A STUDY OF HERBICIDAL EFFICIENCY IN CERTAIN VEGETABLE CROPS

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by

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ABSTRACT

This study was undertaken to evaluate new herbicides which could prove useful in reducing production costs to the commercial vegetable grower. These herbicides were tested under a variety of environmental conditions to determine if they could control weeds under varying conditions. A total of eighteen experiments were conducted during 1962 and 1963 on the following vegetable crops: carrots, transplanted celery, onions, and white beans. In 1963, five experiments in carrots, onions, and white beans were designed to compare costs between chemical and mechanical weeding. These were located in the six major vegetable growing areas of Manitoba.

Carrots. The herbicides amiben, solan, trifluralin, and linuron were compared with the standard herbicide varsol in this crop. Amiben, solan, and trifluralin each gave weed control equal to and longer lasting than varsol which is the only herbicide used commercially at present by carrot growers in Manitoba. Linuron was less effective in these experiments.

Transplanted Celery. Two herbicides, solan and amiben, were evaluated for weed control in celery. Solan gave commercial weed control in the three experiments conducted in this crop. Amiben was less effective in these experiments.

Onions. Mixtures of three herbicides, CIPC, CDAA and DCPA were compared with applications of CIPC and CDAA alone in four onion

experiments. The most effective treatment in controlling annual weeds in onions was a mixture of CIPC and CDAA applied pre-emergence. Singly, the application of either of these herbicides was not as effective as the mixture. A combination of CDAA and DCPA gave commercial control in limited trials and should be tested further.

White Beans. Amiben, linuron, DCPA, and trifluralin were tested for efficiency in controlling annual weeds and crop tolerance in white beans. Amiben and trifluralin were the most effective herbicides while linuron gave good weed control but severely injured the crop. DCPA was ineffective in these experiments.

Cost study trials in carrots, onions, and white beans showed that herbicides reduced weeding costs by reducing the hours of labor required to clear the crop of weeds and by decreasing the number of mechanical cultivations required to obtain maximum crop yields.

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CHAPTER I

INTRODUCTION

Commercial vegetable growers in Manitoba are involved in a highly competitive business. They are continually searching for less costly and more efficient methods of producing high quality produce. The control of weeds constitutes one of the major expenses in vegetable production. Some reports from the U.S.A. state that cultivation and hand weeding account for as much as forty per cent of the total costs in growing vegetable crops.

Vegetable production is a growing industry in Manitoba. The acreage of vegetables grown for the fresh market in 1963 showed an increase of eight per cent over that of 1962. Produce grown for canning is also of considerable economic importance in this province.

In Manitoba, vegetable growers have reported weeding costs in carrots and onions exceeding $100.00 per acre. Owing to the shortage and high costs of skilled labor, and the inadequacy of the commonly known herbicides to meet the growers' requirements, the studies reported in this project were undertaken to find new chemical treatments which would be biologically and economically more desirable.

In 1962, the main emphasis was placed on screening new herbicides and comparing their performance with the standard herbicides already in use. Projects were conducted on four important crops, namely, carrots, celery, onions, and white beans. Herbicidal rates, formulations, and time of application were evaluated. These trials were repeated in 1963 and supplemented with a series of cost study trials comparing chemical

and mechanical control methods in carrots and onions. Varying environmental conditions were chosen for the purpose of evaluating the weed control efficiency of the new herbicides and the tolerance of the crop on which they were tested.

CHAPTER II

REVIEW OF LITERATURE

Weed Control in Carrots. Chemical weed control in carrots began during the early 1940's with the discovery of selective petroleum oils. Due to the wartime shortage of hand labor, herbicidal oil sprays saved many thousands of acres of carrots from abandonment (13).

The selectivity of herbicidal oils is based on gravity, boiling point, viscosity and aromatic content. In order for a petroleum oil to be selective in carrots the gravity reading should be above 38 degrees A.P.I. (American Petroleum Institute) (9), having a boiling point between 300° and 400° F. (12, 15, 69) and have a viscosity reading of 50 seconds or less (9). The aromatic hydrocarbons are the most phytotoxic of the hydrocarbon groups found in petroleum oils, followed by the unsaturated paraffins and then the saturated paraffin group (9). It has been demonstrated that these petroleum oils should be applied when the weeds are approximately two inches in height for the most efficient control (37, 70). Oils applied at 80 to 100 gallons per acre have given excellent weed control without injury to carrots, parsnips, asparagus or dill. (3, 36, 70) Nylund (44) found that carrots harvested thirty-nine days after spraying with Stoddard solvent had off flavors but not when the carrots were harvested fifty-two days after spraying. Subsequent reports verified that petroleum oils of the Stoddard solvent type were the most effective for weed

control in carrots (10, 14, 28, 36, 37, 51, 68, 69). However, Beatty (5) reported that growers, though widely using the light aromatic oils, would prefer a herbicide less bulky in weight, less expensive and one providing a longer lasting control of weeds. Petroleum oils are contact herbicides and give no residual weed control (16).

Considerable research has also been carried out with other herbicides, some of which have shown considerable promise for weed control in carrots. This group includes 3 amino-2, 5-dichlorobenzoic acid (amiben), 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea (linuron), a,a,a-trifluoro-2, 6-dinitro-N, N dipropyl-p-toluidine (trifluralin), N-(3 chloro-4-methylphenyl)-2-methylpentanamide (solan), and isopropyl N-(3-chlorophenyl)-carbamate (CIPC) (26, 55, 56, 57, 59). These chemicals have shown promising results in carrots in other areas but the effectiveness of these herbicides has not been fully investigated under Manitoba conditions.

Weed Control in Celery. A limited amount of research has been carried out on chemical weed control in celery. Herbicidal oils have been used to a limited extent but with variable results. Application to celery fourteen days after transplanting controlled weeds without causing any abnormalities or yield reduction but application twenty-eight days after transplanting severely reduced yields (34, 55). In other tests, 2 methyl-4-chlorophenoxybutyric acid (MCPB) gave appreciable weed control and did not damage the celery or reduce yields but the herbicide did not control purslane (Portulaca oleracea) or

chickweed (Stellaria media) (54, 57, 58).

Guzman (30) tested 2-chloro-N, N-diallyl-acetamide (CDAA), 2 chloroallyl diethyldithio carbamate (CDEC) and a mixture of CIPC and CDEC on celary planted in organic soils. When the treatments were applied over-all and were followed by irrigation, CDAA at eight pounds per acre, CDEC at four pounds per acre, and CIPC at four pounds per acre plus CDEC at four pounds per acre gave excellent weed control.

In other experiments solan has efficiently controlled weeds in this crop without reducing yields (25, 26, 57). This appears to be the most promising herbicide in celery. Prior to 1962 none of these herbicides had been tested on celery under Manitoba conditions.

Weed Control in Onions. Two of the earliest chemicals to be tested for weed control in onions were iron sulphate and sulfuric acid. The action of the salt was greatly affected by relative humidity. Under conditions where less than 100 per cent humidity existed the salt crystallized on the leaves and caused no damage to the weeds. The acid was markedly affected by temperature; under cool conditions, e.g. at 6°C., it took five times as long to act as at 30°C. (4). Grasses (Gramineae spp.), purslane (Portulaca oleracea), and lamb's quarters (Chenopodium album) were shown to be tolerant to sulfuric acid (43). Warren and Ellis (73) reported in 1950 that the difficulties in handling sulfuric acid and the lack of control of some of the common weeds limited its use.

The next group of chemicals to be tested on onions were potassium cyanate (KOCN) and calcium cyanamide. It was found that KOCN was most

effective when applied after the weeds had emerged but were in the early seedling stage (33). It was found, however, that this treatment as a one per cent solution applied at 100 gallons per acre could injure onions and a side spray application was recommended (39). Calcium cyanamide was reported to be an effective pre-emergence treatment at 75 to 150 pounds per acre (33). The research reports of regional weed control conferences have reported that KOCN and cyanamide dust gave weed control results ranging from poor to excellent (1, 8, 25, 26, 34, 35, 41, 45, 46, 54, 55, 56, 75). Onion tip burn damage was noted in some of the reports with both treatments (25, 75). These chemicals require several re-treatments during the growing season to obtain efficient weed control. The growers desire a herbicide that is easy to handle and requires only one, or, at the most, two applications for efficient weed control.

CIPC was first reported in the research reports of regional weed conferences in the early 1950's as giving good weed control in onion sets and seeded onions (2, 29, 31, 38, 40, 45, 62, 74, 77). The action of CIPC appears to depend on soil type. Blouch and Fults (6) reported that CIPC gave excellent selective control of annual grasses (Gramineae spp.) without crop injury on Fort Collins loam, a medium textured soil, relatively high in organic matter, nitrate and phosphate. Non-selective phytotoxicity resulted, however, when the same rates were applied to Valentine loamy fine sand and Terry silty clay loam. Both of these soils were deficient in organic matter and low in fertility and it was believed that a substantial portion of the herbicide had

been absorbed on the organic colloids.

CDAA was first tested in 1954 for weed control in vegetable crops. Gantz and Slife (27) found that residual properties of CDAA in the soil depended on temperature, soil moisture, and soil type. Very little breakdown of CDAA was found to occur at 40° to 60° F. regardless of soil moisture conditions. Furthermore, CDAA did not leach as badly in silt or high organic matter soils as in sandy or light soils. The volatility of CDAA depended on the soil moisture with volatility increasing when soil moisture increased and decreasing when soil moisture decreased (17).

Other research reports indicate that CIPC, at six to eight pounds per acre, and CDAA, at four pounds per acre, will give excellent weed control for approximately one month following application (1, 24, 26, 34, 54, 55, 56, 57, 58, 59). These reports have recommended that a mixture of CDAA at four to five pounds per acre plus CIPC at four to six pounds per acre would possibly give better results than the use of either herbicide alone (25, 26, 59, 60). Since 1956 the herbicides widely used in onions in North America, according to Beatty (5), are CDAA and CIPC. These two chemicals had not been fully recommended for use in onions in Manitoba in 1962. Further testing was required to obtain this recommendation.

Weed Control in White Beans. The selective weed control properties of the dinitro phenol herbicides in legumes and vegetable crops were discovered in the 1940's. Several research workers have demonstrated that dinitro-o-secondary butyl phenol (DNBP) at three to

six pounds per acre has given efficient weed control in large seeded legumes such as peas, runner, dwarf French, and climbing French beans (52, 71, 72). Where heavy rain followed treatment, growth retardation and yield reduction occurred. This herbicide, however, does not control annual grasses (Gramineae spp.) (53). Also, it requires high temperature and relative humidity for maximum efficiency. These conditions do not occur very often during the early growing season in Manitoba.

