THE UNIVERSITY OF MANITOBA

HERBICIDAL PROPERTIES OF ETHYL-N-BENZOYL-N-(3,4 DICHLOROPHENYL)-2 AMINOPROPIONATE

by

FREDERICK ARNOR HOLM

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF PLANT SCIENCE

WINNIPEG, MANITOBA

October, 1972

AN ABSTRACT OF THE THESIS OF

FREDERICK ARNOR HOLM presented on September 20, 1972

TITLE: HERBICIDAL PROPERTIES OF ETHYL-N-BENZOYL-N-(3,4, DICHLOROPHENYL)-2 AMINOPROPIONATE.

Field, greenhouse and laboratory experiments were conducted to investigate the herbicidal properties of ethyl-N-benzoyl-N-(3,4 dichlorophenyl)-2 aminopropionate (Shell Research Code WL-17731).

WL-17731 selectively controlled wild oats in spring wheat. The degree of selectivity in barley was not adequate at rates tested.

Typical injury symptoms on wild oats included stunting, increased tillering, leaf tip necrosis, chlorosis and leaf deformities. In plants treated at later growth stages, the panicle very often failed to develop fully and did not emerge from the boot.

Under field conditions, control of wild oats using WL-17731 improved with the age of the wild oats up to the shot blade stage. Treating the wild oats prior to the four leaf stage did not give adequate control. At the four to five leaf stage, 1.0 to 1.25 pounds per acre gave satisfactory control.

Treating the leaf sheath and the base of the leaf blade resulted in greater control than when the mid-point or the tip of the leaf blade was treated. In greenhouse trials, rotating the nozzle 45° increased the effectiveness of WL-17731.

Wild oats grown under low light intensity were more severly affected by WL-17731 treatment than plants grown under high light intensity.

WL-17731 reduced cell elongation in stem internodes, reduced the internode diameter and caused a decrease in size and organization of the vascular bundles. Examination of growing point tissue squashes indicated that WL-17731 did not act as a mitotic poison.

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. E. H. Stobbe for his valuable advice and guidance during the course of the research project.

The financial support of Shell Canada Limited and the assistance of Mr. B. Bowden is gratefully acknowledged.

Thanks are also due to Dr. A. K. Storgaard for providing encouragement and advice and for reviewing the manuscript. Thanks also to Dr. G. Findley who reviewed the manuscript.

Mr. H. Nelson assisted in many aspects of the project and his help is greatly appreciated.

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

INTRODUCTION

Wild oat (*Avena fatua* L.) is a serious threat to field crop production on approximately 32 million acres in the prairie provinces. Severe reductions in crop yield can be caused by as few as ten, forty and seventy wild oat plants per square yard in flax, wheat and barley, respectively (Bowden and Friesen, 1967; Bell and Nalewaja, 1968).

Summerfallow and delayed seeding are effective in reducing the severity of wild oat infestations. Delayed seeding, however, often results in reduced crop yields for the year in which it is carried out and summerfallow has the disadvantage of producing no income in the summerfallow year so that any benefits must be averaged over at least two years.

Chemical control of wild oats in cereals and flax has been practised in Western Canada since the early 1960's. Three compounds, barban, diallate and triallate can be used successfully for the control of wild oats in a variety of crops. Effective wild oat control with any of these compounds requires a combination of a high level of managerial skill and suitable environmental conditions. Consequently, satisfactory results are not always obtained. This factor, coupled with the relatively high cost of these chemicals, has limited their acceptance in Western Canada.

An acceptable herbicide for wild oat control should provide effective control over a wide range of growth stages while remaining non-phytotoxic to a variety of crops. The herbicide, ethyl-N-benzoyl-N-(3,4 dichlorophenyl)-2 aminopropionate (WL-17731), has shown a high degree of phytotoxicity to wild oats at growth stages ranging from the three leaf to the flag leaf stage at rates which are tolerated by wheat. Experiments were conducted under field conditions and in controlled environments to study the herbicidal properties of this compound. Field experiments were designed to evaluate the selectivity of WL-17731 between wild oats and wheat and to assess the phytotoxicity of the compound to barley. Controlled environment experiments were conducted to further study the selectivity of WL-17731 between wheat and wild oats. In addition, several experiments were conducted to gain some insight into the mode of action of WL-17731 in an effort to find ways of increasing its effectiveness under field conditions.

LITERATURE REVIEW

Weed-Crop Competition

From a survey conducted by Alex (1966), Bowden (1970-Personal communication) calculated that, of the 75 million acres of cultivated land in the Prairie Provinces, approximately 32 million acres are infested with wild oats (*Avena fatua* L.) to an extent that may be considered economically important. Although wild oats have been recognized as a serious weed problem since their introduction from Europe in the late 1880's, it is only recently that detailed studies have been conducted to determine the actual extent of the crop losses due to wild oat competition.

Friesen and Shebeski (1960) reported that, where wild oats made up more than 50% of total weed population, cereal and flax yields were reduced up to 49.6%. Bowden and Frisen (1967) and Bell and Nalewaja (1968) studied the effect of wild oat competition on the yield of cereals and flax. In a two year study at two fertility levels, Bowden and Friesen (1967) found that 160 wild oat plants per square yard reduced the yield of wheat and flax by 54% and 75%, respectively. They also found that wild oats begin to exert their influence very early. Significant yield reductions occurred in both wheat and flax when the wild oats were removed as early as the two leaf stage. In a two year study at two locations and two fertility levels, Bell and Nalewaja (1968) reported that 160 wild oat plants per square yard resulted in wheat and barley yield reductions of 43% and 31%, respectively.

The magnitude of these losses suggests that an effective method of wild oat control would result in large increases in crop yields. George

Batho (1933) stated, "It is a simpler matter to get rid of wild oats than most other weeds". The severity of the wild oat problem in Western Canada 39 years later attests to the great difficulty actually involved in controlling this persistent weed.

Wild oats persist because their seeds ripen and fall to the ground before the crop is harvested. Some wild oat seed may remain dormant for several years even when conditions are conducive to germination. Thurston (1961) found that, under field conditions, the maximum length of survival of wild oat seed was 61 months. Banting (1962) found that, after 13 years of continuous cropping, at least five years of summerfallow were necessary to eliminate wild oats when the area was not re-infested with wild oat seed.

Although cultural control methods such as summerfallow and delayed seeding are effective in reducing wild oat infestations, there are disadvantages associated with their use. Summerfallow produces no income from the land in the year involved. Delayed seeding, which usually consists of waiting until one or two crops of wild oats have been produced and worked down before an early maturing crop such as barley is sown, deprives the crop of early spring moisture and usually results in decreased crop yields. Siemens and Helgason (1968) referred to an experiment conducted by Dr. W. H. Johnston on the effect of seeding date on the yield of barley under Manitoba conditions. He found that yield of barley dropped of from eight to ten per cent with each week delay in seeding after May 20.

The introduction of the carbamate herbicides, barban[1], diallate[2], and triallate[3], has provided Western Canadian farmers with an effective means of controlling wild oats.

Barban

Barban was first field tested in Western Canada and the United States during the summer of 1958 (Hoffmann, et al. 1958). In more intensive field testing conducted by the Spencer Chemical Company, Universities and the Research Branch of the Canada Department of Agriculture during 1959 and 1960 (Friesen, H. A., 1959; Molberg and Banting, 1959; Bingham and Pullen, 1960; Forsberg, 1960, Friesen, G., 1960), barban continued to show selectivity between wild oats and wheat, barley and flax.

Subsequent work on this compound has been directed toward determining the optimum rate, stage and method of application. Several workers (Forsberg, 1960; Friesen, H. A., 1960; Holmes and Pfeiffer, 1962) have reported that satisfactory control of wild oats with barban could be achieved with as little as 4 ounces per acre when applied at the proper stage of growth. These and other workers (Molberg and Banting, 1959; Forsberg, 1960; Friesen, H. A., 1961a) have stressed the importance of proper timing of barban application. In general, the most sensitive stage of wild oats is from the 1½ to 2½ leaf stage. Friesen, G. (1967) concluded that successful timing of barban application could be more closely

---

1. 4-chloro-2-butynyl N-(3-chlorophenyl) carbamate

2. s-2,3-dichloroallyl N,N-diisopropylthiolcarbamate

3. s-2,3,3-trichloroallyl N,N-diisopropylthiocarbamate

correlated to days after emergence than to leaf stage. He suggested that wild oats may pass through a physiologically susceptible stage independent of growing conditions or morphological development. The observation made by Friesen, H. A. (1961b) that 16 ounces per acre of barban applied to wild oats at the 3½ to 4 leaf stage resulted in effective wild oat control may support this conclusion. He did not, however, state the chronological age of the plants at the time of treatment. Both Friesen, G. (1967) and Friesen, H. A. (1961) noted that severe wheat injury resulted when barban was applied at a date later than that of the susceptible stage of wild oats. Injury to wheat as a result of barban treatment has also been noted by Forsberg (1960).

The method of barban application is a critical factor in obtaining good wild oat control. Factors such as spray volume, sprayer pressure, and angle of spray pattern have all been implicated.

The activity of barban had been observed to be inversely related to the spray volume in the range from 5 to 40 gallons per acre (Carder, 1959; Molberg and Banting, 1959; Hoffmann _et al_. 1960; Friesen, H. A., 1961a).

High pressures have also been shown to increase the effectiveness of barban. Friesen, H. A. (1960) reported that increasing the pressure from 45 to 80 pounds per square inch increased the control of Rodney oats from 55% to 85% when barban rate was kept constant at 4 ounces per acre and total spray solution was kept constant at 5 gallons per acre. Gull and Zeisig (1960) observed that in spring wheat, durum wheat and barley, the wild oat seed set and head count decreased when barban was applied at high pressures. Friesen, H. A. (1963) reported on the influence of spray pressure on the activity of barban. He found that, at rates of 2, 4 and 8 ounces per acre and volumes of 5 to 10 gallons per acre, increasing the pressure from 45 to 90 pounds per square inch consistently decreased the number of wild oat culms.

Directing the nozzles on the boom 45° forward also tended to increase the activity of barban (Gull and Zeisig, 1960; Korven, 1961). Neidermeyer (1970) showed that when wild oat plants were in the 1½ leaf stage the ligule was the most sensitive portion of the first leaf. Other areas on the first leaf in decreasing order of sensitivity to barban were the leaf-base, mid-point and leaf-tip. Directing the spray pattern from a flat-fan nozzle 45° forward would result in more spray solution reaching the most sensitive area. Hibbitt (1969) showed that the per cent retention of a given spray was reduced as the angle of incidence of the spray droplets increased. This effect was probably due to increased droplet bounce and/or droplet run-off at the steeper angles of incidence. Directing the nozzles 45° forward decreased the angle of incidence of the spray droplets on the nearly vertical wild oat seedlings and resulted in better wild oat control due to increased spray retention.

Diallate and Triallate

Several workers (Molberg and Banting, 1958; Selleck, 1958; Selleck, 1961) reported that, when diallate was applied at a rate of 1.5 pounds per acre and incorporated with a disc, satisfactory control of wild oats was achieved. Barley, flax and rape appeared to be tolerant of the herbicide but injury to wheat was reported at rates over two pounds per acre.

Diallate was widely tested in Western Canada in 1959. A number of workers (McCurdy, 1959; Selleck, 1959; Sexsmith, 1959) indicated that two pounds per acre incorporated prior to seeding gave excellent control of wild oats. With respect to crop tolerance, flax appeared to be the most tolerant followed by barley. Yield increases were noted in both these crops as a result of diallate treatment. Wheat stands, on the other hand, were reduced by as much as 25% by two pounds of diallate per acre.

Since 1960, diallate has been compared to it's tri-chloro analogue, triallate, by several research workers in Western Canada (Skoglund et al. 1960; Dryden, 1961; Molberg, 1961; Dryden and Whitehead, 1962; Friesen, G., 1962). In general, they found that triallate was equal to or slightly better than diallate with respect to wild oat control and that wheat and barley were slightly more tolerant of triallate.

Investigations have been carried out to determine the influence of time of herbicide application, various soil incorporation implements and depth of incorporation on the selectivity of diallate and triallate (Dryden, 1961; Friesen, H. A., 1961b; Molberg, 1961; Dryden and Whitehead, 1962). Results of these investigations suggested that the risk of injury to wheat and barley was less when the crop was seeded prior to herbicide application. Incorporation with one or two passes of a drag harrow resulted in satisfactory wild oat control and very little crop injury. Only the disc and drag harrow resulted in adequate incorporation. Other implements such as rod weeders and cultivators were not satisfactory as they tended to result in uneven incorporation. Incorporation of the herbicide to depths greater than two inches resulted in excellent wild oat control, but at these deeper incorporation depths, the risk of injury to the crop was also increased.

The apparent importance of seed and herbicide placement to obtaining selective control of wild oat in wheat lead to more detailed field and greenhouse investigations in this area. Friesen et al. (1962) reported that when wheat and wild oat seeds were planted immediately below a half inch layer of soil containing six parts per million diallate, approximately 90% of the wild oats and 50% of the wheat were killed. When the seeds were planted 1½ inches below this treated layer, 90% of the wild oats died and the wheat was unaffected. These results agreed with the findings of Parker (1963) who demonstrated that, just prior to the emergence of the first leaf, the most sensitive zone in wild oats, wheat and barley seedlings is 10 to 15 millimeters above the coleoptile node. The selectivity of diallate and triallate against wild oats in wheat and barley is thus explainable. In wild oats, elongation of the mesocotyl raises this sensitive region away from the seed at a very early stage. The corresponding zones of wheat and barley are not elevated away from the seed until a much later stage when the seedlings are known to be more tolerant to these two herbicides. Thus, when barley or wheat seeds are placed at least one inch below a band of treated soil, their sensitive zones are not exposed to the herbicide until a degree of tolerance has been achieved. Wild oats, on the other hand, are more sensitive, are exposed at an earlier stage and are thus more readily controlled.

Mode of action of carbamates

The carbamates act as mitotic poisons. Canvin and Friesen (1959) reported the CDAA[1] inhibited cell division and root elongation in barley. IPC[2], at one part per million, completely inhibited cell division in barley. At higher concentrations, it caused endopolyploidy, binucleate cells, elongations of cells and vacuolation of cells. Morrison (1962) found that cells of wheat and barley seedlings germinated in diallate solution displayed swelling, polyploidy and irregularly shaped multinucleate restitution nuclei. Banting (1970) noted that the number of cell divisions in both wild oats and wheat decreased as the concentration of either diallate or triallate was increased. Mitotic abnormalities included short thick chromosomes, dumbell-shaped nuclei, chromosome clumps, doubling of chromosome number, chromosome bridges and micronuclei. Wheat was much more resistant than wild oats to either chemical. Diallate appeared to be more toxic than triallate to wheat.

Neidermeyer (1970) reported that translocation of barban was similar in wheat and wild oats. Placement studies indicated that barban was translocated upward rather than downward. When barban was placed on the coleoptile above the first node there was no effect on wheat or barley. When barban was placed on the internode below the first node, the growth of wild oats was reduced indicating upward movement to the shoot apex. He

---

1. 2-chloro N,N-diallyacetamide

2. isopropyl N-phenylcarbamate

concluded that the phytotoxic action of barban was not dependent on downward translocation of barban *per se* in the plant but on some indirect action of barban.

