(d) <u>The Effect of TCA and Dalapon in Combination with 2,4-D, 1959.</u>

The first indications of morphological injury were evident 4 days after the initial application of the herbicides. Plants treated with 2,4-D were stunted slightly and appeared pale green in color. Treatment with TCA or dalapon had no visible effect on the plants. However, plants treated with either of these chemicals in combination with 2,4-D exhibited considerable stunting. This suggests a possible synergistic effect between 2,4-D and TCA or dalapon. Pfeiffer (26) found that TCA or dalapon (at 1½ pounds per acre as a pre-planting treatment) applied to peas increased the wettability and probable permeability of the surface of the leaves and, therefore, increased susceptibility to other herbicides. A similar reaction appears likely when flax is treated with TCA or dalapon in combination with 2,4-D.

Treatment at the early bud stage with 2,4-D alone or in combination with each of the other two herbicides resulted in slight twisting and bending of the flax stems. These deformities were not apparent two weeks after treatment. At flowering time, however, the petals of plants treated with dalapon plus 2,4-D were bleached and contrasted sharply with the darker blue petals in the adjacent plots (Plate 7). Flowering was also delayed by this treatment (Plate 8), but no delay in maturity could be detected at harvest time.

The response of the variety Marine in this experiment suggests that combinations of 2,4-D and TCA or dalapon may be used successfully for weed control in flax. Treatment with 2,4-D at 5 ounces per acre and dalapon at 1 pound per acre at the 4 to 6 leaf stage did not result in a significant reduction in yield, but treatment with 1 pound of dalapon per acre at the early bud stage or with TCA at 4 pounds per acre reduced yields significantly. The combined treatments of 2,4-D with TCA or dalapon decreased yields significantly, but only slightly below those of the component parts. The stage of development at the time of treatment was not important, (see Appendix 13).

PLATE 7.

Plate 7. Bleached flower petals in flax plots treated with dalapon in combination with 2,4-D.

PLATE 8.

Plate 8. Flax plots treated with dalapon in combination with 2,4-D, showing delayed flowering.

Table 13. The effect of 2,4-D, dalapon and TCA on Marine flax, 1959.

Herbicide	Treatment Rate	Treatment Stage	Yield Bu./ac.	Oil Content %	Iodine Number	Viability %
Check			29.9	40.79	184.38	96.0
Dalapon	1 lb./ac.	1. 4-6 leaf stage	27.7	40.58	180.78 **	95.6
		2. early bud stage	26.0 *	40.33	182.22 *	98.0
TCA	4 lb./ac.	1. 4-6 leaf stage	25.9 *	40.23	183.87	96.2
		2. early bud stage	22.9 **	39.75 **	182.63 *	93.2
2,4-D	5 oz./ac.	1. 4-6 leaf stage	28.9	39.95 **	182.12 *	94.8
		2. early bud stage	29.1	40.58	185.11	97.4
Dalapon plus 2,4-D	1 lb./ac. 5 oz./ac.	1. 4-6 leaf stage	25.5 *	40.14 *	177.79 **	96.6
		2. early bud stage	25.9 *	39.98 *	179.34 **	93.4
TCA plus 2,4-D	4 lb./ac. 5 oz./ac.	1. 4-6 leaf stage	23.3 **	39.84 **	182.11 *	94.4
		2. early bud stage	22.6 **	40.05 *	182.73	97.0

** significant at 1 percent
* significant at 5 percent

The oil content of flax seed was not reduced by applications of dalapon at either treatment stage, but 2,4-D applied at the 4 to 6 leaf stage and TCA applied at the early bud stage lowered oil content significantly. The treatment combination of 2,4-D with either dalapon or TCA also decreased oil content of flax, but interaction between herbicides was negligible (see Appendix 14). Significant decreases in oil quality followed all treatments except TCA applied at the 4-6 leaf stage, 2,4-D and TCA and 2,4-D at the early bud stage. None of the treatments affected flax seed viability (Table 13).

The inconsistent behavior of the 1 pound per acre rate of dalapon on Marine flax (experiments "c" and "d") appears to be a consequence of environmental differences at the time of application. Although the two spray dates were only five days apart the differences in temperature and humidity are large. In the "2,4-D experiment" (d) discussed above, dalapon was applied on June 13 when the recorded high temperature for the day was 67 degrees F. and the humidity at noon was 40 percent. In the "TCA and dalapon experiment" (c) the herbicide was applied on June 18 when the temperature reached a high of 83 degrees F. and the humidity at noon was 79 percent. Damage to the treated material was much greater at the latter date of treatment. Since no other differences were apparent in the material it is thought that the higher temperature and humidity on June 18 increased the rate and amount of dalapon absorption by the plant and, therefore, increased injury.