Other herbicides tested in legumes have been sodium pentachlorophenol (PCP) and CDAA. The herbicide PCP applied pre-emergence gave greater control of weeds and higher yields than CDAA in one test (49). Where PCP was used over-all only one cultivation was required during the growing season to obtain maximum yield. In another test a mixture of CDAA and DNBP gave excellent control of annual weeds in soy beans. Some varieties of soy beans showed injury symptoms that were attributed to CDAA but this was not permanent at the rates used (32). In tests conducted at the University of Manitoba (unpublished) PCP has not given efficient control of weeds under Manitoba conditions.

The most promising chemical to be tested in large seeded legumes is amiben. Staniforth et al (67) found that amiben treatments were an adequate substitute for rotary hoeing in 1961 and superior to rotary hoeing in 1960 and 1962. Burnside and Lipke (7) demonstrated that amiben could provide weed control at the rate of one pound per acre provided rainfall followed within three or four days of application.

They found that as the proportion of amiben increased less water was required for optimum weed control. Wild mustard (Brassica campestris) was somewhat resistant to amiben in these tests.

The persistence of amiben in soil appears to be influenced by soil type. Rauser and Switzer (50) found that loss of amiben activity was most rapid in sandy soil, less rapid in clay soil, and least rapid in a high organic matter soil. These differences were apparently related to leaching. Sheets (63) found that amiben could be photo-inactivated but this could not be demonstrated to occur on soil surfaces.

Many brief abstracts dealing with various chemical weed control studies have been published. The herbicides amiben, up to four pounds per acre, trifluralin, up to four pounds per acre, and linuron, up to two pounds per acre have been reported to give excellent control of weeds in white beans (18, 19, 20, 21, 22, 23, 24, 61). Linuron, however, has been reported to seriously reduce the yield of white beans at rates as low as one pound per acre (18, 22, 61).

Many competition studies between weeds and vegetable crops have been reported. The seriousness of weed competition depends on the weed population, duration of competition, relative time of crop and weed emergence, and year to year variations in seasonal rainfall (42). Staniforth and Weber (65, 66, 76) found that yield reductions due to weeds were approximately ten per cent of weed free beans when weeds were present during the entire season. Stahler (64) reported that the light intensity at ground level in soybeans is reduced ninety per cent

or more by shade. Pavlychenko (48) indicated that reduced light affects the root: top ratio.

The control of weeds is important in obtaining maximum yields in vegetable crops. Herbicides which have provided effective weed control in other areas had not been adequately tested under Manitoba conditions prior to 1962.

CHAPTER III

MATERIALS AND METHODS

The experiments described in this report will be discussed under the following headings:

I. Weed Control in Carrots

II. Weed Control in Transplanted Celery

III. Weed Control in Onions

IV. Weed Control in White Beans

I. WEED CONTROL IN CARROTS

Six separate experiments were conducted on this crop, all located in the Portage la Prairie area. Three experiments were designed to evaluate new and promising herbicides for selective weed control; two of which were conducted in 1962 and one in 1963. In one experiment in 1962, a comparison was made between single and repeated applications of several herbicides. Two experiments carried out in 1963 were designed to study the comparative costs of chemical versus mechanical weed control methods. Because of their dissimilarity these three projects will be discussed separately.

Herbicidal Evaluation Trials. The purpose of these experiments was to evaluate eight herbicides for selective weed control in carrots grown under different soil conditions. The two experiments in 1962 were conducted on a sandy soil and a silty loam soil and are designated as location (1) and location (2), respectively. In 1963, the experiment,

designated as location (3), was located on a silty loam soil.

In 1962, the crops were sown on May 18 at location (1), and on May 26 at location (2). Pre-emergence treatments were applied on May 28 and June 6 for the two locations respectively. Post-emergence treatments were applied on June 21 and July 10 respectively. At location (3) the crop was planted on May 28, pre-emergence treatments were applied on June 3, Varsol treatments on June 18, and the post-emergence treatments on July 3. Individual plots consisted of four rows, thirty feet long and the rows were spaced fifteen inches apart. The experimental design in 1962 was a randomized block design and in 1963 a split plot design. Treatments were replicated four times in all experiments. In 1963, one-half of each plot was kept weed free by hand weeding even though the entire plot was chemically treated. The time required to weed each half plot was recorded.

The weed infestation at location (1) was very heavy and consisted of green foxtail, wild buckwheat, perennial sow thistle, wild mustard, thyme-leaf spurge and prostrate pigweed. At location (2) the weed infestation was light to moderate and consisted of wild oats, wild mustard and green foxtail. All weeds in this experiment were hand pulled on July 30. The weed infestation at location (3) was extremely heavy with wild mustard, green foxtail, wild oats, wild buckwheat, and lamb's quarters being predominant. The scientific name of these weeds is presented in Appendix 25.

Due to the very heavy weed growth at location (1), the carrot crop was literally smothered by the weeds and yields were not obtained

in this experiment.

Single and Repeated Application of Herbicides. This experiment (location (4)) was located on a sandy soil to determine if repeated applications of highly soluble herbicides would provide effective weed control throughout the duration of the growing season.

The effectiveness of four herbicides were compared in this experiment. Three herbicides, 3 amino-2, 5-dichlorobenzoic acid (amiben), isopropyl-N-(3-chlorophenyl)carbamate (CIPC) and N-(3-chlorophenyl-4-methylphenyl)-2-methylpentanamide (solan) were applied at six pounds per acre. Single applications at this rate were compared with two applications of three pounds per acre each and three applications of two pounds per acre each. A fourth chemical, 2-chloro-4-diethyl-amino-6-isopropylamino-S-triazine (ipazine) was applied at one pound per acre in the single application as compared with a double application of one pound per acre each time and a triple application with one pound per acre being applied the first time and a half-pound per acre being applied the second and third times.

The crop was sown on May 18 and pre-emergence treatments were applied on June 4, with the exception of solan which was applied on June 6. The first post-emergence treatments were applied on June 19 and the second on July 10. Individual plots consisted of four rows, spaced fifteen inches apart, and thirty feet long. The treatments were replicated four times in a randomized block design. The weed infestation in the experimental area was extremely heavy and consisted

of green foxtail, wild buckwheat, perennial sow thistle, red root pigweed, wild mustard, thyme-leaf spurge, and prostrate pigweed.

The solan and amiben plots were wheel-hoed on July 19. Carrot yields were recorded in September. The carrots were suppressed by the heavy weed infestation in the ipazine, CIPC and weedy check plots, and yields from these treatments were not recorded.

Cost Comparison between Chemical and Mechanical Weed Control Methods. Four recently introduced herbicides were compared with varsol on two silty loam soils designated as location (5) and location (6). Weed control efficiency by chemical and mechanical methods and the costs of each method were compared.

The crop was sown on May 8 at location (5) and on May 24 at location (6). Pre-emergence treatments were applied on May 16 at location 5 and the pre-emergence treatments and varsol were applied on June 3 at location (6). At location (5) the varsol treatments were applied on June 7; the solan post-emergence treatments and varsol on the solan pre-emergence treatments were applied on June 18; varsol was again applied on varsol treated plots on July 3. At location (6) solan post-emergence treatments, varsol on varsol treated plots and varsol on solan pre-emergence treated plots were applied on June 25.

In these two experiments individual plots consisted of four rows, spaced fifteen inches apart, and thirty feet long. Treatments were replicated four times in a split plot design. The entire plot was treated and one-half of each plot was hand-weeded. All chemical treatments were weeded twice during the growing season and the hand-weeded

check plots were weeded three times. The time required for each hand weeding was recorded and used in cost study determinations. Inter-row cultivations with a wheel-hoe were carried out several times during the season to simulate natural production practices.

There was a very heavy weed infestation at location (5) consisting of green foxtail, wild oats, wild mustard, wild buckwheat, perennial sow thistle, common lamb's quarters and Canada thistle. At location (6) the weed infestation was also heavy and the main weed species were green foxtail, red root pigweed, wild mustard, wild oats, perennial sow thistle and field horsetail.

II. WEED CONTROL IN TRANSPLANTED CELERY

In 1962, a herbicide evaluation trial was conducted in transplanted celery near Charleswood, Manitoba. Two experiments, designed to compare timing and rates of application of solan, were conducted in celery in 1963, with one located near Portage la Prairie and the other in the St. Vital area.

Herbicidal Evaluation Trials. Since no previous herbicidal tests had been conducted in this crop in Manitoba an evaluation trial was carried out in 1962 to compare four commercially available herbicides for effectiveness and safety. In 1963, the chemical solan was evaluated for efficiency of weed control and crop tolerance. The chemical was applied at varying rates and at varying dates following the transplanting of celery in the field.

The 1962 experiment was located on an Osborne clay soil and is

designated as location (1). The 1963 experiments were located on a silty loam and a heavy clay loam designated as locations (2) and (3) respectively. The crop was transplanted to the field on June 25, June 11, and June 14 at locations (1), (2), and (3) respectively. At location (1) herbicides available in liquid form were applied fourteen days after transplanting. Thirty-five days after transplanting the plots were hand weeded and the granular treatments were applied. At locations (2) and (3), solan was applied at two pounds and four pounds per acre seven days after transplanting, at four pounds per acre fourteen days after transplanting and at six and eight pounds per acre twenty days after transplanting. Amiben was applied at four pounds per acre seven days after transplanting.

The weed infestation at location (1) was moderately heavy but consisted of purslane only. At location (2) the weed infestation was moderately heavy, the main weed species consisting of green foxtail, wild mustard, Canada thistle, common lamb's quarters and red root pigweed. The weed infestation at location (3) was heavy, consisting of purslane, red root pigweed, knotweed, giant ragweed, and barnyard grass.

In 1962, the treatments were replicated twice in a randomized block design; in 1963 the treatments were replicated four times in a randomized block design. The plots consisted of four rows, spaced one foot apart and twelve feet long.

III. WEED CONTROL IN ONIONS

Four trials were conducted on onions in 1962 and 1963. In 1962, an experiment designed to compare granular and liquid formulations was located in the Fort Garry area. Two duplicate experiments in onions were conducted in 1963, one located near Portage la Prairie and the other at Fort Garry. These were designed to compare chemical and mechanical weed control methods. A herbicide screening trial located near Vivian, Manitoba, was designed to evaluate herbicides for weed control in onions grown on organic soils.