WL-17731

WL-17731 is an experimental herbicide produced by Shell Research in Great Britain. It was first field tested in Western Canada in 1969. Bowden (1969) reported that 5.0 pounds per acre of WL-17731 applied at the one to two leaf stage of wild oats did not give satisfactory control whereas at the five to six leaf stage, 1.0 pounds per acre of WL-17731 gave excellent wild oat control. The wheat appeared to be damaged slightly by 4.0 pounds per acre of WL-17731 applied at the six leaf stage. Cushon (1969) stated that although applying WL-17731 at the five to seven leaf stage gave the best visual assessment of weed control, the highest wheat yields were obtained when the WL-17731 was applied at the two to four leaf stage of wild oats. Dryden and Chow (1969) found that the best control of wild oats and the greatest increases in wheat yield were obtained when WL-17731 was applied at the late four leaf stage of the wild oats. At earlier application dates, heavier rates of WL-17731 were necessary to obtain similar results.

METHODS AND MATERIALS

Field Experiments

Field experiments were conducted in 1970 at three different locations in Manitoba.

Altamont. A heavily infested (90 wild oat plants per square metre) field of Manitou wheat on a Pembina clay loam soil was selected as the experimental site. There were very few broad-leaved weeds in the field selected. The field was summerfallowed during the 1969 growing season and no chemical fertilizer was applied in the spring of 1970. Wheat was sown during the second week of June with a double-disc drill.

Graysville. A field of flax stubble was chosen as the experimental site. The soil at this location was an Almasippi very fine sandy loam. Manitou wheat was sown on May 29 at a rate of 75 pounds per acre with a double-disc drill. Just prior to seeding, year old wild oat seed and 120 pounds per acre of 11-48-0 fertilizer were spread and harrowed in. Three days after seeding, 34-0-0 fertilizer was spread over the area at a rate of 200 pounds per acre. Wild oat density at this site was very low. As the season progressed, areas of high salinity became evident throughout the site. This was evidenced by a heavy infestation of saline goosefoot (*Chenopodium salinum*). Wild mustard (*Brassica kaber*) and green foxtail (*Seteria viridis*) were also prevalent throughout the area. As a result, yield data from this site were not considered to be reliable and conclusions were based mainly on visual assessment.

Winnipeg. A heavy clay soil at the University of Manitoba was chosen for one experiment. Conquest barley was sown at a rate of 72 pounds per acre on June 15. There were no wild oats at this location and plots were kept free of broad-leaved weeds by hand weeding as required.

Unless otherwise stated a wettable powder formulation of WL-17731 (40% active ingredient) was used in all field experiments. All rates of WL-17731 are expressed in terms of active ingredient and were applied in combination with 1.0 imperial gallon per acre of Modified Kornoil (a product of Shell Canada Limited). All chemical treatments were applied with a small-plot bicycle wheel sprayer which delivered 11.0 gallons per acre at a pressure of 35.0 pounds per square inch and a speed of 3.0 miles per hour. All treatments were replicated four times. Weed control and crop tolerance were assessed visually on two occasions after treatment. Plot size was 2.13 metres by 7.32 metres. An area 1.21 metres by 6.10 metres in size was harvested from the centre of each plot to determine grain yield. An analysis of variance was conducted on the data and differences significant at the 5% level of probability were considered meaningful.

Experiment I. The effect of stage of application of WL-17731 on wild oat control in Manitou wheat.

An experiment designed to investigate the effect of stage of application of WL-17731 on the control of wild oats in wheat was conducted at both Altamont and Graysville. WL-17731 was applied at rates of 1.0 and 1.5 pounds per acre at five stages of wild oat growth. Experimental design was a randomized complete block with eleven treatments.

Experiment II. The effect of rate of WL-17731 on the control of wild oats in Manitou wheat.

Experiments were conducted at Altamont and Graysville, Manitoba to determine the effect of the rate of WL-17731 on the control of wild oats in wheat. WL-17731 was applied at rates of 0.75, 1.0, 1.25, 1.50 and 2.0 pounds per acre at two stages of growth. Experimental design was a split-plot with stages of application as main-plots and rates of application as sub-plots.

Experiment III. Tolerance of Conquest barley to four formulations of WL-17731 applied at two stages of growth.

The effect of four different formulations of WL-17731 applied to Conquest barley at the five and seven leaf stages was examined at Winnipeg, Manitoba. The four formulations in question were a wettable powder (W.P.) and three emulsifiable concentrates (SD-30053, FX-2000 and FX-2062). The wettable powder and SD-30053 formulations were applied in combinations with 1.0 gallon per acre of Modified Kornoil. All chemical treatments were applied at a rate of 2.0 pounds per acre. Experimental design was a randomized complete block with nine treatments.

Experiment IV. The effect of WL-17731 on the growth of wild oats under field conditions.

An experiment was conducted at Graysville, Manitoba to determine the effect of various rates of WL-17731 on the growth of wild oats in a crop of Manitou wheat. WL-17731 was applied at rates of 0.25, 0.50, 1.0, 2.0

and 4.0 pounds per acre at two stages of growth. Experimental design was a split-plot with stages of application as main-plots and rates of application as sub-plots. On the date of spraying, and periodically thereafter, five wild oat plants were collected at random from each plot and their dry weights were determined. Grain yields were not determined in this experiment.

Experiment V. The effect of wild oat competition and herbicide treatments on the yield of Manitou wheat.

This experiment was conducted at Altamont, Manitoba to study the effect of wild oat competition and various treatments on tillering and yield of Manitou wheat. Treatments were applied at two stages of growth. WL-17731 was applied at rates of 1.0, 1.25, 1.50, 1.75 and 2.0 pounds per acre. Barban was applied at 5.0 ounces per acre in 6.0 gallons per acre total solution at 45 pounds per square inch at 3.0 miles per hour. Spray nozzles were directed forward at an angle of 45^{o}. Weed free checks were first weeded when the wild oats were in the one leaf stage and were kept free of weeds by hand weeding as required. One treatment consisted of a hand weeding carried out at the time the main-plot treatments were applied. An estimate of the number of fertile wheat tillers per two metres of drill row was obtained by counting the number of fertile tillers in each of four 0.5 metre sections of drill row in each plot. Experimental design was a split-plot with stages of application as main-plots and rates of application as sub-plots.

Greenhouse Experiments.

Five seeds of each species in question were sown one inch deep in 2,475 cubic centimetres of soil in 3,000 cubic centimetre metal containers. The diameter of the containers was 15.2 centimetres. Three evenly spaced holes were punched in the lower edge of the container walls to provide drainage. The soil used was a 3:1:1 mixture of topsoil, peatmoss and sand. The constituents, in their respective proportions, were thoroughly mixed in a small portable cement mixer. A constant amount of 13-13-13 fertilizer was added to each batch of soil during the mixing process.

After seeding, the pots were placed on greenhouse benches under fluorescent light banks which provided approximately 950 foot-candles at plant height during a 16 hour photoperiod. The temperature in the greenhouse ranged from 18^{o}C to 29^{o}C. Most seedlings had emerged by the fifth day after planting. When the seedlings were in the two leaf stage, they were thinned to the three most uniform plants per pot. Pots were surface watered as required. Unless otherwise stated, the wettable powder formulation of WL-17731 was used in all experiments. In every case, WL-17731 was applied in combination with 1.0 gallon per acre of Modified Kornoil. Application rates are expressed in terms of active ingredient.

Treatments were applied with a single nozzle pot sprayer equipped with a Tee Jet 65015 flat fan nozzle. The sprayer delivered a total of 12.3 gallons per acre at a pressure of 35 pounds per square inch and a nozzle speed of three miles per hour. After treatment the pots were returned to the greenhouse bench and arranged at random under the light banks. The pots were re-arranged frequently both prior to and following treatment to compensate for any non-uniformity under the light banks. All experiments were conducted using a completely randomized design. Analysis of variance was carried out on the data. Differences significant at the 5% level of probability were considered meaningful.

Experiment VI. Dosage response of wild oats and Manitou wheat to WL-17731.

An experiment was conducted to determine the effect of several rates of WL-17731 on the growth of wild oats and wheat.

WL-17731 was applied to wild oats at 0.5, 1.0, 2.0, 4.0 and 8.0 pounds per acre and to wheat at 0.5, 1.0, 2.0, 4.0, 8.0 and 16.0 pounds per acre at two stages of growth. The wild oats were treated in the two leaf stage (12 days after emergence) and in the four leaf stage (25 days after emergence). Wheat was treated in the three leaf stage (16 days after emergence) and in the five leaf stage (24 days after emergence). Check plants of both wild oats and wheat were harvested on both spray dates to determine the dry weight of the shoots at the time of treatment. Shoots of wild oats and wheat were harvested 21 and 25 days after the latter treatments were applied, respectively. Dry weights of the shoots were determined and recorded. Results are expressed as the relative growth (RG) of the treated plants as percent of the check plants.

$$RG = \frac{W_t - W_i}{W_c - W_i} \times 100$$

Where: W_t = dry weight of the treated plants

W_c = dry weight of the check plants

W_i = weight of the plants at the time of treatment

<u>Experiment VII</u>. The effect of WL-17731 on the growth of wild oats and Manitou wheat.

Experiments with wild oats and wheat similar to the dosage response experiments were set up and the plants allowed to grow to maturity. Wild oats were treated in the two leaf stage (13 days after emergence) and in the four to five leaf stage (25 days after emergence). Manitou wheat was treated in the two to three leaf stage (15 days after emergence) and in the five leaf stage (30 days after emergence). Records were kept of the effect on maturity, the number and height of fertile tillers and the weight and germinability of seed produced.

<u>Experiment VIII</u>. The effect of angle of spray pattern on the activity of WL-17731.

Duplicate experiments were conducted to determine if directing the spray pattern at an angle of 45° would have any effect on the activity of WL-17731 against wild oats. WL-17731 was applied at 0.25, 0.50, and 1.0 pounds per acre. All rates were applied with the spray pattern directed perpendicular to the path of the nozzle and with the spray pattern directed 45° in the direction of the nozzle path. The vertical distance between the nozzle tip and the soil surface was adjusted so that the length of the spray pattern was the same in both cases. In one experiment, treatments were applied at the three leaf stage (15 days after emergence) and plants were harvested for dry weight determinations 24 days later. In the second experiment, treatments were applied at the four leaf stage (15 days after emergence) and the plants were harvested 23 days later. Results are given as the average of the two experiments.

Laboratory Experiments

Experiment IX. The effect of time of application of WL-17731 on the growth of wild oats at two different light intensities.

Germinating wild oat seeds were planted in the same type of soil and containers used in the greenhouse experiments. After seeding the pots were placed in a large growth cabinet under incandescent and fluorescent lights which provided approximately 2,000 foot candles at plant height. The temperature regime was controlled at 21^{o}C during the 16 hour photoperiod and 15^{o}C during the nyctoperiod. Relative humidity was not controlled but remained high due to the continual presence of open water on the bottom of the growth cabinet.

Most seedlings had emerged by the third day after planting. When the seedlings reached the two leaf stage they were thinned to two plants per pot. Pots were surface watered as required. The wettable powder formulation of WL-17731 was used in this experiment and was applied as in the greenhouse experiments at the rate of 1.0 pound of active ingredient per acre. Plants were treated at the two, three, four, five and six leaf stages. At each treatment date, representative plants were harvested and a record made of the length of leaf on the main culm and the dry weight of the entire plant was determined. Notes were also taken on the position and condition of the growing point. Treated plants were harvested, along with their respective checks, 28 days after treatment. A similar experiment was conducted using the same techniques, but with a light intensity in the cabinet of approximately 1,050 foot candles at plant height. Each treatment was replicated four times.

Experiment X. Site of uptake of WL-17731 in wild oats.

The response of wild oats to various rates of WL-17731 applied to different points on wild oat plants was investigated. Ten seeds of wild oats were sown 2.5 centimetres deep in 1,200 cubic centimetres of soil in 1,350 cublic centimetre metal containers, whose diameter was 10.2 centimetres. Drainage was provided by punching two evenly spaced holes in the lower edge of the tins. The soil mix was the same as that used in the greenhouse experiments. After planting, the pots were placed in a small growth cabinet (Model E7H, Controlled Environments Limited) in the laboratory. Illumination of 1,400 foot candles eight inches below the plexiglass barrier was provided during a 16 hour photoperiod. The temperature regime was controlled at $22 \pm 2^{o}C$ during the photoperiod and $17 \pm 2^{o}C$ during the nyctoperiod. Relative humidity was not controlled but was regulated by placing shallow pans of open water on the bottom of the cabinet. The pots were removed daily, surface watered and returned to the growth cabinet. The arrangement of the pots within the growth cabinet was altered daily. When the plants were in the two leaf stage they were thinned to six plants per pot.

Technical grade WL-17731 was formulated in a 1:1 v/v mixture of water and acetone containing 2.0% Triton X-155 at a concentration of 32 μg active ingredient per μl. This formulation was stable for up to one minute which was sufficient time to treat one plant. The emulsion was re-established by thorough mixing with a vortex mixer just prior to treating each plant. A 5 μl droplet containing 160 μg of WL-17731 was applied to the base and mid-point of the leaf blade or to the sheath of the leaf one centimetre below the ligule. Treatments included applications to the first leaf when the plants were in the one and one half leaf stage, to both the first and second leaves when the plants were in the two and one half leaf stage and to the first, second and third leaves when the plants were in the three and one half leaf stage.

Treatments were evaluated by measuring the length of the blades of leaves which emerged after the treatments were applied. The data was analyzed as a completely randomized design. Results were expressed as a percent of the respective checks. The study was subsequently repeated in the same growth cabinet with five rather than six plants per pot.

Experiment XI. Histological and cytological effects of WL-17731 on wild oats.

The cytological effects of WL-17731 on wild oats were investigated. Wild oat plants from Experiment X which were showing typical symptoms of WL-17731 injury as well as untreated plants were selected for sectioning and microscopic examination. Longtitudinal and transverse sections of stem tissue were made using a Lab-Line/Hooker rotary plant microtome. The plant tissue was mounted in styrofoam blocks and several sections approximately 40 μ thick were made. Sections were held in 30% ethanol until the staining procedure was carried out. Sections were held in 0.1% safranin for ten minutes, transferred to 70% ethanol for two minutes, held in 1% fast green for forty seconds and then exposed to cellosolve (Sass, 1958). The sections were then mounted in a drop of balsam on glass slides and covered with cover slips. Slides were examined under magnification and photographs made of stem sections from both treated and untreated plants.

Experiment XII. The effect of WL-17731 on germinating seeds of Harmon oats and Manitou wheat.

The effect of WL-17731 on germinating seeds of oats and wheat was studied. Twenty seeds of both oats and wheat were used in each treatment. It was determined that the germination of the seed used in this experiment was essentially 100%. Treatments consisted of various concentrations of technical grade WL-17731 in 20 millilitres of acetone. Concentrations used were: 0, 80, 160, 320, 640, 1280, 2560 and 5120 ppm. Seeds were exposed to the solutions for 24 hours in stoppered flasks left on the laboratory bench. Seeds were then drained, washed once for ten seconds in acetone and dried in a dessicator under line vacuum for 24 hours. The dried seeds were then placed on two layers of moist filter paper in petri plates and germinated in the dark for 110 hours at laboratory temperature (approximately 24^{o}C). The number of seeds germinated and the length of their shoots and primary roots were recorded. Shoot tips, including the growing point, were collected and fixed in 3:1 ethanol-acetic acid. The shoot tips were then fixed for ten minutes in 1N HCl at 18.3^{o}C, stained in Fuelgen solution for a minimum of twenty minutes, mounted in a drop of

1% aceto-carmine on a glass slide and covered with a cover slip. The cover slip was then tapped gently to break up and disperse the cells. Cells in which individual chromosomes could be distinguished were considered to be dividing. A minimum of ten microscope fields were counted for each treatment selected for this part of the experiment.