Treatment with TCA at 4 pounds per acre resulted in injury to flax in both experiments in 1959. In 1958 the effect of TCA at 4 pounds per acre was less pronounced. Because the chemical is absorbed in the root zone, it is suggested that the greater supply of moisture in 1959 transported more of the herbicide to this area and that this, coupled with excellent growing conditions, resulted in a greater total uptake, and consequently greater injury, than in 1958.

SUMMARY AND CONCLUSIONS

In 1958, treatments with 4 pounds of TCA per acre and 1 pound of dalapon per acre were tolerated by flax, i.e. there was little or no injury to the crop. In 1959, comparable treatments significantly reduced yield, oil content and oil quality of the three flax varieties. In both years treatment with TCA was less injurious than dalapon to flax yield. Treatment with 8 pounds of TCA per acre reduced yields in both years and damaged the oil content and oil quality in 1959. Seed viability was not affected by TCA treatments in either year. Treatment with dalapon at 3 pounds per acre reduced yields, oil content and oil quality in both years and lowered seed viability in 1959.

The amount of injury caused by these herbicides appears to be related to environmental conditions at the time treatments were made. Treatment with TCA resulted in more injury when soil moisture was adequate, than when the soil was dry. Similarly, dalapon treatments resulted in greater damage if applied when temperature and humidity were high.

The stage of growth at the time of treatment was not a factor influencing flax response to TCA or dalapon. In general flax responded in about the same manner to treatments made at either the 4 to 6 leaf stage or the early bud stage of growth. This suggests that the tolerance of flax plants to these herbicides is not altered appreciably from the early to the late stage, and decreases in yield attributable to stage of growth should not be expected if the herbicide is applied within these limits.

Significant differences were detected between varieties in many of these experiments. However, the response of these varieties to herbicidal treatment was not consistent and variety recommendations are not possible.

The results from the experiment in which 2,4-D was combined with each of the two herbicides indicated that the yield from plots treated with 2,4-D in combination with either TCA or dalapon was not significantly lower than that of plots treated with 2,4-D, TCA or dalapon alone. However, the trend toward slightly lower yields from such combinations suggests that the lowest recommended rate of each herbicide should be used.

The results of these experiments indicate that under Manitoba conditions TCA may be used with greater safety than dalapon for the control of green foxtail in flax. Because dalapon at 1 pound per acre did not damage the flax crop consistently in experiments, the practice of using this herbicide as an alternative to TCA may be feasible under certain environmental conditions. The lowest recommended rate should be used and care practiced when applying it to the crop. However, because of the difficulty in predicting the weather, TCA should be used in preference to dalapon. The addition of 2,4-D at 5 ounces per acre to either TCA or dalapon treatments should not increase flax injury more than when the chemicals are used alone.

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Appendix 1.

Analysis of variance for the effect of TCA on the yield of flax, 1958.

Source of Variance	D.F.		M.S.
Varieties	2		63.97
Replications	4		70.27
Error 1.	8		109.40
Subtotal	14		
Treatments	4		22.19 **
Rates (rate 1 vs. rate 2)		(1)	28.98 *
Dates (date 1 vs. date 2)		(1)	20.53
Rates x Dates		(1)	2.60
Check vs. All Treatments		(1)	36.68 *
Treatment x Variety	8		6.98
Error 2	47		5.74
Total	73		

** 1.00 percent level of significance
* 5.00 " " "
C.V. 9.46 percent

Appendix 2.

Analysis of variance for the effect of TCA on the oil content (percentage), 1958.

Source of Variance	D.F.	M.S.
Varieties	2	11.37
Replications	4	6.56
Error 1	8	4.05
Subtotal	14	
Treatments	4	0.34
Treatment x Variety	8	0.66
Error 2	48	0.48
Total	74	

C.V. 1.71 percent

Appendix 3.

Analysis of variance for the effect of TCA on the oil quality

(iodine number), 1958.