Studies on Herbicidal Efficiency and Cost Comparisons in Onions. Two chemicals, CDAA and CIPC, are the herbicides most commonly used in onions. Injury to the crop by both chemicals has been reported. In 1962, a study was undertaken to evaluate granular and liquid formulations for weed control and crop tolerance. By 1963, a new chemical DCPA was shown to be a selective herbicide for weed control in onions. A trial was duplicated at two locations to evaluate mixtures of the three chemicals CIPC, CDAA, and DCPA, for weed control and crop tolerance; also a study on the cost of chemical and mechanical weed control was undertaken at one location.

The experiments were located on an Osborne clay soil, designated as location (1) (the 1962 experiment), a clay loam soil, designated as location (2) (the 1963 experiment located at Fort Garry), and a sandy loam soil, designated as location (3) (the 1963 experiment located at Portage la Prairie). The crop was sown on May 27, May 3, and May 6

at locations (1), (2), and (3) respectively. The pre-emergence treatments were applied on June 9 and the post-emergence treatments June 29 at location (1). At locations (2) and (3), the first pre-emergence treatments were applied on May 6 and on May 8, the second on May 15 and on May 16, and the third on May 22 and on May 23 respectively. The post-emergence treatments were applied on July 15 and July 18 at locations (2) and (3) respectively.

The plots consisted of four rows spaced fifteen inches apart and were thirty feet in length. Treatments were replicated four times in a randomized block design at location (1), and in a split plot design at locations (2) and (3).

At location (3), the entire plot was chemically treated and one-half of the plot was kept weed-free by hand weeding. No inter-row cultivation was carried out. The time required to weed each half plot was recorded.

The weed densities at locations (1), (2), and (3) were medium, heavy and light respectively. The main weed species were red root pigweed, purslane, annual spurge, and small seedling maples at location (1); wild mustard, wild buckwheat, prostrate pigweed, green smartweed, and common mallow at location (2); and green foxtail, wild oats, field pennycress, red root pigweed, common lamb's quarters, and wild buckwheat at location (3).

Due to a severe hail storm at location (1) and losses from onion maggots and drought at location (2), yield determinations were not taken in these experiments.

Evaluation of Herbicides in Onions Grown on Organic Soil. Organic soils are being developed for the commercial production of vegetable crops in Manitoba. An experiment was designed in 1963 to evaluate five herbicides for weed control efficiency on this soil type. Also crop tolerance to the herbicides was compared on two common varieties.

The crop was sown on June 5, all pre-emergence treatments were applied on June 19 and the post-emergence treatments on July 9. Individual plots consisted of four rows spaced one foot apart and the row length was fifteen feet. Treatments were replicated four times in a randomized block design. One half of each plot was seeded to the variety Autumn Spice and the other half to the variety Aristocrat.

The main weed species at this location were bienniel wormwood, common lamb's quarters, perennial sow thistle, maple-leaved goosefoot, strawberry blight and rough cinquefoil. The weed infestation in the experimental area was medium to heavy.

Yield determinations in the onion crop were recorded in September. The two centre rows (one row from each variety) from each plot for a length of ten feet were dug, topped, and weighed in the field.

IV. WEED CONTROL IN WHITE BEANS

A total of five experiments were conducted in this crop in 1962 and 1963. Three experiments were designed as herbicide evaluation trials, two of which were conducted in 1962 with one being located

near Portage la Prairie and the other near Morden; the third, carried out in 1963, was located near Morden. In 1963, two duplicate trials were conducted to compare five promising pre-emergence herbicides in this crop. One of these was located near Portage la Prairie and the other near Morden. Since there was no similarity between the two types of experiments, they will be discussed under separate headings.

Herbicidal Evaluation Trials. Since very little previous work had been conducted in white beans in Manitoba, three herbicidal evaluation trials were designed to compare twelve herbicides for weed control efficiency and crop tolerance. Two were conducted in 1962 and one in 1963.

These experiments were located on a clay loam soil designated as location (1) (Portage la Prairie, 1962) and a sandy loam designated as location (2) (Morden, 1962) and location (3) (Morden, 1963). The crop was sown on June 5 at locations (1) and (2) and on June 13 at location (3). Pre-planting treatments were applied on June 4 at location (1). Pre-emergence treatments were applied on June 8, June 11, and June 17, at locations (1), (2), and (3) respectively. The post-emergence treatments were applied on June 20 at locations (1) and (2).

Plots consisted of three rows spaced twenty-eight inches apart at location (1) and twenty-four inches apart at location (2). The rows were thirty feet long. At location (3) the plots consisted of two rows with a twenty-four inch spacing between the rows and the

length of row was fifteen feet. The treatments were replicated four times in a randomized block design at all three locations.

The weed densities were heavy, light to medium, and light at locations (1), (2), and (3) respectively. The main weed species at location (1) were green foxtail, perennial sow thistle, red root pigweed, and field bindweed; at location (2) they were green foxtail, wild mustard, common lamb's quarters, wild buckwheat, and Russian thistle; and at location (3) they were common lamb's quarters, green foxtail, Russian thistle, knotweed and wild mustard.

Inter-row cultivation, using a wheel-hoe, was carried out in July at all three locations.

Pre-emergence Herbicide Trials. Four herbicides were shown to be efficient weed killers in 1962. These herbicides were therefore evaluated further in 1963. The experiments were located on a silty loam soil designated as location (4) (near Portage la Prairie) and a sandy loam designated as location (5) (near Morden). The plots consisted of two rows spaced twenty-eight inches apart at location (4) and twenty-four inches apart at location (5). The rows were thirty feet in length. The entire plots were treated and half of each plot was kept weed free by wheel hoeing to simulate mechanical weeding. The treatments were replicated four times in a split-plot design.

At location (4) the crop was sown on May 29; at location (5) on June 13. Amiben treatments were applied on June 3 at location (4) and all other treatments on June 7. All pre-emergence treatments at location (5) were applied on June 17.

Weed density was high at location (4); it consisted of Canada thistle, green foxtail, field pennycress, wild oats, and wild mustard. At location (5) the density was light, consisting of common lamb's quarters, wild mustard, green foxtail, knotweed, and Russian thistle.

ASSESSMENT OF RESULTS

Weed control and crop injury ratings were recorded at one or two intervals following the herbicidal treatments. Ratings were based on a 0-10 scoring system (0 - no control or injury: 10 - complete control).

All crop yield determinations were made in September. Carrot and onion yields were recorded on the basis of harvesting the two centre rows from each plot for a distance of ten feet. The carrots and onions were dug, topped and weighed in the field. Celery yields were recorded on the basis of twenty plants per plot in 1962 and ten plants per plot in 1963. The celery plants were cut, trimmed, and weighed in the field. White bean yields were taken on the basis of one row, ten feet long per plot in 1962, and two rows, ten feet long per plot in 1963. The white bean plants were hand pulled, bagged, dried, threshed, cleaned, and weighed.

SPRAYING TECHNIQUES

In 1962, herbicides were applied with a small plot sprayer delivering 5.5 gallons of total solution per acre at 45 psi. In 1963, the herbicides were applied in a total of 30 gallons total solution

per acre under 50 psi. Granular herbicides were applied with a Gandy spreader which was adapted to deliver two 14 inch bands. The liquid sprayer and granular applicator shown in Figures (1) and (2) were designed by the University of Manitoba, particularly for this project.

CLIMATIC CONDITIONS

Meteorological data was recorded at most of the locations at which experiments were carried out, namely, Portage la Prairie, Morden, Winnipeg international Airport, and at the University of Manitoba, Fort Garry. Data are presented in Appendix 1 - 4.

The 1962 growing season in eastern Manitoba was one of the coolest and wettest on record. Temperatures were well below normal for all months with the exception of June which was above normal. Total precipitation from May 1 to August 1 at Winnipeg International Airport was 21.55 inches, an all time high.

Temperatures during the 1963 growing season were below normal for the month of May, but well above normal for the balance of the growing season. Precipitation was heavy during May and June but inadequate during late July and August to maintain normal growth without supplementary irrigation.

Figure 1. Small plot precision sprayer designed by the University of Manitoba for plot work of the type reported in this thesis.

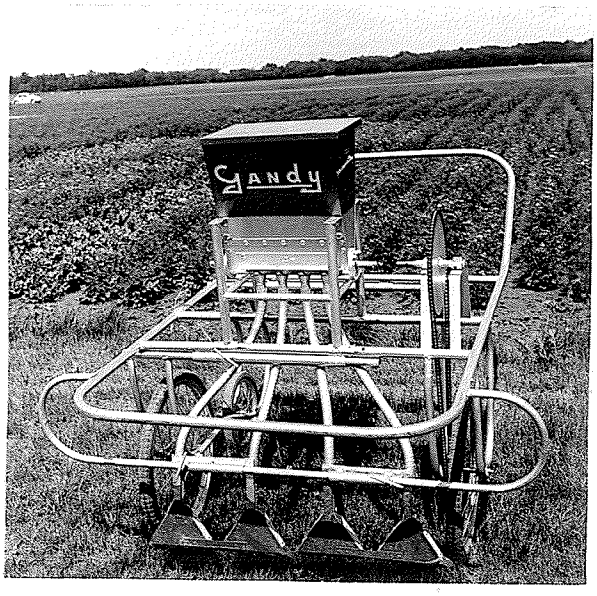

Figure 2. Small plot Gandy granular applicator adapted by the University of Manitoba for plot work of the type reported in this thesis.

CHAPTER IV

RESULTS AND DISCUSSION

I. WEED CONTROL IN CARROTS

Herbicidal Evaluation Trials. These experiments were designed to evaluate five herbicides for weed control in carrots and were carried out at three locations. In 1962, at location (1) (Portage la Prairie) none of the herbicides evaluated provided weed control that could be considered commercially acceptable. Weed competition at this location was so great that the crop was entirely suppressed and yield determinations were not recorded.

At the second location in 1962 (Portage la Prairie) only three treatments provided reasonably effective weed control and satisfactory carrot yields. These were mixtures of amiben and CIPC, amiben and solan, and amiben and ipazine, applied pre-emergence. Amiben alone was slightly less effective than the above mixtures. All other treatments were relatively ineffective. Data for these two locations are presented in Table I. The three most effective treatments at location (2) resulted in carrot yields that were equal to the weed free check.