RESULTS AND DISCUSSION

Experiment I. The effect of stage of application of WL-17731 on wild oat control in Manitou wheat.

An experiment was conducted at two locations to investigate the effect of stage of application of WL-17731 on wild oat control in spring wheat. Wild oat control ratings and wheat yields from Altamont and Graysville are presented in Tables 1 and 2, respectively. An explanation of the rating system used to indicate wild oat control and crop tolerance is given in Table 29 of the Appendix.

TABLE 1. THE EFFECT OF WL-17731 APPLIED AT SEVERAL STAGES ON WILD OAT CONTROL AND WHEAT YIELD (ALTAMONT).

Treatment Rate (lb[1]/ac)	Stage When Treated		Wild Oat Control	Wheat Yield (gm/m^2)
	Wild Oat	Wheat		
0			0	129
1.0	2-3 ls[2]	4-5 ls	2.1	132
1.0	4-5 ls	5-6 ls	7.3	129
1.0	5-6 ls	7 ls	8.5	143
1.0	flag ls	flag ls	7.0	122
1.0	heading	heading	0.3	116
1.5	2-3 ls	4-5 ls	3.5	151
1.5	4-5 ls	5-6 ls	8.0	139
1.5	5-6 ls	7 ls	9.0	154
1.5	flag ls	flag ls	8.3	140
1.5	heading	heading	1.1	132

1. Active ingredient.

2. Leaf stage.

TABLE 2. THE EFFECT OF WL-17731 APPLIED AT SEVERAL STAGES ON WILD OAT CONTROL AND WHEAT YIELD (GRAYSVILLE).

Treatment Rate (lb/ac)	Stage When Treated		Wild Oat Control	Wheat Yield (gm/m^2)
	Wild Oat	Wheat		
0			0	78
1.0	2 ls	1-2 ls	0.3	105
1.0	3 ls	2 ls	2.3	96
1.0	4-5 ls	3-4 ls	4.7	86
1.0	6-7 ls	6-7 ls	7.6	85
1.0	flag ls	flag ls	8.7	81
1.5	2 ls	1-2 ls	1.3	109
1.5	3 ls	2 ls	1.3	101
1.5	4-5 ls	3-4 ls	5.3	81
1.5	6-7 ls	6-7 ls	8.7	103
1.5	flag ls	flag ls	9.0	90

Wheat was not injured by any treatment, whereas, wild oat control using WL-17731 improved with later applications up to the flag leaf stage. The 1.5 pounds per acre rate was more effective than the 1.0 pound per acre rate. No significant differences in wheat yield were detected between treatments at either location. At Altamont, low fertility and late seeding may have decreased the ability of the crop to respond to reduced wild oat competition. At Graysville, the wild oat competition was not sufficient to cause yield depression. At both locations, wild oat control was not acceptable when the plants were treated before the five leaf stage.

<u>Experiment II</u>. The effect of rate of WL-17731 on the control of wild oats in Manitou wheat.

Experiments were conducted at two locations to determine the effect of rate of WL-17731 on the control of wild oats in Manitou wheat.

Wild oat control ratings and wheat yields from Altamont and Graysville are presented in Tables 3 and 4, respectively.

TABLE 3. EFFECT OF WL-17731 APPLIED AT SEVERAL RATES ON WILD OAT CONTROL AND WHEAT YIELD (ALTAMONT).

Treatment Rate (lb/ac)	Stage When Treated		Wild Oat Control	Wheat Yield (gm/m^2)
	Wild Oat	Wheat		
0.00	4 ls	5-6 ls	0.0	146
0.75	"	"	5.4	124
1.00	"	"	6.4	144
1.25	"	"	6.0	151
1.50	"	"	7.5	152
2.00	"	"	7.3	129
0.00	5-6 ls	6 ls	0.0	133
0.75	"	"	7.0	124
1.00	"	"	7.5	106
1.25	"	"	7.5	110
1.50	"	"	8.4	128
2.00	"	"	8.7	135

TABLE 4. EFFECT OF WL-17731 APPLIED AT SEVERAL RATES ON WILD OAT CONTROL AND WHEAT YIELD (GRAYSVILLE).

Treatment Rate (lb/ac)	Stage When Treated		Wild Oat Control	Wheat Yield (gm/m^2)
	Wild Oat	Wheat		
0.00	3-4 ls	4-5 ls	0	95
0.75	"	"	4.6	94
1.00	"	"	5.3	97
1.25	"	"	5.8	98
1.50	"	"	6.4	96
2.00	"	"	6.5	88
0.00	flag ls	flag ls	0	106
0.75	"	"	8.3	95
1.00	"	"	8.9	92
1.25	"	"	9.0	109
1.50	"	"	9.0	96
2.00	"	"	9.0	96

Altamont At the four leaf stage of wild oats, 1.5 pounds per acre of WL-17731 was required to provide acceptable control while, at the five to six leaf stage, 0.75 pounds per acre of WL-17731 was sufficient. Thinning of the wheat stand was noticed in the plots treated with 1.0 and 1.25 pounds per acre of WL-17731 at the five to six leaf stage. As this effect was not apparent at the higher rates, it was probably due to some unknown factor rather than to a phytotoxic action of the WL-17731. Wheat yields for several of the treatments were significantly lower ($p = .01$) than check plot yields. However, these lower yields were not associated with specific treatments and it was assumed that they were due to some form of field variation not completely compensated for by the randomization. Mean yield for plots treated at the four leaf stage was significantly greater (p = .05) than the mean for the five to six leaf stage which indicates that any benefit derived from the increased wild oat control was off-set by the increased duration of wild oat competition in the plots treated at the five to six leaf stage. Photographs of plots treated at several stages with WL-17731 and barban are shown in Plate 1. They clearly demonstrate that control of wild oats by WL-17731 is better when applied at the 4-6 leaf stage than when applied at the 2-3 leaf stage. This is in contrast to barban which is most effective when applied at the 2-3 leaf stage.

Graysville At the three to four leaf stage, not rate of WL-17731 controlled wild oats satisfactorily. For the highest rates of 1.5 and 2.0 pounds per acre, the wild oat control ratings were 6.4 and 6.5, respectively, and neither was considered acceptable. At the flag leaf stage, even the lowest rate of WL-17731 was associated with near cessation in wild oat development. The 1.0 pound per acre rate completely prevented further development and seed production. None of the treatments resulted in increased wheat yields.

Experiment III. Tolerance of Conquest barley to four formulations of WL-17731 applied at two stages of growth.

One experiment was conducted to assess the tolerance of Conquest barley to four formulations of WL-17731 applied at two stages of growth. Visual assessment of the phytotoxicity of WL-17731 to barley and barley grain yield are presented in Table 5.

Plate 1. Wild oat control in wheat using WL-17731 and barban at several stages.

Plate 1a. Weedy Check.

Plate 1b. WL-17731 (1.0 lb/ac) applied at the 2-3 leaf stage of wild oats.

Plate 1c. WL-17731 (1.0 lb/ac) applied at the 4-5 leaf stage of wild oats.

Plate 1d. WL-17731 (1.0 lb/ac) applied at the 5-6 leaf stage of wild oats.

Plate 1e. Barban (5.0 oz/ac) applied at the 2-3 leaf stage of wild oats.

Plate 1f. Barban (5.0 oz/ac) applied at the 4-5 leaf stage of wild oats.

TABLE 5. EFFECT OF SEVERAL FORMULATIONS OF WL-17731 ON BARLEY.

Treatment	Stage When Treated	Crop Tolerance Rating	Yield (gm/m^2)[1]
Weedy Check		9.0	399a
W.P.[2] + oil	5 ls	5.0	169b
W.P. + oil	7 ls	3.8	110cd
SD-30053 + oil	5 ls	3.4	120cd
SD-30053 + oil	7 ls	2.5	100cd
FX-2062	5 ls	4.8	169b
FX-2062	7 ls	3.5	108cd
FX-2000	5 ls	3.0	132bc
FX-2000	7 ls	2.1	81d

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

2. Wettable powder.

All formulations of WL-17731 severly damaged barley. Plant height was reduced to approximately one-half that of check plants, maturity was delayed by three weeks and yields were significantly decreased. The wettable powder plus oil combination appeared to be the least phytotoxic formulation. All formulations were more phytotoxic when applied at the later stage of growth. Plates 2b and c show the severe stunting of Conquest barley treated with WL-17731 as compared to untreated barley in Plate 2a.

At the five leaf stage, SD-30053 plus oil was the most phytotoxic on the basis of grain yield. At the seven leaf stage, yields were not significantly different and were the same as that from the SD-30053 plus oil applied at the five leaf stage.

Plate 2. Effect of WL-17731 on Conquest barley.

Plate 2a. Unsprayed Check.

Plate 2b. WL-17731 (formulation FX-2000) applied at 2.0 lb/ac to barley at the five leaf stage.

Plate 2c. WL-17731 (formulation SD-30053 plus oil) applied at 2.0 lb/ac to barley at the seven leaf stage.

<u>Experiment IV</u>. The effect of WL-17731 on the growth of wild oats under field conditions.

An experiment was conducted at Graysville to determine the effect of WL-17731 on the growth of wild oats in a crop of wheat.

Dry matter changes in wild oats receiving various treatments at the two to three and six leaf stage are presented in Figures 1 and 2, respectively.

When wild oats were sprayed at the two to three leaf stage considerable growth occurred after treatment. All treatments inhibited the growth of wild oats but even the highest rate (4.0 lb/ac) did not completely inhibit

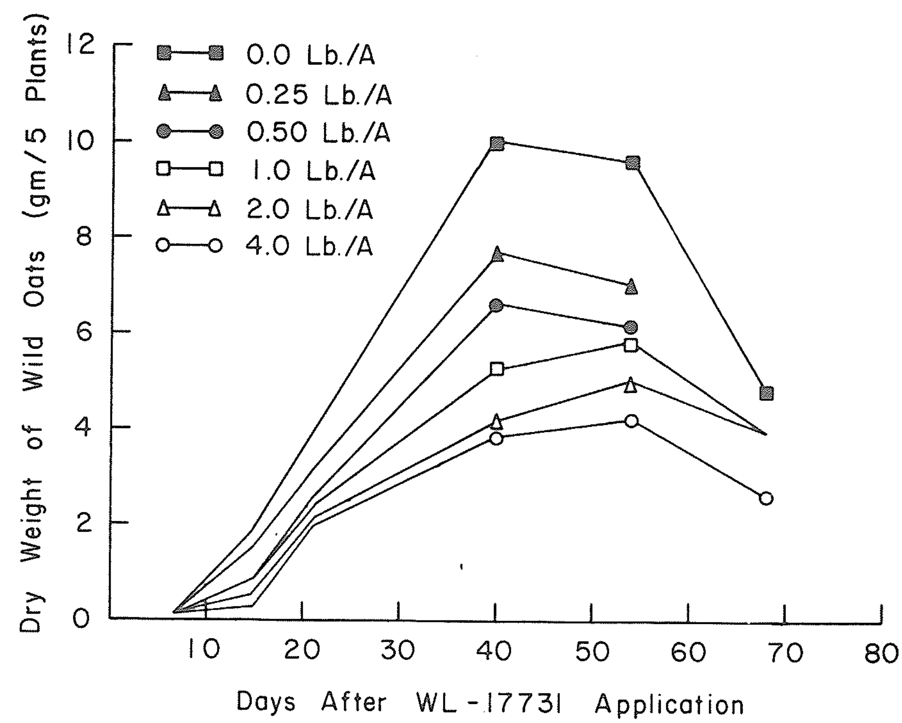

Figure 1. Dry matter changes in wild oats following application of WL-17731 at several rates (2-3 leaf stage).

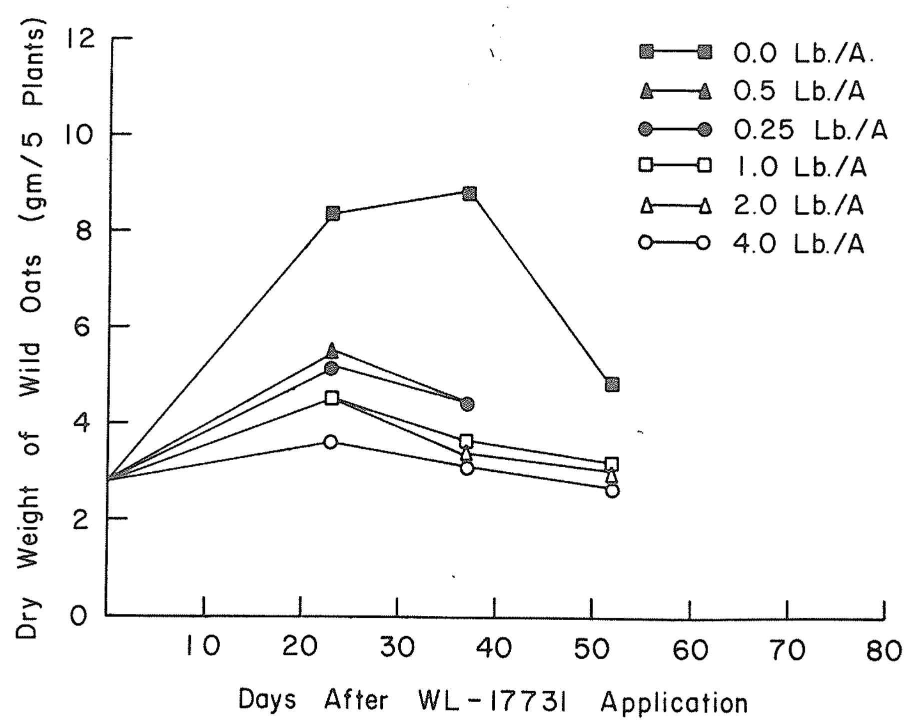

Figure 2. Dry matter changes in wild oats following application of WL-17731 at several rates (6 leaf stage).

subsequent growth or prevent seed formation.

WL-17731 applied at the six leaf stage caused a marked reduction in the growth of wild oats. Rate of application of WL-17731 appears to be less important than stage of wild oat growth at time of treatment. The 4.0 pounds per acre rate almost halted the growth of wild oat plants and all rates above 0.5 pounds per acre completely prevented wild oat seed production.

Experiment V. The effect of wild oat competition and herbicide treatments on the yield of Manitou wheat.

An experiment was conducted at Altamont to study the effect of wild oat competition and herbicide treatments on the development of a crop of Manitou wheat.

Wild oat control ratings, the number of fertile wheat tillers per two metres of drill-row and wheat yield are given in Table 6.

At the two to three leaf stage, barban at 5.0 ounces per acre gave excellent control of wild oats while none of the WL-17731 treatments effectively controlled wild oats. At the four to five leaf stage, barban was ineffective and one pound or more per acre of WL-17731 gave acceptable wild oat control.