Source of Variance	D.F.	M.S.
Varieties	2	1,148.00 **
Replications	4	49.00
Error 1	8	52.00
Subtotal	14	
Treatments	4	1.00
Treatment x Variety	8	2.50
Error 2	48	2.50
Total	74	

** 1.00 percent level of significance
 * 5.00 " " " "
C.V. 0.82 percent

Appendix 4.

Analysis of variance for the effect of TCA on the viability (percent germination) of flax, 1958[1].

Source of Variance	D.F.	M.S.
Varieties	2	2,901.50 **
Replications	4	105.75
Error 1	8	61.63
Subtotal	14	
Treatments	4	52.50
Treatment x Variety	8	31.75
Error 2	48	70.79
Total	74	

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 13.15 percent

1. Transformed data.

Appendix 5.

Analysis of variance for the effect of dalapon on the yield of flax, 1958.

Source of Variance	D.F.		M.S.
Varieties	2		104.50
Replications	4		49.81
Error 1	8		29.78
Subtotal	14		
Treatments	4		485.90 **
Rates (rate 1 vs. rate 2)		(1)	1,347.08 **
Dates (date 1 vs. date 2)		(1)	25.87
Rates x Dates		(1)	126.73 **
Check vs. All Treatments		(1)	391.89 **
Treatment x Variety	8		73.84 **
Error 2	47		13.66
Total	73		

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 21.11 percent

Appendix 6.

Analysis of variance for the effect of dalapon on the oil content (percentage) of flax, 1958.

Source of Variation	D.F.		M.S.
Varieties	2		15.75 **
Replications	4		3.53
Error 1	8		1.86
Subtotal	14		
Treatments	4		7.13 **
Rates (rate 1 vs. rate 2)		(1)	11.68 **
Dates (date 1 vs. date 2)		(1)	9.27 **
Rates x Dates		(1)	4.49 **
Check vs. All Treatments		(1)	3.12 *
Treatment x Variety	8		0.55
Error 2	48		0.47
Total	74		

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 1.68 percent

Appendix 7.

Analysis of variance for the effect of dalapon on the oil quality (iodine number), 1958.

Source of Variance	D.F.		M.S.
Varieties	2		606.00 **
Replications	4		48.00 *
Error 1	8		11.50
Subtotal	14		
Treatments	4		109.00 **
Rates (rate 1 vs. rate 2)		(1)	190.18 **
Dates (date 1 vs. date 2)		(1)	90.18 **
Rates x Dates		(1)	11.88
Check vs. All Treatments		(1)	141.95 **
Treatment x Variety	8		9.00 *
Error 2	48		4.00
Total	74		

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 1.01 percent

Appendix 8.

Analysis of variance for the effect of dalapon on the viability (percent germination) of flax, 1958[1].

Source of Variance	D.F.	M.S.
Varieties	2	415.50 *
Replications	4	46.63
Error 1	8	90.44
Subtotal	14	
Treatments	4	78.63
Treatment x Variety	8	44.00
Error 2	48	46.78
Total	74	

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 10.33 percent

1. Transformed data.

Appendix 9.

Analysis of variance for the effect of TCA and dalapon on the yield of flax, 1959.

Source of Variance	D.F.		M.S.
Varieties	2		66.41 **
Replications	5		4.76
Error 1	10		8.76
Subtotal	17		
Treatments	9		1,072.74 **
Chemicals (TCA vs. dalapon)		(1)	3,586.01 **
Rates (rate 1 vs. rate 2)		(1)	2,320.03 **
Dates (date 1 vs. date 2)		(1)	11.90
Rates x Dates		(1)	2.51
Chemicals x Rates		(1)	1,596.00 **
Chemicals x Dates		(1)	25.33 *
Chemicals x Rates x Dates		(1)	7.29
Check vs. All Treatments		(1)	2,103.98 **
Check 1 vs. Check 2		(1)	1.56
Error 2 (treatment error)	45		4.37
Treatment x Variety	18		22.59 **
Error 3 (treatment x variety error)	90		2.55
Total	179		

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 9.17 percent

Appendix 10.

Analysis of variance for the effect of TCA and dalapon on the oil content (percentage) of flax, 1959

Source of Variance	D.F.		M.S.
Varieties	2		55.38 **
Replications	5		0.99
Error 1	10		0.58
Subtotal	17		
Treatments	9		6.47 **
Chemicals (TCA vs. dalapon)		(1)	4.75 **
Rates (rate 1 vs. rate 2)		(1)	22.64 **
Dates (date 1 vs. date 2)		(1)	0.01
Rates x Dates		(1)	0.36
Chemicals x Rates		(1)	8.53 **
Chemicals x Dates		(1)	0.46
Chemicals x Rates x Dates		(1)	0.01
Check vs. All Treatments		(1)	20.95 **
Check 1 vs. Check 2		(1)	0.56
Error 2 (treatment error)	45		0.50
Treatment x Variety	18		0.19
Error 3 (treatment x variety error)	90		0.19
Total	179		

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 1.36 percent

Appendix 11.