In 1963, only six herbicidal treatments were included. Amiben granular, amiben liquid, and varsol gave outstanding weed control. However, the varsol treatment gave temporary weed control only and considerable hand weeding was necessary to provide satisfactory yields. Other treatments were relatively ineffective from the standpoint of weed control and, unless followed by hand weeding, crop yields were

very low. Data are presented in Table II. No observable herbicidal damage to the crop resulted from any of the treatments at the three locations.

In the Tables alphabetical letters are used to denote significant differences in treatment yields. For example, (a) is significantly different from (b) but neither are significantly different from (ab).

Single and Repeated Applications of Herbicides. This experiment was designed to evaluate single and repeated applications of herbicides for weed control in carrots. The experiment was conducted on a sandy soil near Portage la Prairie. Pertinent data for this experiment are presented in Table III.

All amiben treatments gave good season long control of weeds and resulted in yields equal to those in the weed free check plots. Solan treatments gave good immediate control, but did not suppress regrowth of green foxtail. Competition from this weed from July to harvest time resulted in a considerable reduction in carrot yields in plots receiving only one or two solan treatments. With three applications of solan at two pounds per acre each time control of weeds was adequate, the resulting yield of carrots being equal to that of the weed free check. The chemicals CIPC and ipazine did not give satisfactory weed control and by mid-July the severe weed competition had eliminated the stand of carrots. No herbicidal damage to the crop was observed in this test. The analysis of variance test (Appendix 6) was conducted only on those treatments where crop yield was obtained.

TABLE I

HERBICIDAL EVALUATION TRIAL IN CARROTS, PORTAGE LA PRAIRIE, 1962
LOCATION 1 AND LOCATION 2

Treatment Herbicide and Rate	Type of Application (1)	Weed Control Rating (0-10) (Loc.1)	Weed Control Rating (0-10) (Loc.2)	Yield of Carrots (Ton per acre) (Loc.2)	
Weed free check	-	10.0	10.0	21.78	a L2
Amiben 4 lb./A + CIPC 4 lb./A	pre-emergence	5.0	5.3	17.65	a b
Amiben 4 lb./A + solan 4 lb./A	"	4.3	7.9	17.49	a b
Amiben 4 lb./A + ipazine 1 lb./A	"	3.4	6.5	15.90	a b c
Amiben 4 lb./A	"	3.3	4.6	14.37	b c d
Solan 4 lb./A + ipazine 1 lb./A	"	1.3	5.0	12.70	b c d
Solan 4 lb./A + CIPC 4 lb./A	"	2.6	4.9	12.04	b c d
CIPC 4 lb./A + ipazine 1 lb./A	"	1.7	3.0	10.67	b c d
Solan 4 lb./A	"	0.6	4.5	10.56	b c d
CIPC 4 lb./A	"	0.9	1.5	8.67	c d
Ipazine 1 lb./A	"	0.4	1.9	8.12	d
Solan 2 lb./A	post-emergence	1.1	0.3	8.23	d
Solan 2 lb./A + CIPC 4 lb./A	"	1.3	0.8	7.84	d
Stoddard solvent 80 gpa.	"	3.8	0.0	7.36	d
CIPC 4 lb./A	"	0.8	0.3	7.30	d
Amiben 2 lb./A + CIPC 4 lb./A	"	4.6	0.0	7.25	d
Ipazine 1 lb./A	"	1.3	0.0	7.19	d
Solan 2 lb./A + amiben 2 lb./A	"	3.8	0.0	6.86	d
Weedy check	-	0.0	0.0	6.71	d
Amiben 2 lb./A	post-emergence	2.5	0.0	6.60	d
Amiben 2 lb./A + ipazine 1 lb./A	"	3.3	0.0	6.53	d
CIPC 4 lb./A + ipazine 1 lb./A	"	1.0	0.0	6.12	d

(1) Pre-emergence -- crops and weeds not emerged at location 1; crops not emerged and weeds in seedling stage at location 2. Post-emergence -- crops and weeds 2 to 6 inches high at location 1, and 3 to 9 inches high at location 2.

(2) Significantly different groups as determined by the Student-Newman-Keul multiple range test.

TABLE II

HERBICIDAL EVALUATION TRIAL IN CARROTS, PORTAGE LA PRAIRIE, 1963

Treatment Herbicide and Rate	Application Date	Weed Control Rating (0-10)	YIELD OF CARROTS	
			Chemical treatments only (Ton /A)	Chemical treatments + hand weeding (Ton /A)
Weed free check -	-	10.0	10.32 b c L2	11.79 a L2
Amiben granular 4 lb./A	June 3 L1	9.7	15.71 a	15.02 a
Amiben liquid 4 lb./A	June 3	9.7	13.61 a b	16.01 a
Varsol 30 gpa	June 18 L1	8.9	7.82 c	14.37 a
Afalon-aresin 1 lb./A	June 3	4.0	2.12 d	13.40 a
Tenoran 2 lb./A	June 3	2.1	2.09 d	12.40 a
H-8043 4 lb./A	July 3 L1	4.9	0.78 d	6.62 b
Weedy check -	-	0.0	0.0 d	0.0 c

L1 June 3 -- pre-emergence to weeds and crop; June 18 -- weeds and crop were in seedling stage.
July 3 -- weeds and crop were 2 to 4 inches in height.

L2 Significantly different groups as determined by the Student-Newman-Keul multiple range test.

TABLE III

SINGLE AND REPEATED APPLICATIONS OF HERBICIDES IN CARROTS,
PORTAGE LA PRAIRIE, 1962

Herbicide	TREATMENT Date 1 L2 (lb./A)	Date 2 L2 (lb./A)	Date 3 L2 (lb./A)	Weed Control Rating (0-10)	Yield of Carrots (Ton/A)
Weed free check	-	-	-	10.0	21.49 a L1
Amiben	3	3	0	8.1	21.78 a
Solan	2	2	2	7.0	20.12 a
Amiben	2	2	2	7.5	18.92 a b
Amiben	6	0	0	7.7	18.15 a b
Solan	6	0	0	6.0	14.51 b c
Solan	3	3	0	7.4	11.96 c
CIPC	6	0	0	3.0	0.0
CIPC	3	3	0	1.1	0.0
CIPC	2	2	2	0.3	0.0
Ipazine	1	0	0	0.3	0.0
Ipazine	1	1	0	0.3	0.0
Ipazine	1	½	½	0.5	0.0
Weedy check	-	-	-	0.0	0.0

L1 Significantly different groups as determined by the Student-Newman-Keul multiple range test.

L2 Date 1 -- June 4 (June 6 for solan treatments)-- pre-emergence to crop and weeds.
Date 2 -- June 19 -- carrots in the two leaf stage, weeds mostly in the three to five leaf stage.
Date 3 -- July 10 -- carrots in the six leaf stage, weeds in the five to ten leaf stage in check plots.

Cost Comparison between Chemical and Mechanical Weed Control Methods. This experiment (conducted at two locations) was designed to evaluate five herbicides, amiben, solan, linuron, varsol and trifluralin for weed control in carrots and to compare the costs of chemical versus mechanical weed control methods. Results obtained from these experiments are presented in Tables IV and V.

All chemical treatments gave good control of weeds at both locations with the exception of the trifluralin treatment at location (5). The linuron treatment at location (5) while giving good immediate control did not check regrowths of green foxtail as seen in Figure 6. The cost of removing the uncontrolled green foxtail at this location greatly increased the weeding costs of this treatment. Causes of the reduced yield in the solan treatment at location 6 are not known but it is unlikely that this was due to herbicidal damage.

Averaging the data for both locations, the total costs for chemical control of weeds was approximately $58.60 per acre while the average cost of hand weeding the weed free check was $153.00 (for approximate chemical costs see Appendix 24). Chemical treatments greatly reduced the man hours and in turn the costs involved in clearing the plots of weeds as compared to the costs of weeding the checks. A figure of $0.75 per hour for hand weeding has been used in this thesis which may be a bit low for Manitoba but if a larger figure is more realistic this would only tend to increase the cost difference between mechanical and chemical, and mechanical weeding. The results

of the varsol, solan and amiben treatments at location (5) are illustrated in Figures 3, 4, and 5.

TABLE IV

COST COMPARISONS BETWEEN CHEMICAL AND MECHANICAL WEED CONTROL METHODS IN CARROTS, PORTAGE LA PRAIRIE, 1963 (LOCATION 5)

Treatments Herbicide Rate and Application Date L2	Weed Control Rating (0-10)	Approximate Weed Control Costs			Yield of Carrots (Ton/A)
		Hand Weeding ($/A) L3	Chemical Treatments ($/A)	Total ($/A)	
Weed free check.	10.0	$132.73	-	$132.73	21.24 a L1
Solan 3 lb./A May 16, repeated June 18	8.5	25.63	$33.84	59.47	24.35 a
Trifluralin 4 lb./A May 16	5.5	41.24	32.52	73.76	23.16 a
Linuron 2 lb./A May 16	7.7	76.58	12.40	88.98	22.81 a
Amiben 3 lb./A May 16	8.0	25.92	16.60	42.52	22.30 a
Solan 2 lb./A May 16 plus varsol 60 gpa June 18	7.8	25.12	35.28	60.41	18.45 a
Varsol 60 gpa June 7, repeated July 13	8.8	10.89	48.00	58.89	17.67 a
Weedy check.	0.0	-	-	-	4.38 b

L1 Significantly different groups as determined by the Student-Newman-Keul multiple range test.

L2 May 16 -- pre-emergence to crop and most weeds, wild oats one inch high.
June 7 -- pre-emergence to crop, weeds two to three inches high.
June 18 -- crop and weeds two to five inches high.
July 13 -- crop and weeds two to eight inches high.

L3 Cost based on $0.75 per hour for labor.

TABLE V

COST COMPARISONS BETWEEN CHEMICAL AND MECHANICAL WEED CONTROL METHODS IN CARROTS, PORTAGE LA PRAIRIE, 1963 (LOCATION 6)

Treatment Herbicide Rate and Application Date L2	Weed Control Rating (0-10)	Approximate Weed Control Costs			Yield of Carrots (Ton/A)	
		Hand Weeding ($/A) L3	Chemical Treatments ($/A)	Total ($/A)		
Weed free check.	10.0	$174.02	-	$174.02	17.03 a	L1
Solan 3 lb/A June 3, repeated June 25	7.9	27.59	$33.84	61.43	11.98 b	
Trifluralin 4 lb/A June 3	8.4	19.31	32.52	51.83	18.34 a	
Linuron 2 lb/A June 3	8.5	29.26	12.40	41.66	16.97 a	
Amiben 3 lb/A June 3	8.5	27.58	16.60	44.18	17.84 a	
Solan 2 lb/A June 3, plus varsol. . 60 gpa June 25	9.0	25.63	35.28	60.91	16.62 a	
Varsol 30 gpa June 3, plus 60 gpa June 25	9.2	21.50	36.00	57.50	17.71 a	
Weedy check.	0.0	-	-	-	6.62	c

L1 Significantly different groups as determined by the Student-Newman-Keul multiple range test.