TABLE 6. EFFECT OF VARIOUS TREATMENTS ON WILD OAT CONTROL, THE NUMBER OF FERTILE TILLERS AND WHEAT YIELD.

Treatment	Wild Oat Control	No. of fertile Wheat tillers /2m. of drill row	Wheat Yield (gm/m^2)
2-3 leaf stage			
Weedy Check	0.0	97[1]	123
Weed Free Check	9.0	145	147
Weed at Spraying	9.0	135	162
Barban 5.0 oz/ac	8.5	152	147
WL-17731 1.0 lb/ac	2.6	95	116
" 1.25 lb/ac	4.0	104	131
" 1.50 lb/ac	4.4	114	162
" 1.75 lb/ac	4.8	121	124
" 2.00 lb/ac	4.8	119	129
4-5 leaf stage			
Weedy Check	0.0	101[1]	141
Weed Free Check	9.0	145	153
Weed At Spraying	9.0	137	143
Barban 5.0 oz/ac	3.6	117	130
WL-17731 1.0 lb/ac	7.9	134	156
" 1.25 lb/ac	8.3	151	154
" 1.50 lb/ac	8.1	132	105
" 1.75 lb/ac	8.0	119	128
" 2.00 lb/ac	8.0	113	114

1. LSD Tillers p.05 = 21.4.

Tiller production was significantly greater in the weed free checks and in the plots hand weeded at the time of spraying. Wheat also tillered more profusely in plots treated with barban at the two to three leaf stage but not at the four to five leaf stage. Although not significant, WL-17731 applied at the two to three leaf stage resulted in a trend toward increased tillering in wheat. This effect was also apparent when WL-17731 was applied at the four to five leaf stage when up to 1.50 pounds per acre of WL-17731 resulted in significant increases in wheat tiller production. Rates of 1.75 pounds per acre and higher did not increase the amount of tiller production.

Yield responses in this experiment were inconclusive. Treatments which resulted in excellent control and little or no phytotoxicity to the crop did not result in significant yield increases.

Experiment VI. Dosage response of wild oats and Manitou wheat to WL-17731.

An experiment was conducted in the greenhouse to determine the effect of various rates of WL-17731 on the growth of wild oats and Manitou wheat.

The dosage response of wild oats and Manitou wheat is shown in Figure 3. None of the herbicide treatments significantly reduced the growth of Manitou wheat. Wild oats, however, were severly stunted by all rates of WL-17731 at both treatment stages. At the two leaf stage, the 0.5 pound per acre rate was as effective as the 8.0 pounds per acre rate. At the four leaf stage, there was an increasing suppression of wild oat

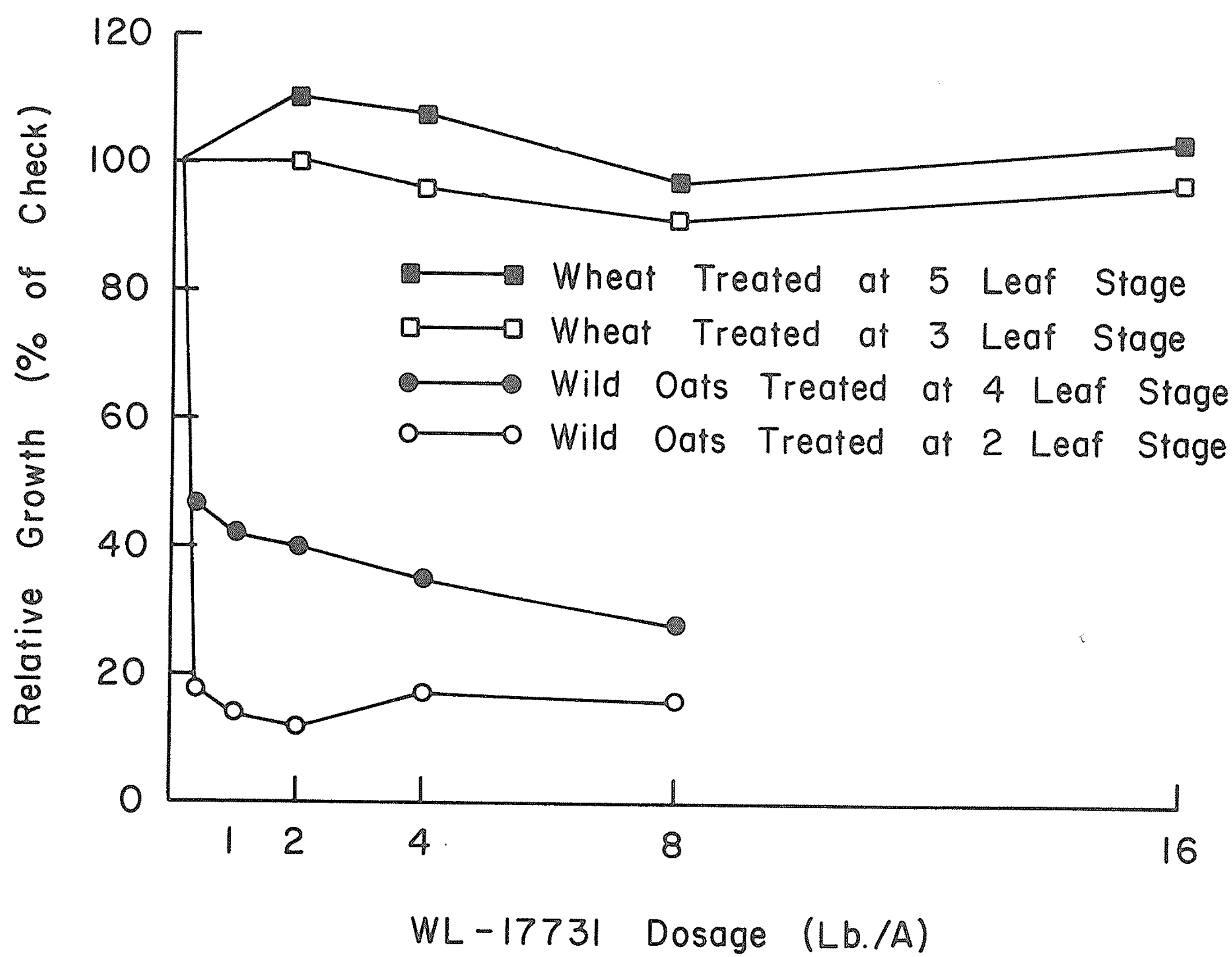

Figure 3. Relative growth depression of wheat and wild oat treated with several rates of WL-17731.

growth with increasing dosage up to 8.0 pounds per acre.

In this experiment, WL-17731 was more effective against wild oats when applied at the two leaf stage. This is not consistent with the field experiments which showed that wild oats became more sensitive to WL-17731 as they grew older. However, in other greenhouse trials, results similar to those reported here have been obtained. (B. Bowden - personal communication).

Typical injury symptoms in wild oat plants treated with WL-17731 are shown in Plate 3. Wild oats treated with WL-17731 were stunted and of a deeper green color than untreated plants. Affected leaves often showed chlorosis at the base of the leaf blade and severely deformed leaves were often very chlorotic. The number of leaves appeared to be similar to the control plants but there was a reduction in size of both the sheaths and the leaf blades. In many cases, the affected leaves emerged through the side of the leaf sheath rather than emerging normally through the top of the sheath. Tillering appeared to be more profuse in the treated plants. A few of the leaves of treated plants developed necrosis from the tips downward. Death of plant tissue did not appear to be a major symptom of WL-17731 treatment.

<u>Experiment VII</u>. The effect of WL-17731 on the growth of wild oats and Manitou wheat.

An experiment was conducted in the greenhouse to determine the effect of various rates of WL-17731 on the growth of wild oats and wheat when

Plate 3. Injury to wild oat plants following treatment with WL-17731.

Plate 3a. Wild oat plant showing dark green color, chlorosis of leaf base, deformed leaves and leaf blades emerging through the side of the leaf sheath.

Plate 3b. Wild oat plant showing dark green color, necrosis of leaf blade from tip downward, deformed leaves and leaf blades emerging through the side of the leaf sheath.

applied at the two stages of growth.

The number and height of fertile wheat tillers and wheat yield are given in Table 7.

TABLE 7. THE EFFECT OF WL-17731 ON WHEAT GROWTH AND DEVELOPMENT.

Treatment (lb/ac)	No. of fertile tillers per 3 plants	Mean Height of fertile tillers (cm)[1]	Seed Yield (gm/3 plants)[1]
3 leaf stage			
0	5.2	74.5 ab	5.1 ab
2.0	4.7	74.0 ab	4.8 ab
4.0	5.5	72.8 ab	4.8 ab
8.0	5.7	71.8 ab	4.5 ab
16.0	5.2	64.6 c	4.0 b
5 leaf stage			
0	5.1	72.2 ab	4.9 ab
2.0	5.0	75.8 a	4.8 ab
4.0	5.5	75.0 ab	4.8 ab
8.0	5.4	70.4 abc	4.9 ab
16.0	5.8	68.4 bc	5.6 a

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

WL-17731 was not phytotoxic to wheat at rates of 8.0 pounds per acre or lower. At a rate of 16.0 pounds per acre applied at the three leaf stage, the wheat stem was shortened and grain yield was decreased. Treating the plants with WL-17731 did not have any effect on the number of fertile tillers, the number of days to maturity or the per cent germination of seed produced by surviving plants.

The results of similar measurements on wild oats are given in Table 8.

WL-17731 tended to increase the number of fertile tillers in wild oats although this did not occur in all treatments. All treated plants were significantly shorter than the control plants. At the three leaf stage, increasing dosage was associated with a greater reduction in plant height. At the five leaf stage, the lower rates were as effective as the higher rates in suppressing the growth of wild oats. The number of days to heading did not appear to be affected by WL-17731 treatment. Seed production was decreased by some of the treatments but no trends could be established. The number of seeds produced in some treatments was not sufficient for a replicated germination test and, as a result, no analysis of variance was conducted on the results. However, the germination of seed produced by treated plants did not differ greatly from those of the check.

TABLE 8. THE EFFECT OF WL-17731 ON WILD OAT GROWTH AND DEVELOPMENT.

Treatment (lb/ac)	No. of fertile tillers per 3 plants[1]	Mean height of fertile tillers (cm)[1]	Seed Yield (gm/3 plants)[1]
3 leaf stage			
0	4.6 ab	93.7 a	4.6 a
0.5	4.4 ab	76.1 b	2.7 bc
1.0	5.6 ab	69.5 bc	3.8 ab
2.0	6.2 a	56.6 c	1.9 c
4.0	5.8 a	61.5 bc	3.1 abc
8.0	4.2 b	56.2 c	2.2 bc
5 leaf stage			
0	3.6 c	100.8 a	3.5 abc
0.5	4.4 abc	58.9 bc	2.6 bc
1.0	5.8 a	63.4 bc	3.6 abc
2.0	3.8 bc	57.7 c	1.9 c
4.0	4.8 abc	57.7 c	3.6 abc
8.0	5.4 abc	60.6 bc	4.6 a

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

Experiment IX. The effect of time of application of WL-17731 on the growth of wild oats at two different light intensities.

Two experiments were conducted under growth cabinet conditions to determine the effect of stage of application of WL-17731 and light intensity on the growth and development of wild oats.

Treatment effects on the dry weight and tillering of wild oats are shown in Tables 9 and 10, respectively. Data on dry matter accumulation and tillering are presented as per cent of treated plants as compared to the checks.

TABLE 9. EFFECT OF LIGHT INTENSITY AND WL-17731 TREATMENT ON GROWTH OF WILD OATS AT SEVERAL GROWTH STAGES.

	Wild oat growth (% of check)	
Leaf stage at time of treatment	High light intensity	Low light intensity
2	77	53
3	93	20
4	116	28
5	93	35
6	74	25

The design of this experiment did not allow for statistical comparisons between or among light intensities. Under high light intensity, WL-17731 had little effect on the growth of the wild oat plants, while at the lower light intensity, growth of wild oats was markedly suppressed.

TABLE 10. EFFECT OF LIGHT INTENSITY AND WL-17731 TREATMENT ON TILLERING OF WILD OATS AT SEVERAL GROWTH STAGES.

Leaf stage at time of treatment	Wild oat tillering (% of check)	
	High light intensity	Low light intensity
2	142	111
3	100	100
4	100	66
5	115	91
6	118	113

At the high light intensity, tillering was increased at the two leaf stage but not at the later stages of application. At the low light intensity, there was no effect on tillering except for the four leaf stage application. At this stage, plants had one tiller and the growing points of the plants were just beginning to rise above the crown. By the time the next treatment was applied, an average of three tillers had already been formed by each plant. Consequently, later application of WL-17731 would not be expected to influence tillering.

The effect of the treatments on the length of the leaves on the main culm was studied. Measurements are shown in Figures 4 and 5 for low and high light intensity, respectively. The length of each leaf on the main culms of treated plants is shown as a per cent of the length of the corresponding leaf on untreated plants. Figure 4 shows that, under low light intensity, WL-17731 had a dramatic effect on the leaf length. Plants treated at the three leaf stage were affected most. Figure 4 also shows

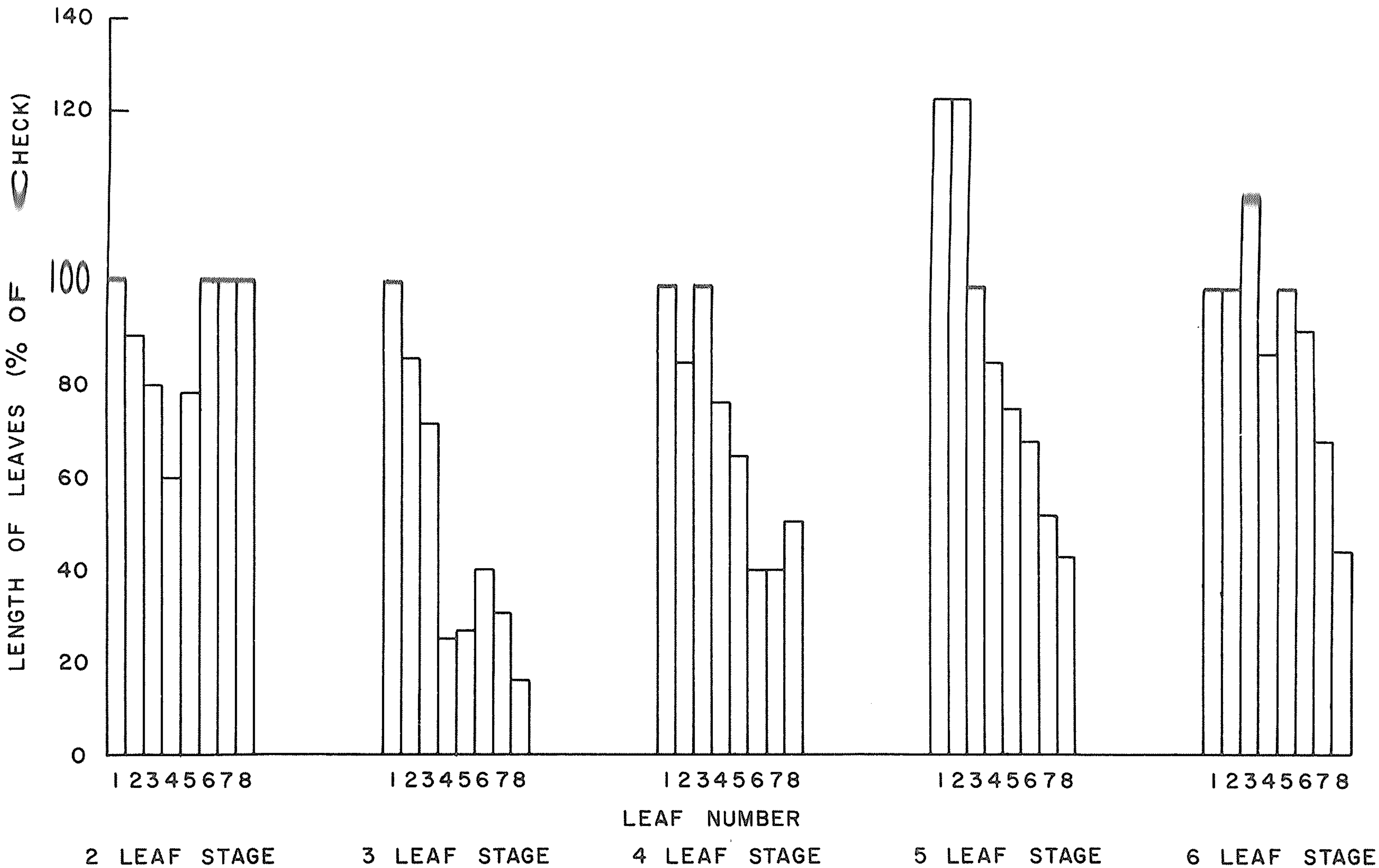

Figure 4. Effect of low light intensity and WL-17731 treatment on leaf elongation in wild oats at several growth stages (% of Check).