Analysis of variance for the effect of TCA and dalapon on the oil quality (iodine number), 1959.

Source of Variance	D.F.		M.S.
Varieties	2		2,439.37 **
Replications	5		34.37
Error 1	10		20.94
Subtotal	17		
Treatments	9		188.44 **
Chemicals (TCA vs. dalapon)		(1)	782.13 **
Rates (rate 1 vs. rate 2)		(1)	248.17 **
Dates (date 1 vs. date 2)		(1)	1.98
Rates x Dates		(1)	19.98 *
Chemicals x Rates		(1)	188.97 **
Chemicals x Dates		(1)	0.93
Chemicals x Rates x Dates		(1)	3.55
Check vs. All Treatments		(1)	450.43 **
Check 1 vs. Check 2		(1)	0.17
Error 2 (treatment error)	45		5.23
Treatment x Variety	18		5.75 **
Error 3 (treatment x variety error)	90		2.09
Total	179		

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 2.22 percent

Appendix 12.

Analysis of variance for the effect of TCA and dalapon on the viability (percent germination) of flax, 1959.

Source of Variance	D.F.		M.S.
Varieties	2		2,050.82 **
Replications	5		57.39
Error 1	10		96.64
Subtotal	17		
Treatments	9		663.21 **
Chemicals (TCA vs. dalapon)		(1)	1,965.44 **
Rates (rate 1 vs. rate 2)		(1)	1,640.25 **
Dates (date 1 vs. date 2)		(1)	2.25
Rates x Dates		(1)	9.00
Chemicals x Rates		(1)	1,560.25 **
Chemicals x Dates		(1)	0.03
Chemicals x Rates x Dates		(1)	53.78
Check vs. All Treatments		(1)	736.09 **
Check 1 vs. Check 2		(1)	1.78
Error 2 (treatment error)	45		19.76
Treatment x Variety	18		39.43
Error 3 (treatment x variety error)	90		28.24
Total	179		

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 5.77 percent

Appendix 13.

Analysis of variance for the effect of 2,4-D, TCA and dalapon on the yield of flax, 1959.

Source of Variance	D.F.			M.S.
Replications	4			19.30 *
Treatments	10			33.14 **
Dates (date 1 vs. date)		(1)		17.05
Dates x Chemicals		(4)		1.35
Chemicals		(5)		62.88 **
2,4-D			(1)	8.64
TCA and dalapon			(2)	138.12 **
Interaction			(2)	14.76
Error	38			6.89
Total	52			

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 10.06 percent

Appendix 14.

Analysis of variance for the effect of 2,4-D, TCA and dalapon on the oil content (percentage) of flax, 1959.

Source of Variance	D.F.		M.S.
Replications	4		0.61 *
Treatments	10		0.56 *
Check vs. All Treatments		(1)	1.89 **
Chemicals		(4)	0.45
Dates		(1)	0.01
Chemicals x Dates		(4)	0.47
Error	39		0.23
Total	53		

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 1.16 percent

Appendix 15.

Analysis of variance for the effect of 2,4-D, TCA and dalapon on the oil quality (iodine number) of flax, 1959.

Source of Variance	D.F.			M.S.
Replications	4			1.70
Treatments	10			22.96 **
Dates (date 1 vs. date 2)		(1)		14.48 **
Dates x Chemicals		(4)		6.02 *
Chemicals		(5)		38.21 **
2,4-D			(1)	21.04 **
TCA and dalapon			(2)	71.41 **
Interaction			(2)	13.59 **
Error	39			1.81
Total	53			

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 1.63 percent

Appendix 16.

Analysis of variance for the effect of 2,4-D, TCA and dalapon on the seed viability (percent germination) of flax, 1959.

Source of Variance	D.F.	M.S.
Replications	4	32.05 *
Treatments	10	12.53
Error	40	9.69
Total	54	

** 1.00 percent level of significance
* 5.00 " " " "
C.V. 3.24 percent