L2 June 3 -- Pre-emergence to the crop, weeds one to two inches in height.
June 25 -- Crop and weeds two to eight inches in height.

L3 Cost based on $0.75 per hour for labor.

Figure 3. Varsol at 60 gallons per acre applied June 7 (post-emergence) and July 13 (post-emergence) on carrots, Portage la Prairie, 1963.

Figure 4. Solan at 3 pounds per acre applied May 16 (pre-emergence) and June 18 (post-emergence) on carrots, Portage la Prairie, 1963.

Figure 5. Amiben at 3 pounds per acre applied May 16 (pre-emergence) on carrots, Portage la Prairie, 1963.

Figure 6. Linuron at 2 pounds per acre applied May 16 (pre-emergence) on carrots, Portage la Prairie, 1963.

II. WEED CONTROL IN TRANSPLANTED CELERY

Herbicidal Evaluation Trials. The herbicide screening trial located at Charleswood (1962) was designed to evaluate four herbicides for weed control in celery. The tests at Portage la Prairie (1963) and St. Vital (1963) were designed to compare varying rates and times of application of solan in this crop. The pertinent data for these experiments are presented in Tables VI, VII, and VIII.

From the standpoint of weed control and crop yield the best treatment in these tests was solan at four pounds per acre applied two weeks after transplanting. Solan at two pounds per acre applied one week after transplanting also gave satisfactory weed control. When this was supplemented by hand and mechanical weeding, good crop yields resulted. Solan at four pounds per acre applied one week after transplanting reduced celery yields at one location. Solan at eight pounds per acre significantly reduced the yield of celery at one location. Inconclusive results were obtained from the use of amiben in that at two locations the herbicide was applied after the weeds had emerged. When amiben was applied at or just prior to weed emergence as was the case at St. Vital, good weed control was obtained.

III. WEED CONTROL IN ONIONS

Studies on Herbicidal Efficiency and Cost Comparisons. In 1962, a trial designed to compare granular and liquid formulations of two herbicides was conducted near Fort Garry. In 1963, two

TABLE VI

HERBICIDAL EVALUATION TRIALS IN TRANSPLANTED CELERY,
CHARLESWOOD, 1962

Treatment Herbicide, Rate and Application Date L2	Weed Control Rating (0-10)	Yield of Celery (Ton/A)	
Weed free check.	10.0	40.29	L1
Solan 2 lb./A July 9	5.8	39.07	
Solan 4 lb./A July 9	8.5	51.46	
Solan 2 lb./A plus amiben 2 lb./A July 9	6.5	39.20	
Amiben granular 4 lb./A July 30.	9.0	48.60	
CDEC granular 6 lb./A July 30.	9.0	40.84	
CDAA-T granular 6 lb./A July 30.	9.0	33.21	
Weedy check.	0.0	31.58	

L1 No significant difference between treatments.

L2 July 9 -- Weeds were approximately one inch in height.
July 30 -- Weeds were not emerged (removed by hand).

TABLE VII

HERBICIDAL EVALUATION TRIALS IN TRANSPLANTED CELERY,
PORTAGE LA PRAIRIE, 1963

Treatment		Weed Control Rating (0-10)	Yield of Celery (Ton/A)
Herbicide and Rate	Application Date Days after Transplanting L2		
Weed free check	-	10.0	32.53 L1
Amiben 4 lb./A	7	4.4	33.17
Solan 2 lb./A	7	5.9	33.67
Solan 4 lb./A	7	7.1	32.17
Solan 4 lb./A	14	8.8	29.57
Solan 6 lb./A	20	6.7	28.73
Solan 8 lb./A	20	7.1	28.43
Weedy check	-	0.0	28.93

L1 No significant difference between treatments.

L2 7 days after transplanting -- weeds were one to two inches in height.
14 days after transplanting -- weeds were two to five inches in height.
20 days after transplanting -- weeds were four to seven inches in height.

TABLE VIII

HERBICIDAL EVALUATION TRIALS IN TRANSPLANTED CELERY,
ST. VITAL, 1963

Treatment		Weed Control Rating (0-10)	Yield of Celery (Ton/A)	
Herbicide and Rate	Application Date Days after Transplanting L2			
Weed free check	-	10.0	32.83 a	L1
Amiben 4 lb./A	7	7.1	33.80 a	
Solan 2 lb./A	7	5.9	33.70 a	
Solan 4 lb./A	7	6.7	26.89 b	
Solan 4 lb./A	14	6.6	31.10 a	
Solan 6 lb./A	20	8.8	30.78 a	
Solan 8 lb./A	20	8.9	26.89 b	

L1 Significantly different groups as determined by the Student-Newman-Keul multiple range test.

L2 7 days after transplanting -- weeds just emerging.
14 days after transplanting -- weeds one to two inches in height.
20 days after transplanting -- weeds three to five inches in height.

TABLE IX

HERBICIDAL FORMULATIONS AND MIXTURES FOR WEED CONTROL IN ONIONS, FORT GARRY, 1962

Treatment Herbicide, rate and Application Date	Weed Control Rating (0-10)
Weed free check	10.0
CDAA liquid 6 lb./A June 9. L1.	6.6
CDAA liquid 6 lb./A June 9, repeated June 29 L1.	8.1
CDAA granular 6 lb./A June 9.	4.9
CDAA granular 6 lb./A June 9, repeated June 29.	4.2
CIPC liquid 6 lb./A June 9.	5.2
CIPC liquid 6 lb./A June 9, repeated June 29.	5.8
CIPC granular 6 lb./A June 9.	4.3
CIPC granular 6 lb./A June 9, repeated June 29.	2.8
CDAA 3 lb./A + CIPC 3 lb./A liquid June 9	6.3
CDAA 3 lb./A + CIPC 3 lb./A liquid June 9, repeated June 29	6.2
CDAA 3 lb./A + CIPC 3 lb./A granular June 9	4.3
CDAA 3 lb./A + CIPC 3 lb./A granular June 9, repeated June 29	3.3
Weedy check	0.0

L1 June 9 -- Pre-emergence to weeds and crop.
June 29 -- Crop in the 2½ leaf stage.
Weeds in the one to four leaf stage.

TABLE X

HERBICIDAL TREATMENTS AND COST COMPARISONS FOR WEED CONTROL IN ONIONS, 1963
FORT GARRY (LOCATION 1) AND PORTAGE LA PRAIRIE (LOCATION 2)

Treatment Herbicide and Rate	Weed Control Rating (0-10) (Loc.1)	(Loc.2)	Approximate weed control costs at Loc.2 Hand Weeding L3 ($/A)	Chemical Treatments ($/A)	Total ($/A)	Yield of Onions at Loc.2 (Ton/A)
Weed free check.	10.0	10.0	$157.11	-	$157.11	17.29 a L2
CIPC 4 lb/A & CDAA 4 lb/A pre-emergence L1 repeated post-emergence L1	8.8	7.8	38.91	$42.80	81.71	15.68 a
CIPC 4 lb/A & CDAA 4 lb/A pre-emergence repeated pre-emergence . . .	9.0	9.4	17.49	42.80	60.29	13.20 a
CIPC 4 lb/A & CDAA 4 lb/A pre-emergence. . .	8.3	8.7	26.87	21.40	48.27	14.57 a
CDAA 6 lb/A pre-emergence repeated post-emergence. . .	6.8	7.2	35.14	29.40	64.54	15.64 a
CDAA 6 lb/A pre-emergence repeated pre-emergence. . .	7.7	8.8	19.68	29.40	49.08	14.31 a
CDAA 6 lb/A liquid pre-emergence	6.2	8.0	25.92	14.70	40.62	15.62 a
CDAA 4 lb/A +DCPA 8 lb/A pre-emergence . . .	6.5	8.0	27.66	36.60	64.26	15.27 a
CDAA 4 lb/A +DCPA 8 lb/A pre-emergence & CDAA 4 lb/A pre-emergence.	8.3	9.5	18.44	46.40	64.84	14.24 a
CDAA 4 lb/A +DCPA 12 lb/A pre-emergence. . .	6.3	7.4	35.00	40.20	75.20	14.16 a
CDAA 6 lb/A granular pre-emergence	6.3	7.6	28.68	16.60	45.28	14.16 a
Weedy check.	0.0	0.0	-	-	-	0.0 b

L1 Pre-emergence -- Weeds and crop not emerged.
Post-emergence-- Crop four to six inches in height, weeds six to ten inches in height in check plots.

L2 Significantly different groups as determined by the Student-Newman-Keul multiple range test.

L3 Cost based on $0.75 per hour for labor.

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experiments were conducted which were designed to compare the effectiveness of several herbicidal combinations in reducing hand weeding costs in onions. Date are presented in Tables IX and X.

In 1962, liquid formulations were more effective in controlling weeds than were granular formulations. The CDAA treatments and the CDAA and CIPC treatments gave satisfactory weed control. The CIPC treatments were not as effective.

In 1963, there was no difference between the CIPC and CDAA and DCPA and CDAA mixtures applied once or twice when both treatments were mechanically or hand weeded. Both mixtures gave equal control at one location and at the other the CIPC and CDAA mixture gave the better weed control. The difference in weed control efficiency of these two mixtures is probably due to the varying soil and moisture conditions at the two locations. CDAA alone did not give efficient broad-leaved weed control and, for this reason, was inferior to the two mixtures.

The cost of weeding the hand-weeded check was $157.00 per acre. The average cost of chemical plus hand weeding was $59.40 per acre. All chemical treatments reduced weeding costs from one-half to one-quarter the amount required for the hand weeded check treatment.

A reduction of approximately ten hours was made in the number of man-hours of labor required to clean the plots of weeds by the use of these chemicals pre-emergence applied twice rather than applied once. The value of this saving would depend on the cost of

the herbicides, time available to conduct the extra weeding operations and the weather. The grower may decide that his time could be better used than in supervising weeding done by hired help or by doing it himself. Thus chemical weeding could become a time saving as well as a cost reducing device.