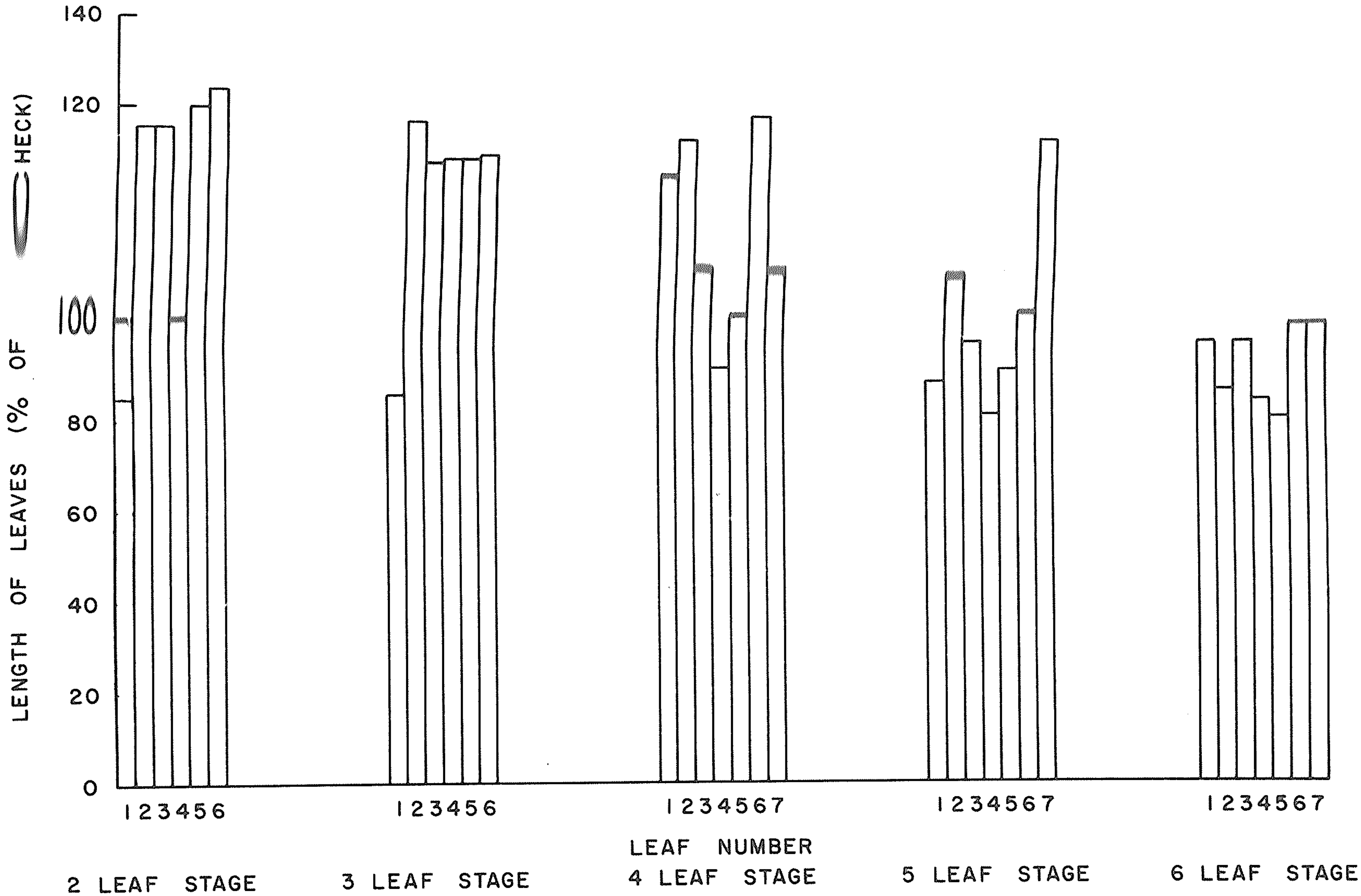

Figure 5. Effect of high light intensity and WL-17731 treatment on leaf elongation in wild oats at several growth stages (% of Check).

that, at low light intensity, the action of WL-17 31 is very rapid. Treatments were applied before the last emerged leaf was fully expanded and at all treatment dates this leaf did not reach the size of the corresponding leaf on the check plants. Also, when treatment occurred at the two leaf stage the plants recovered by the time the plants reached the 6 leaf stage because the 6th, 7th and 8th leaves were normal length. Figure 5 shows that, under high light intensity, WL-17731 had almost no effect on the length of the leaves on the main culm.

Experiment X. Site of uptake of WL-17731 in wild oats.

Experiments were conducted under growth chamber conditions to determine the effect of applying WL-17731 to various parts of wild oat plants.

Data showing the effect of WL-17731 when applied to mid-point, base and sheath of wild oat leaves at three stages of growth are given in Figures 6, 7 and 8. Length of leaves is shown as a per cent of the length of corresponding leaves on check plants.

When WL-17731 was applied at the one and one half leaf stage (Figure 6) and the two and one half leaf stage (Figure 7), all suppression of subsequent leaf growth was caused by treatments to either the leaf sheath or the leaf base. When WL-17731 was applied at the three and one half leaf stage (Figure 8), only treatments applied to the leaf sheath caused a suppression in growth of subsequent leaves. Similar results were obtained using a commercial emulsifiable concentrate formulation of WL-17731 (FX-2039).

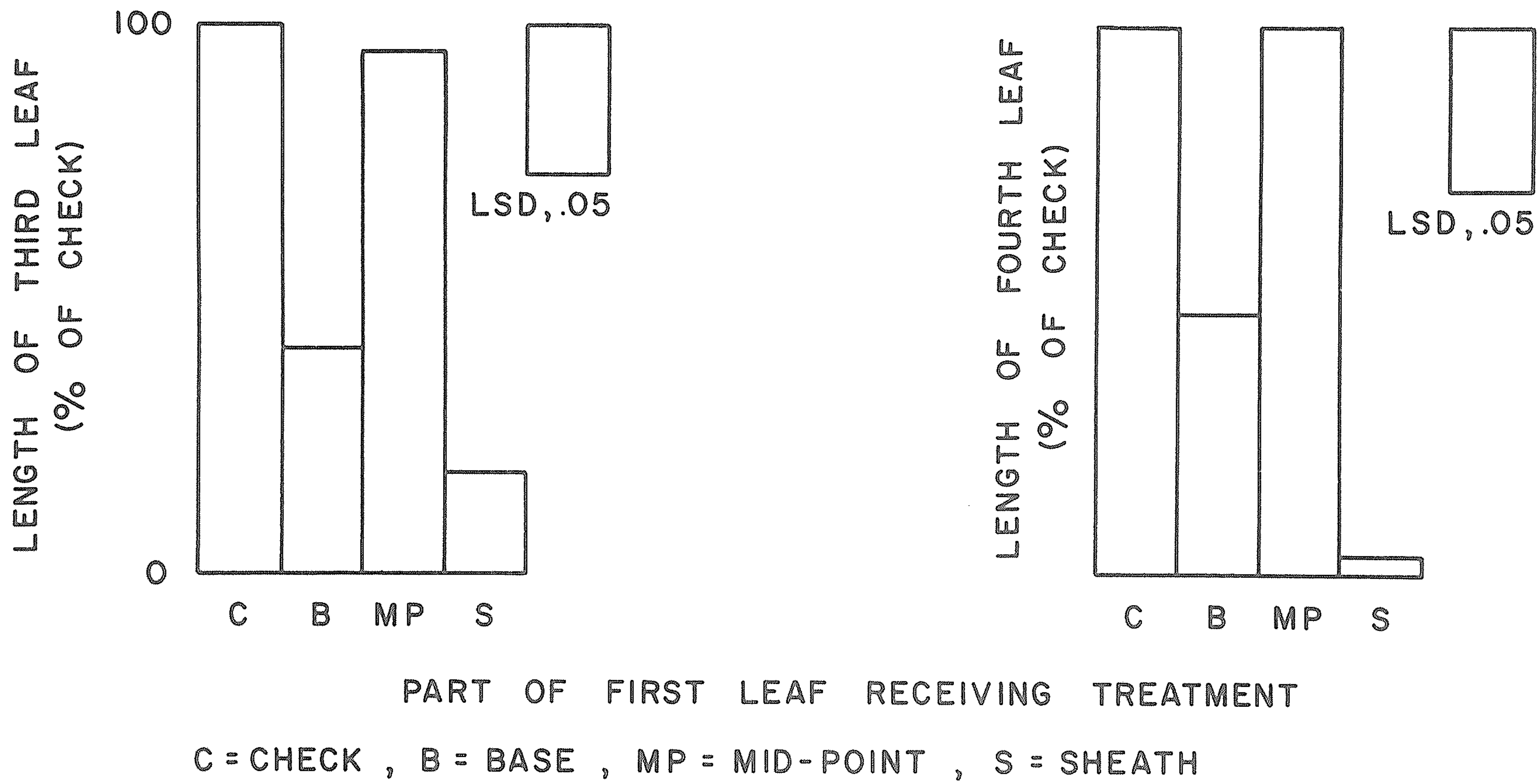

Figure 6. Effect of WL-17731 on leaf length when applied to various parts of wild oat plants at the $1\frac{1}{2}$ leaf stage.

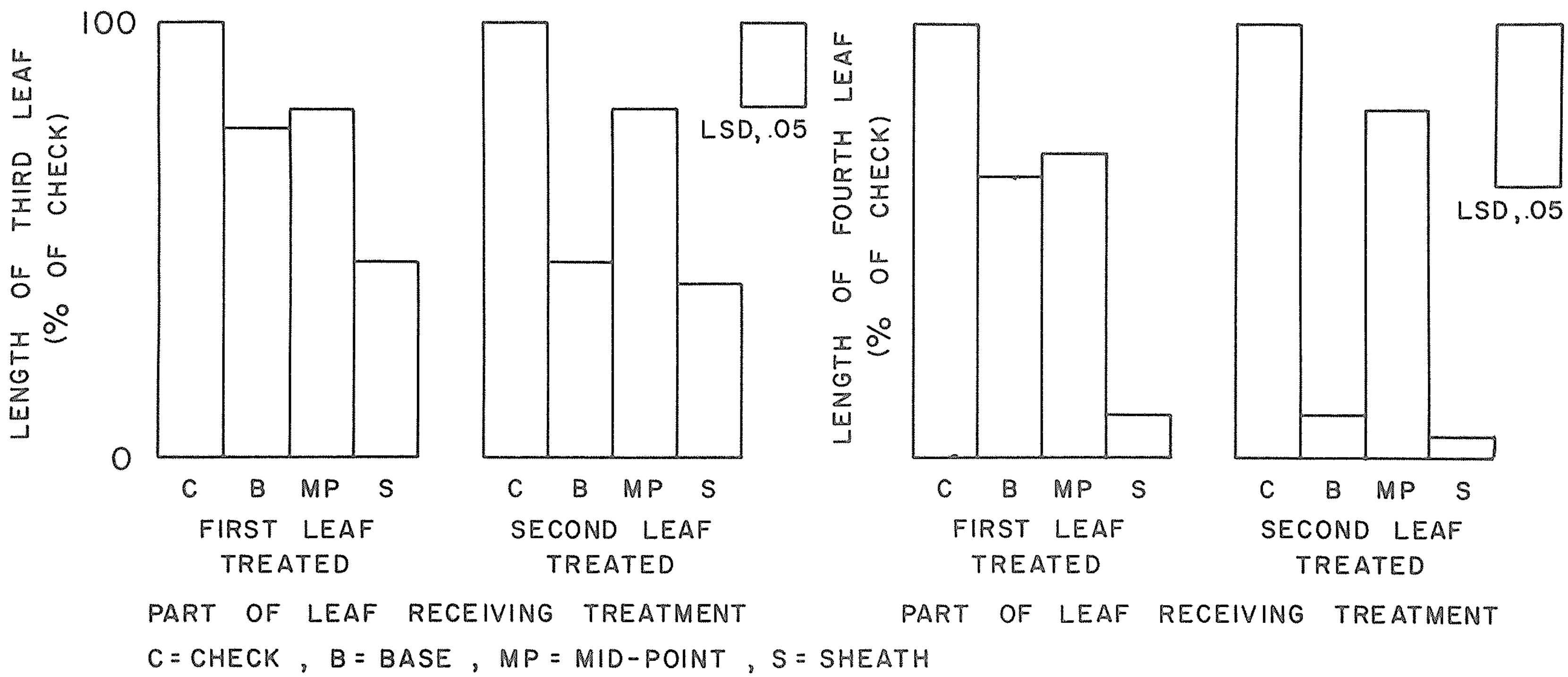

Figure 7. Effect of WL-17731 on leaf length when applied to various parts of wild oat plants at the 2½ leaf stage.