Figures 7, 8, 9, and 10 illustrate the results obtained at Portage la Prairie (1963) with the treatments CDAA at four pounds per acre and CIPC at four pounds per acre applied once, CDAA at four pounds per acre and DCPA at twelve pounds per acre, CDAA at four pounds per acre and CIPC at four pounds per acre applied twice pre-emergence and the weedy check. The results obtained at Fort Garry with the treatments CDAA at four pounds per acre and CIPC at four pounds per acre applied once and twice pre-emergence, CDAA granules at six pounds per acre applied once pre-emergence and the weedy check are shown in Figures 11, 12, 13, and 14.

Herbicidal Evaluation Trials on Organic Soil. In 1963, a screening trial was conducted to determine which chemicals would control weeds in onions grown on organic soils. The experiment was located near Vivian, Manitoba.

All chemicals tested provided good control of annual weeds belonging to the Chenopodiaceae family. However, no control of the biennial or perennial species of weeds resulted from any of the treatments.

The weed free check in this experiment out yielded all chemical treatments. Competition from the uncontrolled weed species

in the chemical plots reduced the yield of these plots. There was no difference between the yields of any herbicidal treatment nor was there a varietal difference in response to herbicides. Data are presented in Table XI.

IV. WEED CONTROL IN WHITE BEANS

Herbicidal Evaluation Trials. As very little weed control work has been conducted in white beans in this province two herbicide screening trials were carried out in 1962.

All herbicidal treatments gave poor weed control at Portage la Prairie. Moisture reserves at this location were low at time of application of the pre-emergence herbicides. Also, no herbicide gave any control of the perennial sow thistle which infested the entire experimental area. The herbicide trifluralin resulted in the highest yields and gave the best control of weeds of all herbicidal treatments. The weed free check out yielded all chemical treatments at this location.

At Morden, the amiben and trifluralin treatments provided excellent weed control. Somewhat less effective control was provided by the CIPC, DCPA and CDEC and DNBP treatments. All other chemical treatments resulted in poor weed control.

Treatments with Hercules 7531 killed the beans at Morden and post-emergence applications of CDEC and DNBP stunted the beans at Portage la Prairie. Herbicidal damage from other treatments was not observed at either location. Data are presented in Tables XII and XIII.

Figure 7. CDAA at 4 pounds per acre and CIPC at 4 pounds per acre applied May 16 (pre-emergence) in onions, Portage la Prairie, 1963.

Figure 8. CDAA at 4 pounds per acre and DCPA at 12 pounds per acre applied May 16 (pre-emergence) in onions, Portage la Prairie, 1963.

Figure 9. CDAA at 4 pounds per acre and CIPC at 4 pounds per acre applied May 8 (pre-emergence) and repeated May 23 (pre-emergence) in onions, Portage la Prairie, 1963.

Figure 10. Weedy check, onions, Portage la Prairie, 1963.

Figure 11. CDAA at 4 pounds per acre and CIPC at 4 pounds per acre applied May 15 (pre-emergence) in onions, Fort Garry, 1963.

Figure 12. CDAA at 4 pounds per acre and CIPC at 4 pounds per acre applied May 6 (pre-emergence) and repeated May 22 (pre-emergence) in onions, Fort Garry, 1963.

Figure 13. CDAA granules applied at 6 pounds per acre in a fourteen inch band over each row, May 15 (pre-emergence) in onions, Fort Garry, 1963.

Figure 14. Weedy check, onions, Fort Garry, 1963.

TABLE XI

EVALUATION OF HERBICIDES IN ONIONS GROWN ON ORGANIC SOIL
VIVIAN, 1963

Treatment Herbicide, Rate and Application Date		Weed Control Rating (0-10)	Yield of Onions Autumn Spice (Ton/A)		Aristocrat (Ton/A)	
Weed free check.		10.0	5.21 a	L2	6.16 a	L2
CIPC 4 lb/A and CDAA 4 lb/A June 19	L1	9.1	3.18 b		2.53 b c d	
CIPC 6 lb/A and CDAA 6 lb/A June 19		9.5	2.60 b c		2.82 b c d	
CDAA 4 lb/A and DCPA 12 lb/A June 19		8.1	1.73 b c		1.27 c d	
CDAA 6 lb/A and DCPA 16 lb/A June 19		9.0	3.16 b		2.60 b c d	
CDAA 6 lb/A June 19		8.3	2.67 b c		2.13 b c d	
CDAA 8 lb/A June 19		9.0	3.12 b		3.45 b c	
Ciba - 3740 4 lb/A July 9	L1	7.3	2.25 b c		2.25 b c d	
Ciba - 3472 4 lb/A July 9		9.0	2.82 b c		4.50 b	
Weedy check.		0.0	0.47 c		0.33 d	

L1 June 19 -- Weeds and crop not emerged.
July 9 -- Weeds and crops two to six inches in height.

L2 Significantly different groups as determined by the Student-Newman-Keul multiple range test.

TABLE XII

HERBICIDAL EVALUATION TRIALS IN WHITE BEANS
PORTAGE LA PRAIRIE, 1962

Treatment Herbicide, Rate and Application Date	Crop Injury Rating (0-10)	Weed Control Rating (0-10)	Yield of White Beans (Bus./A)	
Weed free check.	0.0	10.0	34.84	a
Trifluralin 4 lb/A June 4 L1	1.0	4.7	16.31	c
Trifluralin 4 lb/A June 8 L1	0.9	4.7	25.73	b
Trifluralin 4 lb/A raked in June 8	1.0	4.4	10.44	c d
Amiben 4 lb/A June 4.	0.9	2.6	10.37	c d
Amiben 4 lb/A June 8.	0.8	2.8	10.56	c d
Amiben 4 lb/A raked in June 8	1.0	4.4	10.44	c d
Amiben 4 lb/A June 20 L1	1.3	2.3	9.53	c d
CDEC liquid 4 lb/A June 8.	0.6	0.0	2.03	d
CDEC liquid 6 lb/A June 8.	0.8	0.7	9.70	c d
CDEC granular 4 lb/A June 8.	0.8	0.7	6.56	c d
CDEC granular 6 lb/A June 8.	1.0	2.2	5.01	d
CIPC 4 lb/A June 8.	0.3	1.0	7.32	c d
DCPA 14 lb/A June 8.	0.8	2.1	13.48	c d
DNBP amine 4 lb/A June 8.	0.4	0.1	3.35	d
CDEC liquid 4 lb/A + DNBP amine 3 lb/A June 20	6.4	2.8	3.92	d
Hercules 7531 4 lb/A June 8.	1.1	0.8	5.68	d
R2061 4 lb/A June 4.	0.9	0.4	3.32	d
R2061 6 lb/A June 4.	0.8	0.4	3.57	d
Weedy check.	0.0	0.0	3.85	d

L1 June 4 -- Pre-planting to crop, June 8 -- pre-emergence to weeds and crop, June 20 -- Weeds and crop two to four inches in height.

L2 Significantly different groups as determined by the Student-Newman-Keul multiple range test.

TABLE XIII

HERBICIDAL EVALUATION TRIAL IN WHITE BEANS
MORDEN, 1962

Treatment Herbicide, Rate and Application Date	Crop Injury Rating (0-10)	Weed Control Rating (0-10)	Yield of White Beans (Bus./A)
Weed free check.	0.0	10.0	19.29 a L2
Trifluralin 4 lb/A June 11 L1.	0.8	8.1	20.61 a
Trifluralin raked in 4 lb/A June 11.	1.0	8.0	17.09 a
Amiben 4 lb/A June 11	1.1	9.0	17.03 a
Amiben raked in 4 lb/A June 11.	1.8	8.0	16.33 a
CDEC liquid 4 lb/A June 11	0.7	1.5	13.97 a
CDEC liquid 6 lb/A June 11	1.3	3.9	14.60 a
CDEC granular 4 lb/A June 11	1.6	2.9	16.17 a
CDEC granular 6 lb/A June 11	2.5	3.6	14.44 a
CIPC 4 lb/A June 11	1.3	5.8	17.81 a
DCPA 14 lb/A June 11	1.3	7.0	16.71 a
DNBP amine 4 lb/A June 11	1.3	1.6	14.52 a
CDEC liquid 4 lb/A + DNBP amine 3 lb/A June 11 . .	1.0	2.8	14.50 a
CDEC liquid 4 lb/A + DNBP amine 3 lb/A June 20 L1	2.3	7.0	13.48 a
Hercules 7531 4 lb/A June 11	10.0	4.3	0.0 b
Weedy check.	0.0	0.0	11.64 a

L1 June 11 -- pre-emergence to weeds and crop.
June 20 -- weeds and crop two to four inches in height.

L2 Significantly different groups as determined by the Student-Newman-Keul multiple range test.

A further herbicidal evaluation trial was conducted at Morden in 1963. Data are presented in Table XIV. Excellent weed control was obtained from the treatments prometryne at two pounds per acre, amiben liquid at four pounds per acre, and trifluralin at four pounds per acre. The treatments N-2995 at five pounds per acre, and amiben granular at four pounds per acre were only slightly less effective. The other two chemical treatments were almost completely ineffective. According to the analysis of variance (Appendix 20), there was no significant difference between yield means for the various treatments. This was undoubtedly due to the relatively light weed infestation at this location. There was no herbicidal damage to the crop observed at this location.

Pre-emergence Herbicide Trials. In 1963, the herbicides amiben, trifluralin, DCPA, EPTC, and linuron were evaluated for weed control in white beans at two locations. Data are presented in Tables XV and XVI.

The treatments amiben at four pounds per acre, trifluralin at six pounds per acre, and linuron at two pounds per acre, provided excellent weed control at both locations. The treatments trifluralin at two and four pounds per acre were equally effective at Morden but at four pounds per acre trifluralin was less effective at Portage. All other chemical treatments were less effective at both locations.

The trifluralin treatments at Portage la Prairie stunted the beans when application was made in the early crook stage. The beans fully recovered from this effect and yields were not affected. The

linuron treatment at two pounds per acre injured the white beans at both locations and yields from these plots were significantly reduced.

Due to the efficient weed control given by the amiben and trifluralin treatments, only one row crop cultivation was required to obtain maximum yields. No hand weeding was carried out on these plots. Since white beans are never hand weeded in Manitoba but are only mechanically weeded, hand weeding data was not recorded in this crop. Amiben is less costly than trifluralin on an acre basis and in these tests was equal to trifluralin in weed control.

The results obtained from the treatments amiben at four pounds per acre, trifluralin at four and six pounds per acre, and linuron at two pounds per acre, obtained at Portage la Prairie, are demonstrated in Figures 15, 16, 17, and 18.