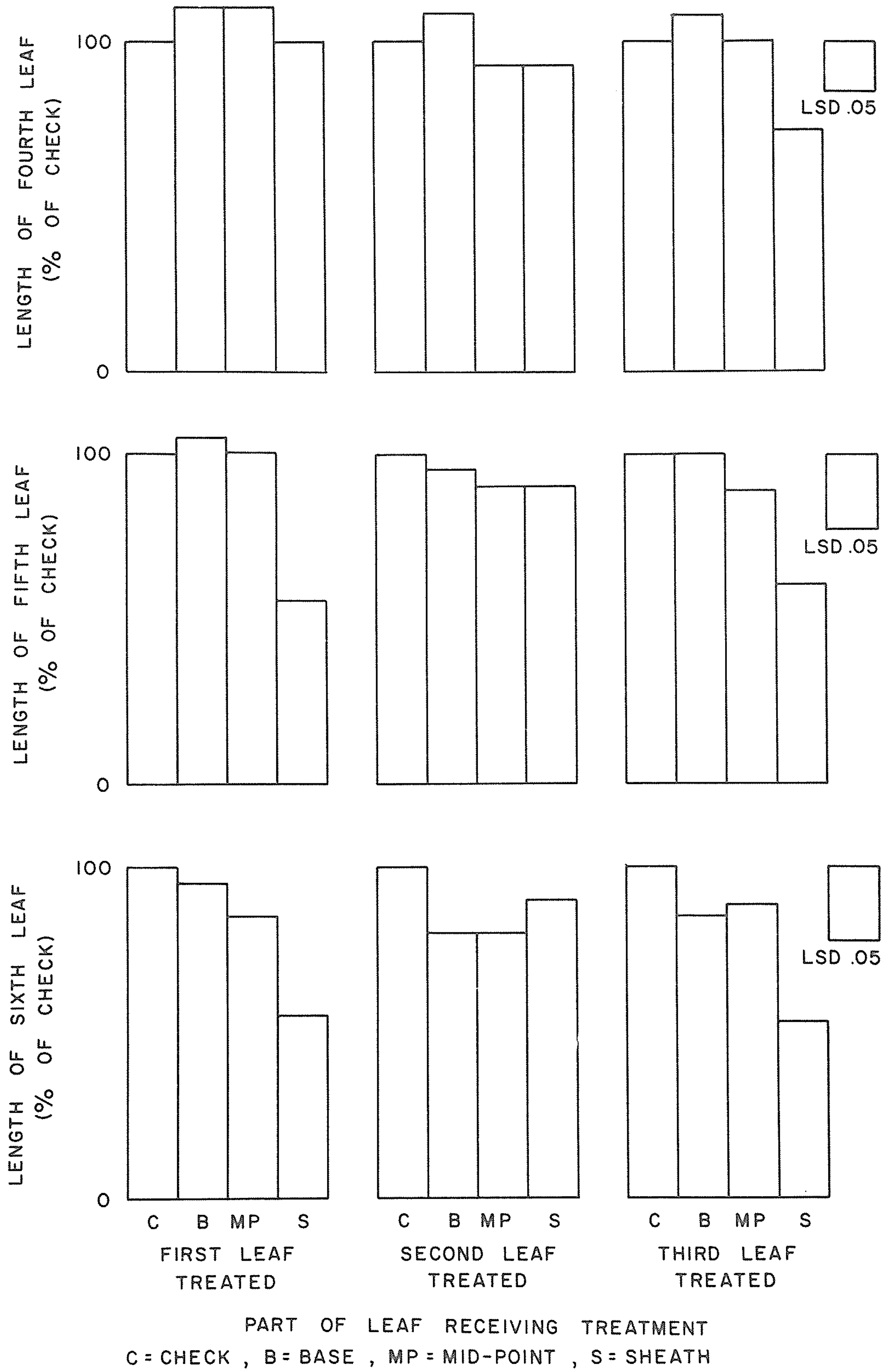

Figure 8. Effect of WL-17731 on leaf length when applied to various parts of wild oat plants at the $3\frac{1}{2}$ leaf stage.

Experiment VIII. The effect of angle of spray pattern on the activity of WL-17731.

Subsequent to the site of uptake experiments, an experiment was conducted in the greenhouse to determine if the angle of spray pattern had any effect on the activity of WL-17731.

Averaged data from the 3 and 4 leaf stage applications showing effect of WL-17731 applied at spray angles of $90^{o}C$ and $45^{o}C$ are given in Figure 9. The effectiveness of WL-17731 in suppressing the growth of wild oats was greater when the nozzle was directed 45^{o} forward to the spray path. This was probably due to increased retention by the plants (Hibbitt, 1969) and perhaps to a more sensitive area of the plants (the sheath) coming into contact with the chemical. Based on the site of uptake, the angle of the spray pattern would appear to be more critical as the plants mature since the sheath becomes the most sensitive part of the plant.

Experiment XI. Histological and cytological effect of WL-17731 on wild oats.

An attempt was made to learn something of the mode of action of WL-17731 by examining cells of treated and untreated plants.

The histological effects of WL-17731 on wild oat stem material is shown in Plate 4. All photographs were made at the same magnification.

The photographs of the stem cross section (Plates 4a and 4b) indicate a decreased stem diameter and increased stem wall thickness in the WL-17731 treated plants. Vascular bundles are more numerous, smaller and less well

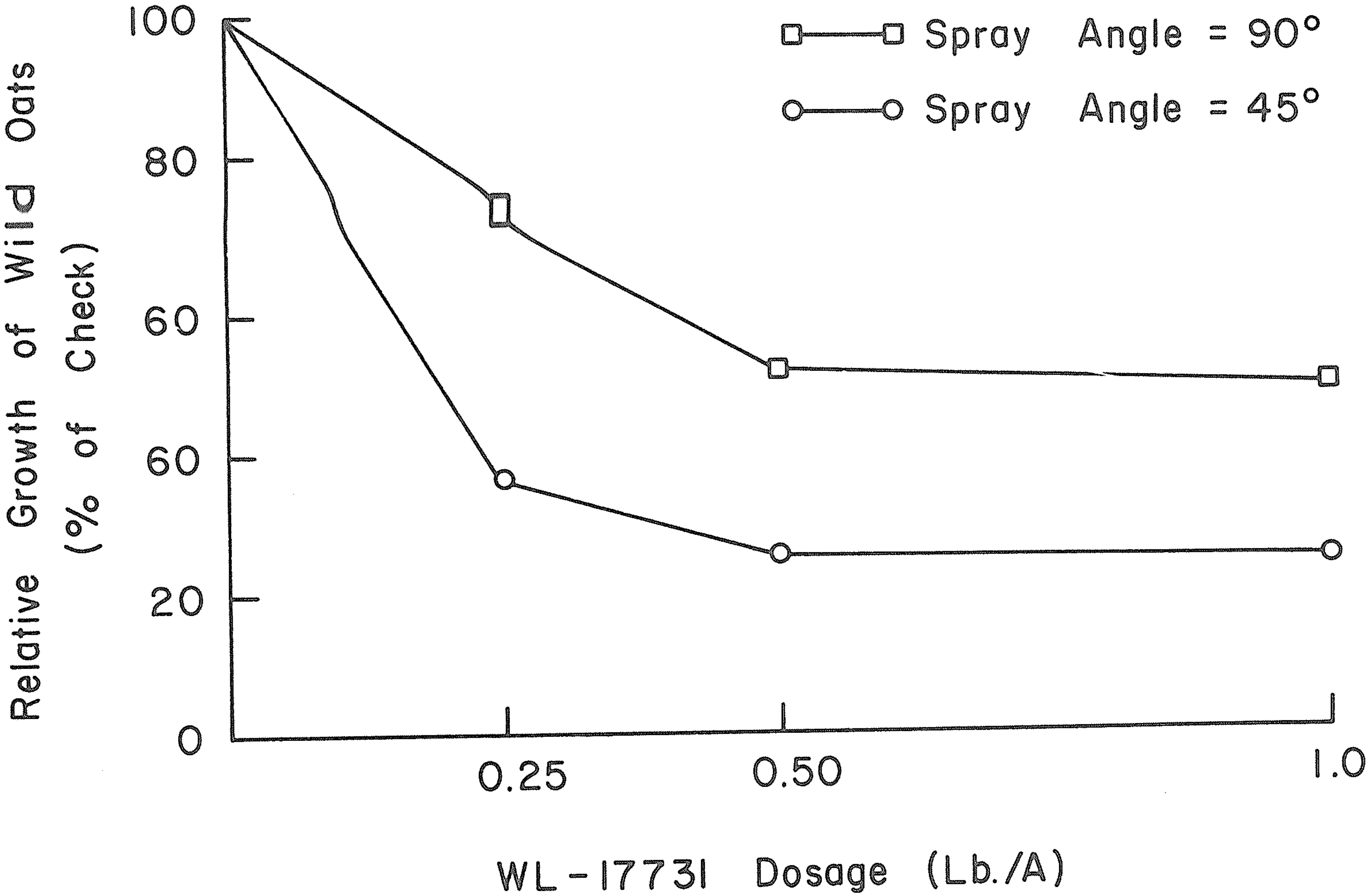

Figure 9. Relative growth depression of wild oats treated with WL-17731 applied at several rates and two different spray angles.

Plate 4. Histological effects of WL-17731 on wild oat stems.

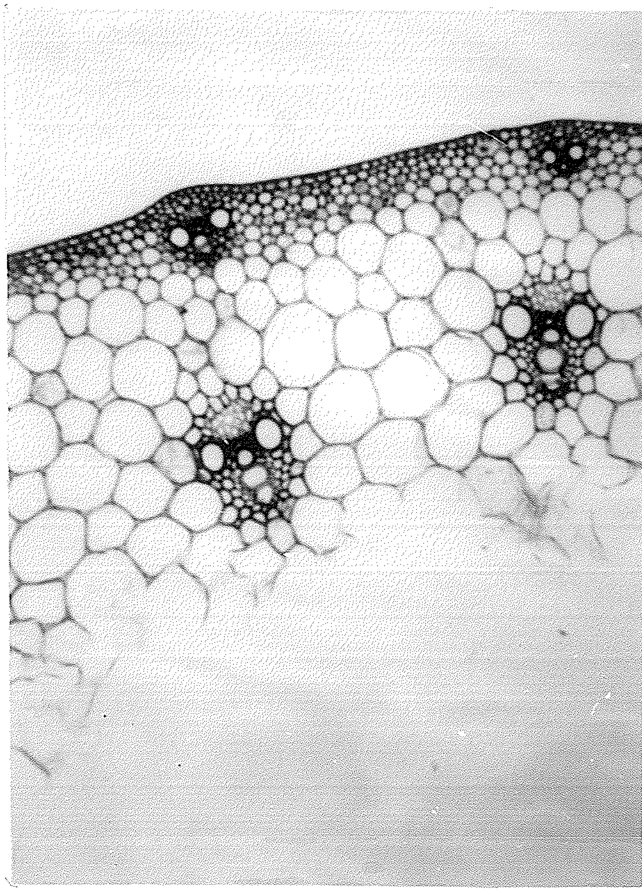

Plate 4a. Cross section of stem from untreated plant.

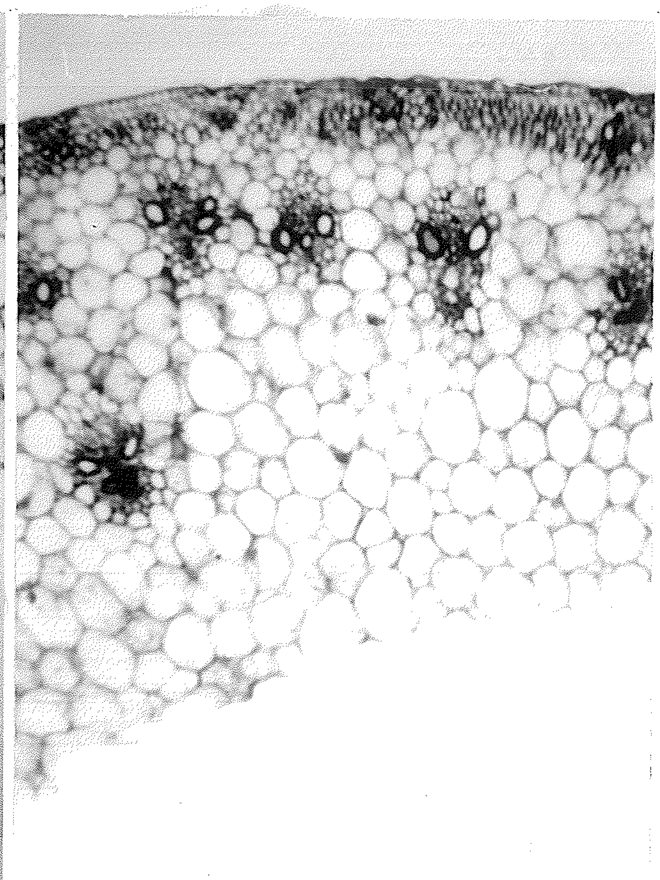

Plate 4b. Cross section of stem from wild oat treated at the six leaf stage with 1.0 pound per acre of WL-17731.

organized. Xylem elements and phloem cells appear much smaller in the treated stems. The longitudinal sections (Plates 4c and 4d) indicate a reduction in the length of the cells in the stem wall. Cell diameter has been reduced and the cells are not arranged in as orderly a fashion as in the check plants. No attempts were made to compare cell numbers in treated and check plants nor to correlate the reductions in cell length with the reduction in internode length. However, it would appear that the main cause of reduction in plant height was a suppression of cell elongation.

<u>Experiment XII</u>. The effect of WL-17731 on germinating seeds of Harmon oats and Manitou wheat.

An experiment was conducted to determine the effect of WL-17731 on germinating seeds of oats and wheat.

The effect of WL-17731 on the germination and sprout development of oats and wheat are presented in Table 11.

Acetone did not affect the germination of oats as the germination of the seed lot used had been determined to be essentially 100% prior to the experiment. Increasing the concentration of WL-17731 progressively decreased the germination of oats and also inhibited shoot and root development in seeds that germinated. Oat shoots were more sensitive than roots to WL-17731. Germination of wheat was decreased approximately 20% by the acetone treatment as the germination of the seed lot used had previously been found to be essentially 100%. WL-17731, up to a concentration of

Plate 4 (Cont.).

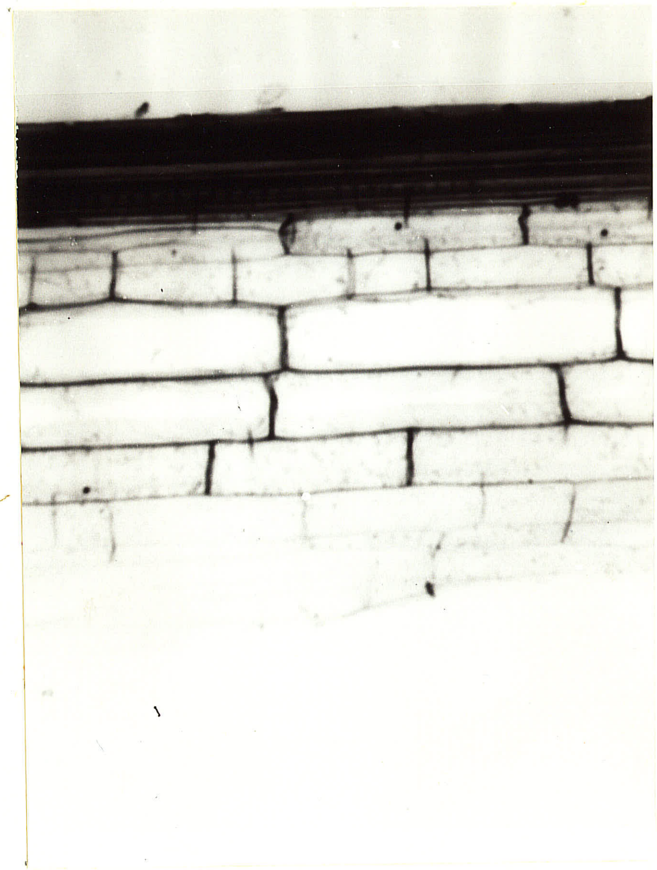

Plate 4c. Longitudinal section of stem from untreated plant.

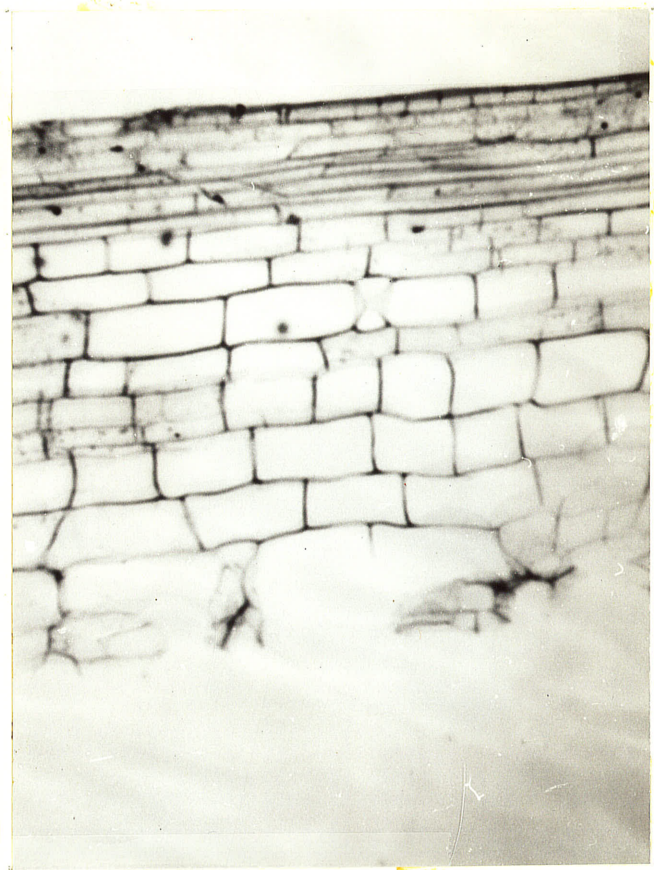

Plate 4d. Longitudinal section of stem from wild oat treated at the six leaf stage with 1.0 pound per acre of WL-17731.

TABLE 11. EFFECT OF WL-17731 ON GERMINATION AND SPROUT DEVELOPMENT OF OATS AND WHEAT.

	Conc. WL-17731 in acetone (ppm)	Germination %	Shoot length (% of check)	Root length (% of check)
Oats	0	95.0	100	100
	80	80.0	109	89
	160	82.5	97	93
	320	67.5	67	75
	640	40.0	47	75
	1280	15.0	34	70
	2560	2.5	7	71
	5120	0.0	0	48
Wheat	0	80.0	100	100
	80	82.5	87.5	107
	160	67.5	90.0	118
	320	65.0	87.5	95
	640	65.0	117.5	123
	1280	65.0	105.0	91
	2560	67.5	97.5	95
	5120	75.0	67.5	70

2560 ppm, did not appear to cause a significant reduction in germination of wheat seed. Shoots and roots of wheat were less sensitive to WL-17731 than were those of oats. There was no apparent difference in the sensitivity of roots and shoots of wheat to up to 5120 ppm of WL-17731.

The effect of WL-17731 on mitosis in oats and wheat was also studied.

The effect of selected treatments on mitosis in growing points of oats and wheat are shown in Table 12.

TABLE 12. EFFECT OF WL-17731 ON MITOSIS IN OATS AND WHEAT.

Species	Treatment	No. of cells observed	No. of cells dividing	Mitotic index (%)
<u>Oats</u>				
	no pretreatment	620	43	6.94
	acetone blank	804	50	6.22
	WL-17731 2560 ppm	767	51	6.65
<u>Wheat</u>				
	no pretreatment	679	40	5.89
	acetone blank	664	41	6.17
	WL-17731 5120 ppm	460	28	6.09

WL-17731 did not appear to have any effect on the mitotic activity of cells in the growing points of oats or wheat. As the WL-17731 treated seeds produced sprouts which were much shorter than those produced by untreated seeds, it would appear that WL-17731 acts as an inhibitor of cell elongation rather than as a mitotic poison as do the carbamate wild oat herbicides (Banting, 1970; Neidermyer, 1970).

SUMMARY AND CONCLUSIONS

In both greenhouse and field trials, WL-17731 exhibits selectivity between wild oats and wheat. Rates as low as 0.75 pounds per acre gave good wild oat control while rates up to 8.0 pounds per acre did not injure wheat grown in the greenhouse. Conquest barley is much more sensitive than wheat and the margin of selectivity does not appear adequate with formulations presently available. However, there appear to be differences in sensitivity of barley varieties to WL-17731 (E. H. Stobbe, personal communication).

WL-17731 suppresses the growth of wild oat but rarely causes death of the plant. Treated plants are stunted and often tiller more profusely than untreated plants. Leaves may exhibit some chlorosis, deformity and necrosis from tips downward. Panicles often do not emerge from the boot of treated plants especially if the plants are treated at the later growth stages.

Under field conditions, wild oats become more sensitive to WL-17731 with increasing age of the plant. At the three to four leaf stage, 2.0 pounds per acre did not satisfactorily control wild oats in a crop of wheat. At the four leaf stage, 1.5 pounds per acre gave acceptable control and at the five to six leaf stage only 0.75 pounds per acre was required to control wild oats. Similar findings have been reported by other workers in Western Canada (Bowden and Broughton, 1970; Molberg, 1970).

Yield responses of wheat were not conclusive in the field tests conducted. Bowden and Friesen (1967) reported that wild oats compete heavily with wheat shortly after wild oat emergence. This is an important factor since wild oats are not satisfactorily controlled by WL-17731 unless application is delayed until at least the four leaf stage. Much more work will be required in an effort to find means of increasing the effectiveness of early application of WL-17731 through modifications in formulation, application techniques, crop management and herbicide combinations.

Seed produced by wild oat plants that survived WL-17731 treatment in the field germinated normally in a laboratory germination test. Seed production on surviving plants was greatly suppressed compared to untreated plants and the later the application date the greater the suppression in seed production. WL-17731 prevents seed production when applied just prior to panicle emergence and this may make it a useful emergency treatment in fields that are heavily infested with wild oats not effectively controlled by another herbicide during the early stages of crop development.

Greenhouse experiments confirmed that WL-17731 has a wide margin of crop safety on wheat. Under greenhouse conditions, wild oats were more susceptible to WL-17731 at earlier growth stages probably due to the low light intensity in the greenhouse. An explanation for this inconsistency with field results is not immediately available. Further investigation showed that WL-17731 was more toxic to wild oats at low light intensity. This finding suggested that perhaps WL-17731 had some effect on cell elongation. Microscopic examination of stem tissue from treated and untreated plants revealed that cells from treated plants were much shorter than cells from untreated plants. This study also revealed that vascular bundles were reduced in size and were less well organized in treated plants and this may account for some of the reduction in wild oat growth due to WL-17731 treatment.

The mitotic index of growing point tissue in wheat and oat seedlings showing extreme symptoms of WL-17731 treatment was not different from check plants. Thus, it appears that WL-17731 is not a mitotic poison as are other common wild oat herbicides.

Spot applications of WL-17731 to various parts of wild oat plants suggested that WL-17731 was most effective in reducing the growth of wild oats when applied to the sheath and to the base of the leaf blade.

These studies with WL-17731 provide some insight into the action of the compound. They also provide the basis for experiments designed to find ways of increasing the effectiveness of WL-17731 under field conditions.

Cell elongation plays a major role in plant growth beginning at the jointing stage. The beginning of the jointing stage roughly coincides with the stage at which the susceptibility of wild oats to WL-17731 begins to increase. Low light intensity tends to stimulate cell elongation and the reduced amount of light which penetrates a growing crop may also enhance the activity of WL-17731. Any cultural or management practice which would increase the competitiveness of the crop at an early stage or that would speed the crop's reaching the jointing stage might increase the activity of WL-17731 and allow it to be applied earlier. This could increase the potential yield of wheat infested with wild oats. Soil fertility could be an important factor in this respect. The interaction of soil fertility level with rates and stages of WL-17731 application should be given consideration in future field testing.

The sheath and leaf base of wild oat appeared to be the most desirable target areas for obtaining maximum wild oat control. Rotating the nozzles by 45^{o} on the spray boom increases spray retention on wild oat plants and also increases spray contact with the leaf sheath. Greenhouse trials showed that this technique increased the effectiveness of WL-17731 and subsequent field testing has confirmed this finding (Stobbe et al. 1971).

WL-17731 shows promise as a wild oat herbicide and may prove a valuable aid to wheat production in Western Canada. It is effective over a wider range of growth stages than is barban and, thus, timing of application is not as critical. Barban is effective at earlier growth stages than WL-17731 and thus removes the competitive effect of wild oats earlier in the season. WL-17731 could serve as an excellent back-up herbicide to barban. Often barban cannot be applied at the proper time due to unfavorable weather conditions or the wild oat emergence may be uneven. In these cases, a herbicide like WL-17731 could prove to be a valuable addition to the chemicals now in use for wild oat control.

Another consideration in assessing the value of new wild oat herbicides has been brought to attention by Jacobsohn and Andersen (1968). They reported large differences in susceptibility between wild oat lines collected in the Red River Valley in the United States to diallate, triallate and barban. They suggested that some lines might not be controlled by recommended rates of these herbicides. It is reasonable to assume that a similar situation exists in Western Canada. Continued use of presently available wild oat herbicides could result in the non-susceptible lines becoming more dominant. If this is to be avoided, it will be necessary to find new wild oat herbicides which can be used in rotation with present compounds in the continuing effort to control wild oats.

BIBLIOGRAPHY

Alex, J. F. 1966. Survey of Weeds of Cultivated Land in the Prairie Provinces. Queen's Printer, Ottawa, Canada. 68 p.

Banting, J. D. 1962. The dormancy behaviour of *Avena fatua* L. in cultivated soil. Can. Jour. Pl. Sci. 42: 22-39.

Banting, J. D. 1970. Effect of diallate and triallate on wild oat and wheat cells. Weed Science 18: 80-84.

Batho, G. 1933. Control of Wild Oats. Circular #111, Manitoba Department of Agriculture and Immigration.

Bell, A. R. and J. D. Nalewaja. 1968. Competition of wild oat in wheat and barley. Weed Science 16: 505-508.

Bingham, H. E. and J. W. Pullen. 1960. Carbyne 1960 field trials. Res. Rept. Nat. Weed Comm. W. Sect. p. 46.

Bowden, B. A. and G. Friesen. 1967. Competition of wild oats (*Avena fatua* L.) in wheat and flax. Weed Res. 7: 349-359.

Bowden, B. A. 1969. Effect of WL-17731 on the control of wild oats in Manitou wheat. Res. Rept. Canada Weed Comm. W. Sect. pp. 68-69.

Bowden, B. A. and C. J. Broughton. 1970. Effect of WL-17731 on wild oats in Manitou wheat at five rates of application and two stages of growth. Res. Rept. Canada Weed Comm. W. Sect. pp. 55-56.

Canvin, D. T. and G. Friesen. 1959. Cytological effects of CDAA and IPC on germinating barley and peas. Weeds 7: 153-156.

Carder, A. C. 1959. Carbyne for wild oat control in spring wheat. Res. Rept. Nat. Weed Comm. W. Sect. p. 38.

Cushon, G. A. 1969. Herbicides to control wild oats in wheat. Res. Rept. Canada Weed Comm. W. Sect. pp. 73-74.

Dryden, R. D. 1961. Three formulations of avadex for the control of wild oats in Selkirk wheat. Res. Rept. Nat. Weed Comm. W. Sect. pp. 35-36.

Dryden, R. D. 1961. Methods of incorporating avadex for wild oat control in Selkirk wheat. Res. Rept. Nat. Weed Comm. W. Sect. pp. 36-37.

Dryden, R. D. and C. W. Whitehead. 1962. Applications of avadex (CP 15336 and CP 23426) in Selkirk wheat. Res. Rept. Nat. Weed Comm. W. Sect. pp. 40-41.

Dryden, R. D. and P. N. P. Chow. 1969. Control of wild oats in Manitou wheat with WL-17731. Res. Rept. Canada Weed Comm. W. Sect. p. 75.

Forsberg, D. E. 1960. Control of wild oats with carbyne. Res. Rept. Nat. Weed Comm. W. Sect. p. 50.

Friesen, G. 1960. Effect of carbyne applied at 10 stages of growth. Res. Rept. Nat. Weed Comm. W. Sect. p. 50.

Friesen, G. 1962. Effect of avadex formulations on wild oats in wheat. Res. Rept. Nat. Weed Comm. W. Sect. p. 43.

Friesen, G. 1967. The efficiency of barban as influenced by growth stages of wild oats and spring wheat. Weeds 15: 160-162.

Friesen, G. and L. H. Shebeski. 1960. Economic losses caused by weed competition in Manitoba grain fields. I. Weed species, their relative abundance and their effect on crop yields. Can. Jour. Pl. Sci. 40: 457-467.

Friesen, H. A. 1959. The influence of dosage and volume of diluent on 4-chloro-2-butynyl N-(3-chlorophenyl) carbamate applied at two growth stages to control wild oat. Proc. W. Can. Weed Cont. Conf. pp. 35-36.

Friesen, H. A. 1960. Effect of nozzle type on the effectiveness of barban on wild oats in Rodney oats. Res. Rept. Nat. Weed Comm. W. Sect. p. 52.

Friesen, H. A. 1961a. Some factors affecting the control of wild oats with barban. Weeds 9: 185-194.

Friesen, H. A. 1961b. Effect of different methods of incorporation of 2,3-DCDT on the control of wild oats in wheat. Res. Rept. Nat. Weed Comm. W. Sect. pp. 38-39.

Friesen, H. A. 1963. Barban at varying dosages, spray pressures and levels of wild oat infestation in Thatcher wheat. Res. Rept. Nat. Weed Comm. W. Sect. p. 69.

Friesen, H. A., J. D. Banting and D. R. Walker. 1962. The effect of placement and concentration of 2,3-DCDT on the selective control of wild oats in wheat. Can. Jour. Pl. Sci. 42: 91-104.

Gull, P. W. and H. C. Zeisig Jr. 1960. Carbyne utility studies 1960. Res. Rept. Nat. Weed Comm. W. Sect. p. 53.

Hibbitt, C. J. 1969. Growth and spray retention of wild oat and flax in relation to herbicidal selectivity. Weed Res. 9: 95-107.

Hoffmann, O. L., R. R. Hopkins and J. W. Pullen. 1958. Wild oat control with 4-chloro-2-butynyl N-(3-chlorophenyl) carbamate (S-847). Proc. Nat. Weed Comm. W. Sect. 12: 3-6.

Holmes, H. M. and R. K. Pfeiffer. 1962. Some aspects of the use of barban for wild oat control in winter wheat. Weed Res. 2: 110-121.

Jacobsohn, R. and R. N. Andersen. 1968. Differential response of wild oat lines to diallate, triallate and barban. Weed Sci. 16: 491-494.

Korven, N. A. 1961. Nozzles and their effectiveness for applying carbyne for wild oat control. Res. Rept. Nat. Weed Comm. W. Sect. p. 70.