TABLE XIV

HERBICIDAL EVALUATION TRIALS IN WHITE BEANS,
MORDEN, 1963

Treatment Herbicide, Rate and Application Date	Weed Control Rating (0-10)	Yield of White Beans (Bus./A)
Weed free check	10.0	22.0 L2
Amiben liquid 4 lb/A June 17 L1	9.8	21.1
Trifluralin 4 lb/A June 17. . .	9.4	22.6
Prometryne 2 lb/A June 17. . .	9.7	17.0
N-2995 5 lb/A June 17. . .	7.8	16.4
Amiben granular 4 lb/A June 17. .	7.5	18.1
H.S.119 3 lb/A June 17. . .	4.0	15.5
H.S. 92 3 lb/A June 17. . .	0.9	18.8
Weedy check	0.0	16.7

L1 June 17 -- Pre-emergence to weeds and crop.

L2 No significant difference between treatments.

TABLE XV

PRE-EMERGENCE HERBICIDE TRIAL IN WHITE BEANS,
PORTAGE LA PRAIRIE, 1963

Treatment Herbicide, Rate and Application Date		Crop Injury Rating (0-10)	Weed Control Rating (0-10)	Approximate Weed Control Costs Chemical treatment ($/A)	Mechanical ($/A)L3	Total ($/A)	Yield of White Beans (Bus./A)	
Amiben 4 lb/A June 3	L1	0.0	9.5	$22.00	$1.00	$23.00	34.78 a	L2
Amiben 2 lb/A June 3		0.0	7.2	11.00	1.00	12.00	37.67 a	
Trifluralin 6 lb/A June 7	L1	5.5	9.6	48.78	1.00	49.78	37.99 a	
Trifluralin 4 lb/A June 7		3.8	6.5	32.52	1.00	33.52	21.87 a b	
Linuron 2 lb/A June 7		6.3	8.8	12.40	1.00	13.40	11.04 b c	
DCPA 12 lb/A June 7		0.0	3.2	40.20	2.00	42.20	18.62 a b	
Weedy Check		0.0	0.0	-	-	-	0.0 c	

L1 June 3 -- Pre-emergence to weeds and crop.
June 7 -- Pre-emergence to weeds, crop in the early crook stage.

L2 Significantly different groups as determined by the Student-Newman-Keul multiple range test.

L3 Cost based on $1.00 per acre for each row crop cultivation. Data obtained from Custom Rates for Farm Operation by G. R. Anderson, Agricultural Economics Bulletin No.4, July 1961. Department of Agricultural Economics and Farm Management, Faculty of Agriculture, University of Manitoba, Winnipeg.

TABLE XVI

PRE-EMERGENCE HERBICIDE TRIAL IN WHITE BEANS,
MORDEN, 1963

Treatment Herbicide, Rate and Application Date		Crop Injury Rating (0-10)	Weed Control Rating (0-10)	Approximate Weed Control Costs Chemical treatment ($/A)	Mechanical ($/A) L3	Total ($/A)	Yield of White Beans (Bus./A)
Amiben 4 lb/A June 17	L1	0.0	9.3	$22.00	$1.00	$23.00	18.68 a b cL2
Amiben 2 lb/A June 17		0.0	5.9	11.00	1.00	12.00	22.34 a b c
Trifluralin 6 lb/A June 17		0.3	9.6	48.78	1.00	49.78	25.86 a
Trifluralin 4 lb/A June 17		0.3	8.4	32.52	1.00	33.52	21.58 a b c
Trifluralin 2 lb/A June 17		0.0	8.3	16.26	1.00	17.26	20.36 a b c
DCPA 12 lb/A June 17		0.0	6.0	40.20	1.00	41.20	21.20 a b c
DCPA 8 lb/A June 17		0.0	6.0	26.80	1.00	27.80	18.87 a b c
EPTC 4 lb/A June 17		0.0	4.4	-	-	-	17.28 a b c
Linuron 2 lb/A June 17		4.0	8.8	12.40	1.00	13.40	12.65 c
Linuron 1 lb/A June 17		0.8	5.9	6.20	1.00	7.20	16.31 a b c
Weedy check.		0.0	0.0	-	-	-	15.44 b c

L1 June 17 -- Pre-emergence to weeds and crop.

L2 Significantly different groups as determined by the Student-Newman-Keul multiple range test.

L3 Cost based on $1.00 per acre for each row crop cultivation.

Figure 15. Amiben at 4 pounds per acre applied June 3 (pre-emergence) in white beans, Portage la Prairie, 1963.

Figure 16. Trifluralin at 4 pounds per acre applied June 7 (pre-emergence) in white beans, Portage la Prairie, 1963.

Figure 17. Trifluralin at 6 pounds per acre applied June 7 (pre-emergence) in white beans, Portage la Prairie, 1963.

Figure 18. Linuron at 2 pounds per acre applied June 7 (pre-emergence) in white beans, Portage la Prairie, 1963.

CHAPTER V

CONCLUSIONS

The purpose of this study was to evaluate new herbicides which could prove useful in reducing production costs to the commercial vegetable grower. These herbicides were tested for efficacy under a variety of environmental conditions. Five additional experiments were conducted in carrots, onions, and white beans, in 1963, to compare weeding costs between mechanical and chemical methods.

Carrots. The herbicides amiben, trifluralin, solan, and linuron, were compared with the standard herbicide varsol in this crop. Five other herbicides were tested in the herbicide evaluation trials. Two chemicals, amiben and varsol, performed well in these tests. With proper application both gave equal weed control. However, amiben had some advantage over varsol in these tests. It required only one treatment for season long weed control whereas varsol required several treatments. Amiben was also less expensive on an acre basis than varsol. Solan was only slightly less effective than amiben or varsol but like varsol it required re-treatment for control of weeds such as green foxtail.

Two other chemicals, linuron and trifluralin, gave promising results in 1963. Trifluralin was equal to amiben in these tests but additional testing is required to confirm the efficacy of this herbicide. Linuron was less effective in that it did not control green foxtail. Other herbicides tested were ineffective in these experiments.

Herbicides were demonstrated to reduce the cost of weeding in carrots by reducing the number of man hours required to clear the crop of weeds. Herbicides, therefore, are able to increase the production efficiency of the grower.

Transplanted Celery. Two herbicides, solan and amiben, were evaluated for weed control and crop tolerance in transplanted celery. Two other herbicides were tested in a herbicide evaluation trial.

Solan was the most effective herbicide in this crop. A rate of two to four pounds per acre applied one to two weeks after transplanting was found to be the most efficient method of application. Amiben was less effective in these tests and the other herbicides tested were ineffective in these experiments.

Onions. The herbicides CIPC, CDAA, DCPA, and mixtures of these herbicides were evaluated for weed control in onions. Two new herbicides, C-3470 and C-3472, were tested on a peat soil location.

The herbicide mixtures, CIPC and CDAA, and CDAA and DCPA, were more effective in controlling weeds in onions than either CIPC or CDAA alone. Based on the rates used in these tests, the CIPC and CDAA mixture was less costly than the CDAA and DCPA mixture. The herbicides C-3470 and C-3472 showed promise as selective herbicides in onions but require further testing.

It was demonstrated that herbicides reduce the cost of weeding in onions by reducing the number of man hours required to clean the crop of weeds.

White Beans. A total of fourteen chemicals were evaluated for weed control in white beans in 1962 and 1963. The herbicides amiben and trifluralin were the most effective of all those tested. They were equally efficient in controlling annual weeds in white beans but at the rates used amiben was less costly than trifluralin. None of the other herbicides were as effective as amiben or trifluralin in the 1962 experiments. The herbicide linuron, while giving good weed control, seriously damaged this crop. The herbicides prometryne and N-2995 showed promise as selective herbicides but were only tested in the one year. Other herbicides that were evaluated in this crop were ineffective in these experiments. Herbicides were demonstrated to reduce the number of mechanical cultivations required to obtain maximum yields.

In the case of carrots, onions, and white beans, where weeding costs were obtained, it would have been desirable to include total costs of production data, so that a proper assessment of weeding in relation to overall costs of production could be made. However, data of this type is not available at present for Manitoba and further research in this area of vegetable growing would be desirable.

It should also be emphasized that registration of herbicides for use in crops including vegetables cannot be based on efficacy alone. Other characteristics such as safety to the applicator and soil and crop residues must also be thoroughly investigated. Therefore, some herbicides evaluated in these experiments, which showed the desired selectivity, may not become commercially available until further extensive evaluations have been concluded.

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APPENDIX 1. Meteorological data, Canada Department of Agriculture, Morden Temperature and Precipitation Summaries, April to September, 1962 and 1963

Temperature Summary

Month	Average Maximum		Average Minimum		Mean Daily		Deviation from Normal	
	1962	1963	1962	1963	1962	1963	1962	1963
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
April	44.4	51.3	24.1	29.6	34.3	48.5	-4.4	+1.8
May	60.5	62.3	42.5	39.3	51.5	50.8	-1.5	-2.2
June	75.6	75.6	53.4	55.5	64.5	65.6	+1.9	+3.0
July	76.8	81.8	54.0	59.6	65.4	70.7	-3.8	+1.7
August	77.6	98.0	53.6	42.0	65.6	66.0	-0.8	+2.0
September	65.5	73.2	41.6	47.0	53.6	60.1	-2.8	+3.9

Precipitation Summary

Month	Total Monthly Precipitation		Deviation from Normal	
	1962	1963	1962	1963
	Inches	Inches	Inches	Inches
April	0.28	1.66	-1.11	+0.27
May	8.40	3.70	+6.14	+1.44
June	2.13	5.99	-0.85	+3.01
July	4.19	5.10	+1.38	+2.26
August	2.97	1.43	+0.78	-0.76
September	0.59	0.55	-1.42	-1.46

APPENDIX 2. Meteorological Data, Portage la Prairie

Temperature and Precipitation Summary

April to September, 1962 and 1963

Temperature Summary

Month	Average Maximum		Average Minimum		Mean Daily		Deviation from Normal	
	1962	1963	1962	1963	1962	1963	1962	1963
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
April	45.3	50.1	23.8	29.9	34.6	40.1	-3.1	+2.3
May	60.8	61.4	42.3	39.1	51.6	50.3	-1.0	-2.3
June	76.6	76.2	54.8	55.3	65.7	65.8	+3.5	+3.6
July	76.5	80.8	53.7	59.1	65.1	69.9	-3.7	+1.1
August	75.8	89.0	54.4	43.0	65.1	67.0	-0.6	+1.0
September	63.6	70.9	42.0	46.0	52.8	58.5	-2.5	+3.2