McCurdy, E. V. 1959. Pre-planting chemicals for wild oat control. Res. Rept. Nat. Weed Comm. W. Sect. p. 50.

Molberg, E. S. 1961. Control of wild oats with pre-planting and pre-emergent application of herbicides. Res. Rept. Nat. Weed Comm. W. Sect. pp. 40-41.

Molberg, E. S. and J. D. Banting. 1958. Pre-planting treatments for wild oat control. Res. Rept. Nat. Weed Comm. W. Sect. p. 47.

Molberg, E. S. and J. D. Banting. 1959. Selective control of wild oat in wheat with carbyne. Res. Rept. Nat. Weed Comm. W. Sect. pp. 51-52.

Molberg, E. S. 1970. Control of wild oats in wheat with WL-17731 applied at different rates and growth stages. Res. Rept. Canada Weed Comm. W. Sect. pp. 85-86.

Morrison, J. W. 1962. Cytological effects of the herbicide "Avadex". Can. Jour. Pl. Sci. 42: 78-81.

Neidermeyer, R. W. 1970. Ph.D. Thesis, North Dakota State University. p. 28.

Parker, C. 1963. Factors affecting the selectivity of 2,3-Dichloroallyl diisopropyl thiol carbamate (Di-allate) against Avena spp. in wheat and barley. Weed Res. 3: 259-276.

Sass, J. E. 1958. Botanical Microtechnique. Third ed. Iowa State University Press. pp. 69-71.

Selleck, G. W. 1958. Various herbicides for wild oat control. Res. Rept. Nat. Weed Comm. W. Sect. pp. 48-49.

Selleck, G. W. 1959. EPTC and avadex for wild oat control in various crops 1959. Res. Rept. Nat. Weed Comm. W. Sect. pp. 52-53.

Selleck, G. W. 1959. Avadex for wild oat control 1959. Res. Rept. Nat. Weed Comm. W. Sect. p. 54.

Selleck, G. W. 1961. Recent advances in the chemical control of wild oats. Weeds 9: 60-71.

Sexsmith, J. J. 1959. Pre-planting herbicide treatments for the control of wild oats, green foxtail and broad-leaf annuals in a variety of crops. Res. Rept. Nat. Weed Comm. W. Sect. p. 56.

Skoglund, N. A., G. W. Selleck and R. T. Coupland. 1960. Effect of avadex on wild oats in three crops 1960. Res. Rept. Nat. Weed Comm. W. Sect. pp. 43-44.

Stobbe, E. H., H. R. Nelson and C. R. Hildahl. 1971. The effect of pressure and nozzle angle in the application of WL-17731. Res. Rept. Canada Weed Comm. W. Sect. p. 340.

Thurston, J. M. 1961. Effect of depth of burying and frequency of cultivation on survival and germination of seeds of Avena fatua and A. ludoviciana. Weed Res. 1: 19-31.

A P P E N D I X

APPENDIX TABLE 1

CROP AND ATMOSPHERIC CONDITIONS AT TIME OF SPRAYING (EXPERIMENT I)

Date	Leaf Stage		Time of Spray Application	Temp. °C	Relative Humidity (%)	Wind Direction and Speed (mph)
	Wild Oats	Wheat				
Altamont						
26/6/70	2-3	4-5	2:30 PM	27	41	WNW 2-3
6/7/70	4-5	5-6	7:00 PM	24	53	W 3-4
10/7/70	5-6	7	8:00 AM	22	71	Calm
17/7/70	flag	flag	11:00 AM	24	67	Calm
27/7/70	heading	heading	1:30 PM	25	48	SW 4-5
Graysville						
15/6/70	1-2	2	11:00 AM	18	90	SE 2-3
18/6/70	2	3	8:30 PM	16	45	Calm
24/6/70	3-4	4-5	9:30 PM	18	51	Calm
5/7/70	6-7	6-7	9:30 PM	24	64	SW 7-8
10/7/70	flag	flag	9:00 AM	24	74	Calm

APPENDIX TABLE 2

CROP AND ATMOSPHERIC CONDITIONS AT TIME OF SPRAYING (EXPERIMENT II)

Date	Leaf Stage		Time of Spray Application	Temp. ^{o}C	Relative Humidity (%)	Wind Direction and Speed (mph)
	Wild Oats	Wheat				
Altamont						
6/7/70	4	5-6	7:00 PM	24	51	W 2-3
10/7/70	5-6	6	7:30 AM	22	77	Calm
Graysville						
24/6/70	3-4	4-5	9:00 PM	18	51	Calm
6/7/70	flag	flag	9:00 PM	24	63	Calm

APPENDIX TABLE 3

CROP AND ATMOSPHERIC CONDITIONS AT TIME OF SPRAYING (EXPERIMENT III)

Date	Leaf Stage	Time of Spray Application	Temp. ^{o}C	Relative Humidity (%)	Wind Direction and Speed (mph)
8/7/70	5	5:30 AM	15	52	Calm
10/7/70	7	11:30 AM	28	76	Calm

APPENDIX TABLE 4

CROP AND ATMOSPHERIC CONDITIONS AT TIME OF SPRAYING (EXPERIMENT IV)

Date	Leaf Stage		Time of Spray Application	Temp. ^{o}C	Relative Humidity (%)	Wind Direction and Speed (mph)
	Wild Oats	Wheat				
18/6/70	2-3	3	8:15 PM	16	45	Calm
5/7/70	6-7	6-7	8:30 PM	27	64	SSW 10

APPENDIX TABLE 5

CROP AND ATMOSPHERIC CONDITIONS AT TIME OF SPRAYING (EXPERIMENT V)

Date	Leaf Stage		Time of Spray Application	Temp. ^{o}C	Relative Humidity (%)	Wind Direction and Speed (mph)
	Wild Oats	Wheat				
26/6/70	2-3	4	2:30 PM	27	41	WNW 2-3
6/7/70	4-5	5-6	7:00 PM	24	53	W 3-4

APPENDIX TABLE 6

ANOVA EFFECT OF STAGE OF APPLICATION ON WHEAT YIELD (EXPERIMENT I)

	Source	df	SS	MS	F
Altamont					
	Treatments	10	5,428	543	0.87 n.s.
	Blocks	3	1,441	480	0.77 n.s.
	Error	30	18,792	626	
	Total	43	25,661		
Graysville					
	Treatments	10	4,696	470	1.7
	Blocks	3	12,296	4099	14.9**
	Error	30	8,233	274	
	Total	43	25,225		

APPENDIX TABLE 7

ANOVA EFFECT OF RATE OF APPLICATION ON WHEAT YIELD (EXPERIMENT II)

	Source	df	SS	MS	F
Altamont					
	Blocks	3	2,491	830	2.70 n.s.
	Stages	1	3,997	3,997	13.02*
	Error	3	921	307	
	Treatments	5	1,875	375	17.86**
	Interaction	5	9,646	1,929	91.86**
	Error	30	630	21	
	Total	47	13,688		
Graysville					
	Blocks	3	866.5	288.5	0.40 n.s.
	Stages	1	303.0	303.0	0.42 n.s.
	Error	3	2,174.9	725.0	
	Treatments	5	709.3	141.9	1.64 n.s.
	Interaction	5	229.9	46.0	0.53 n.s.
	Error	30	2,594.0	86.5	
	Total	47	6,300.5		

APPENDIX TABLE 8

ANOVA EFFECT OF WL-17731 FORMULATION ON YIELD OF BARLEY (EXPERIMENT III)

Source	df	SS	MS	F
Treatments	8	297,053	37,132	4.2**
Blocks	3	8,072	2,690	57.9**
Error	24	15,394	641	
Total	35	320,519		

APPENDIX TABLE 9

ANOVA EFFECT OF VARIOUS TREATMENTS ON WHEAT YIELD (EXPERIMENT V)

Source	df	SS	MS	F
Blocks	3	1,683	561	0.28 n.s.
Stages	1	66	66	0.03 n.s.
Error	3	5,990	1,997	
Treatments	8	6,576	822	0.59 n.s.
Interaction	8	13,326	1,666	1.19 n.s.
Error	48	67,254	1,401	
Total	71	94,895		

APPENDIX TABLE 10

ANOVA EFFECT OF VARIOUS TREATMENTS ON TILLERING IN WHEAT (EXPERIMENT V)

Source	df	SS	MS	F
Blocks	3	1,051	351	0.31 n.s.
Stages	1	953	953	0.83 n.s.
Error	3	3,428	1,143	
Treatments	8	12,071	1,509	3.32**
Interaction	8	9,749	1,219	2.69*
Error	48	21,786	454	
Total	71	49,038		

APPENDIX TABLE 11

ANOVA DOSAGE RESPONSE OF WILD OATS TO WL-17731 (EXPERIMENT VI)

Source	df	SS	MS	F
Treatments	11	19.73	1.7936	66.18**
Error	48	1.30	0.0271	
Total	59	21.03		

APPENDIX TABLE 12

ANOVA DOSAGE RESPONSE OF MANITOU WHEAT TO WL-17731 (EXPERIMENT VI)

Source	df	SS	MS	F
Treatments	8	2.23	0.279	0.43 n.s.
Error	36	23.6	0.656	
Total	44	25.8		

APPENDIX TABLE 13

ANOVA EFFECT OF WL-17731 ON TILLERING IN MANITOU WHEAT (EXPERIMENT VII)

Source	df	SS	MS	F
Treatments	9	5.05	0.5611	0.85 n.s.
Error	40	26.4	0.6600	
Total	49	31.45		

APPENDIX TABLE 14

ANOVA EFFECT OF WL-17731 ON HEIGHT OF WHEAT CULMS (EXPERIMENT VII)

Source	df	SS	MS	F
Treatments	9	520.66	57.8511	2.84*
Error	40	815.62		
Total	49	1,336.28		

APPENDIX TABLE 15

ANOVA EFFECT OF WL-17731 ON MATURITY OF MANITOU WHEAT (EXPERIMENT VII)

Source	df	SS	MS	F
Treatments	9	122.9	13.66	0.36 n.s.
Error	40	1,537.6	38.44	
Total	49	1,660.5		

APPENDIX TABLE 16

ANOVA EFFECT OF WL-17731 ON WHEAT YIELD (EXPERIMENT VII)

Source	df	SS	MS	F
Treatments	9	47.22	5.2467	6.11**
Error	40	34.34	0.8585	
Total	49	81.56		

APPENDIX TABLE 17

ANOVA EFFECT OF WL-17731 ON GERMINATION OF MANITOU WHEAT (EXPERIMENT VII)

Source	df	SS	MS	F
Treatments	9	4.2	0.4667	1.94 n.s.
Error	40	7.2	0.240	
Total	49	11.4		

APPENDIX TABLE 18

ANOVA EFFECT OF WL-17731 ON TILLERING OF WILD OATS (EXPERIMENT VII)

Source	df	SS	MS	F
Treatments	11	40.2	3.6545	2.19*
Error	48	80.0	1.6667	
Total	59	120.2		

APPENDIX TABLE 19

ANOVA EFFECT OF WL-17731 ON HEIGHT OF WILD OAT CULMS (EXPERIMENT VII)

Source	df	SS	MS	F
Treatments	11	12,426.4	1,129.67	8.31**
Error	48	6,523.9	135.91	
Total	59	18,950		

APPENDIX TABLE 20

ANOVA EFFECT OF WL-17731 ON WILD OAT SEED PRODUCTION (EXPERIMENT VII)

Source	df	SS	MS	F
Treatments	11	48.6	4.4182	3.20**
Error	48	66.2	1.3792	
Total	59	114.8		

APPENDIX TABLE 21

ANOVA EFFECT OF ANGLE OF SPRAY ON DRY MATTER PRODUCTION IN WILD OATS (EXPERIMENT VIII)

Source	df	SS	MS	F
Treatments	6	22.35	3.7250	13.05**
Error	28	7.99	0.2854	
Total	34	30.34		

APPENDIX TABLE 22

ANOVA EFFECT OF APPLYING WL-17731 TO VARIOUS PARTS OF THE FIRST LEAF OF WILD OATS ON THE LENGTH OF THE THIRD LEAF (EXPERIMENT X)

Source	df	SS	MS	F
Treatments	3	3,837.7	1,279.2	19.97**
Error	16	1,024.8	64.0	
Total	19	4,862.5		

APPENDIX TABLE 23

ANOVA EFFECT OF APPLYING WL-17731 TO VARIOUS PARTS OF THE FIRST LEAF OF WILD OATS ON THE LENGTH OF THE FOURTH LEAF (EXPERIMENT X)

Source	df	SS	MS	F
Treatments	3	8,011.3	2,670.4	21.92**
Error	16	1,949.2	121.8	
Total	19	9,960.5		

APPENDIX TABLE 24

ANOVA EFFECT OF APPLYING WL-17731 TO VARIOUS PARTS OF THE FIRST AND SECOND LEAF OF WILD OATS ON THE LENGTH OF THE THIRD LEAF (EXPERIMENT X)

Source	df	SS	MS	F
Treatments	6	3,424	570.7	12.84**
Error	28	1,244	44.4	
Total	34	4,668		

APPENDIX TABLE 25

ANOVA EFFECT OF APPLYING WL-17731 TO VARIOUS PARTS OF THE FIRST AND SECOND LEAVES OF WILD OATS ON THE LENGTH OF THE FOURTH LEAF (EXPERIMENT X)

Source	df	SS	MS	F
Treatments	6	14,526	2,421	13.25**
Error	28	5,116	183	
Total	34	19,642		

APPENDIX TABLE 26

ANOVA EFFECT OF APPLYING WL-17731 TO VARIOUS PARTS OF THE FIRST, SECOND AND THIRD LEAVES OF WILD OATS ON THE LENGTH OF THE FOURTH LEAF (EXPERIMENT X)

Source	df	SS	MS	F
Treatments	9	1,475	163.92	5.14**
Error	40	1,276	31.89	
Total	49	2,751		

APPENDIX TABLE 27

ANOVA EFFECT OF APPLYING WL-17731 TO VARIOUS PARTS OF THE FIRST, SECOND AND THIRD LEAVES OF WILD OATS ON THE LENGTH OF THE FIFTH LEAF (EXPERIMENT X)

Source	df	SS	MS	F
Treatments	9	2,785	309.48	4.22**
Error	40	2,934	73.34	
Total	49	5,719		

APPENDIX TABLE 28

ANOVA EFFECT OF APPLYING WL-17731 TO VARIOUS PARTS OF THE FIRST, SECOND AND THIRD LEAVES OF WILD OATS ON THE LENGTH OF THE SIXTH LEAF (EXPERIMENT X)

Source	df	SS	MS	F
Treatments	9	1,745	193.86	3.62
Error	40	2,142	53.55	
Total	49	3,887		

APPENDIX TABLE 29

EXPLANATION OF VISUAL WEED CONTROL AND CROP TOLERANCE RATINGS

Rating	Degree of Weed Control	Degree of Crop Tolerance
0	No control	No tolerance
1	Very poor control	Very severe stand reduction
2	Poor control	Severe stand reduction
3	Slight control	Moderate stand reduction
4	Moderate control	Slight stand reduction
5	Fair control	Plant height reduced
6	Nearly acceptable control	Slight deformity
7	Acceptable control	Acceptable tolerance
8	Very good control	High degree of tolerance
9	Complete control	Complete tolerance