Precipitation Summary

Month	Total Monthly Precipitation		Deviation from Normal	
	1962	1963	1962	1963
	Inches	Inches	Inches	Inches
April	0.43	2.26	-0.71	+1.12
May	5.03	2.34	+3.04	+0.35
June	1.69	3.91	-1.69	+0.58
July	2.67	5.17	-0.08	+2.42
August	7.13	1.69	+4.90	-0.54
September	0.29	0.48	-1.73	-1.56

APPENDIX 3. Meteorological data, University of Manitoba, Fort Garry. Temperature and Precipitation Summary, April to September, 1962 and 1963

Temperature Summary

Month	Average Maximum		Average Minimum		Mean Daily		Deviation from Normal	
	1962	1963	1962	1963	1962	1963	1962	1963
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
April	42.5	50.1	22.7	29.8	32.6	40.0	-5.4	+2.0
May	60.8	61.3	42.0	37.8	51.4	49.6	-1.0	-2.8
June	75.4	75.9	54.6	55.7	65.0	65.8	+3.3	+4.1
July	75.6	81.7	55.2	60.1	65.4	70.9	-2.9	+2.6
August	75.1	74.7	54.5	56.8	64.8	65.8	-1.2	-0.2
September	64.4	70.5	42.3	45.9	53.4	58.2	-1.7	+3.1

Precipitation Summary

Month	Total Monthly Precipitation		Deviation from Normal	
	1962	1963	1962	1963
	Inches	Inches	Inches	Inches
April	0.45	3.46	-0.72	+2.29
May	5.29	2.03	+3.32	+0.06
June	1.86	2.57	-1.33	-0.62
July	6.44	2.54	+3.73	-0.17
August	4.47	1.77	+1.71	-0.99
September	0.46	0.90	-1.70	-1.26

APPENDIX 4. Meteorological Data, Winnipeg International Airport

Temperature and Precipitation Summaries,

April to September, 1962 and 1963

Temperature Summary

Month	Average Maximum		Average Minimum		Mean Daily		Deviation from Normal	
	1962	1963	1962	1963	1962	1963	1962	1963
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
April	42.5	51.4	22.4	30.2	32.5	40.8	-5.5	+2.8
May	61.5	61.5	41.5	38.1	51.5	49.8	-0.9	-2.6
June	75.8	76.3	54.4	56.1	65.1	66.2	+3.1	+4.2
July	76.0	82.4	55.8	60.1	65.6	71.3	-2.8	+3.0
August	75.6	90.0	54.9	43.0	65.3	67.0	-0.5	+1.0
September	64.8	71.5	43.0	45.2	53.9	58.4	-1.5	+3.3

Precipitation Summary

Month	Total Monthly Precipitation		Deviation from Normal	
	1962	1963	1962	1963
	Inches	Inches	Inches	Inches
April	0.67	3.56	-0.53	+2.36
May	5.21	2.59	+3.14	+0.52
June	2.11	3.43	-0.53	+0.79
July	6.11	2.12	+3.39	-0.59
August	6.83	2.09	+4.34	-0.43
September	0.62	0.63	-1.54	-1.53

APPENDIX 5. Analysis of Variance

Herbicide Evaluation Trial in Carrots, 1962, Location 2

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	28.7796	2.63
Treatments	21	105.0720	9.59 ##
Error	63	10.9560	
Total	87		

significant at the 1% level of probability.

APPENDIX 6. Analysis of Variance

Single and Repeated Applications of Herbicides in Carrots, 1962

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	43.0405	2.19
Treatments	7	152.0625	7.74 ##
Error	21	19.6529	
Total	31		

significant at the 1% level of probability.

APPENDIX 7. Analysis of Variance

Cost Comparison between Chemical and Mechanical Weed Control Methods in Carrots, 1963, Location 1

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	41.0772	1.43
Treatments	7	332.8578	11.58 ##
Error A.	21	28.7550	
Weeding	1	105.8327	6.77 #
Weeding x Treatments	7	86.4602	5.53 ##
Error B.	24	15.6330	
Total	63		

significant at the 5% level of probability.

significant at the 1% level of probability.

APPENDIX 8. Analysis of Variance

Cost Comparison between Chemical and Mechanical Weed Control Methods in Carrots, Weeding Data, 1963, Location 1

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	6.6612	1.14
Treatments	5	28.9851	4.98 ##
Error	15	5.8191	
Total	23		

significant at the 1% level of probability.

APPENDIX 9. Analysis of Variance

Cost Comparison between Chemical and Mechanical Weed Control Methods in Carrots, 1963, Location 2

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	22.7039	3.96 #
Treatments	7	167.0346	29.12 ##
Error A	21	5.7353	
Weeding	1	0.7877	0.28
Weeding x Treatments	7	3.8946	1.39
Error B.	24	2.7940	
Total	63		

significant at the 5% level of probability.

significant at the 1% level of probability.

APPENDIX 10. Analysis of Variance

Cost Comparison between Chemical and Mechanical Weed Control Methods in Carrots, Weeding Data, 1963, Location 2

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	1.1873	0.88 L1
Treatments	5	1.3871	1.03
Error	15	1.3516	
Total	23		

L1 Not significant at the 1% level of probability.

APPENDIX 11. Analysis of Variance

Herbicide Evaluation Trial in Carrots, 1963, Location 3

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	12.0447	1.84
Treatments	7	296.0298	45.13 ##
Error A	21	6.5602	
Weeding	1	455.2889	50.15 ##
Weeding x Treatments	7	55.0596	6.06 ##
Error B	24	9.0787	
Total	63		

significant at the 1% level of probability.

APPENDIX 12. Analysis of Variance

Herbicide Evaluation Trial in Transplanted Celery, 1962, Location 1

ANOVA

Source	d.f.	M.S.	F.
Replicates	1	135.14	2.11
Treatments	7	77.60	1.21 La
Error	7	63.90	
Total	15		

La Not significant at the 1% level of probability.

APPENDIX 13. Analysis of Variance

Herbicide Evaluation Trial in Transplanted Celery, 1963, Location 2

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	170.496	16.714 ##
Treatments	7	11.571	1.134
Error	21	10.201	
Total	31		

significant at the 1% level of probability.

APPENDIX 14. Analysis of Variance

Herbicide Evaluation Trial in Transplanted Celery, 1963, Location 3

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	52.494	11.206 ##
Treatments	6	35.607	7.587 ##
Error	18	4.693	
Total	27		

significant at the 1% level of probability.

APPENDIX 15. Analysis of Variance

Formulations, Mixtures and Cost Study Trials in Onions, 1963
Location 3

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	25.0152	2.61
Treatments	11	138.2467	14.40 ##
Error A.	33	9.5999	
Weeding	1	2652.3038	434.05 ##
Weeding x treatments	11	66.6867	10.91 ##
Error B	36	6.1106	
Total	95		

significant at the 1% level of probability.

APPENDIX 16. Analysis of Variance

Formulations, Mixtures and Cost Study Trials in Onions,
Weeding Data, 1963, Location 3

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	11.2169	5.95 ##
Treatments	9	9.3206	2.29 ##
Error	27	1.8852	
Total	39		

significant at the 1% level of probability.

APPENDIX 17. Analysis of Variance

Evaluation of Herbicides in Onions Grown on Organic Soil, 1963

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	33.3233	15.67 ##
Treatments	9	29.0011	13.63 ##
Error A	27	2.1270	
Varieties	1	0.2500	0.002
Varieties x Treatments	9	2.1489	1.91
Error B	30	1.1237	
Total	79		

significant at the 1% level of probability.

APPENDIX 18. Analysis of Variance

Herbicide Evaluation Trial in White Beans, 1962, Location 1

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	2899.6	0.67
Treatments	19	44243.1	10.22 ##
Error	57	4330.21	
Total	79		

significant at the 1% level of probability.

APPENDIX 19. Analysis of Variance

Herbicide Evaluation Trial in White Beans, 1962, Location 2

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	5542.059	2.69
Treatments	15	13013.04933	6.32 ##
Error	45	2060.60164	
Total	63		

significant at the 1% level of probability.

APPENDIX 20. Analysis of Variance

Herbicide Evaluation Trial in White Beans, 1963, Location 3

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	77479.436	7.252 ##
Treatments	8	12628.445	1.182
Error	24	10684.0183	
Total	35		

significant at the 1% level of probability.

APPENDIX 21. Analysis of Variance

Pre-emergence Herbicide Trial in White Beans, 1963, Location 1

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	184414.37	1.02
Treatments	7	1360666.00	7.52 ##
Error A	21	180964.4466	
Weeding	1	1254960.1	
Weeding x Treatments	7	102273.8428	18.01 ##
Error B	24	69672.4583	1.47
Total	63		

significant at the 1% level of probability.

APPENDIX 22. Analysis of Variance

Pre-emergence Herbicide Trial in White Beans, 1963, Location 2

ANOVA

Source	d.f.	M.S.	F.
Replicates	3	15493.65	1.04
Treatments	11	60345.89	4.03 ##
Error A	33	14965.80	
Weeding	1	164755.60	15.65 ##
Weeding x Treatments	11	6307.16	
Error B	36	10528.17	
Total	95		

significant at the 1% level of probability.

APPENDIX 23. Index to Herbicides used in this Report

Herbicide Name or Designation	Chemical
Afalon-Aresin	3-(3, 4-dichlorophenyl)-2,2,2, dimethyl-valeramine plus N-(4-chlorophenyl)-N^1-methoxy-N-methylurea.
Amiben	3 amino-2, 5-dichlorobenzoic acid.
CDAA-T	a-chloro-N, N-diallylacetamide plus trichlorobenzyl chloride.
CDAA	a-chloro-N, N-diallylacetamide.
CDEC	2-chloroallyl diethyldithiocarbamate.
Ciba-3470	N-4(p-methoxy-phenoxy)-phenyl-N^1, N^1-dimethylurea.
CIPC	isopropyl-N-(3-chlorophenyl) carbamate.
DCPA	2, 3, 5, 6-tetrachloroterephthalic acid.
EPTC	ethyl-N, N-di-n-propylthiolcarbamate.
DNBP amine	amine salt of 4, 6-dinitro-o-sec-butylphenol.
Hercules-7531	1-(5-(3a, 4, 5, 6, 7, 7a-hexahydro-4, 7-methanoindanyl))-3, 3-dimethylurea.
Hercules-8043	N-(3, 4-dichlorophenyl)-2, 2 dimethyl-valeramide.
H.S.-92	1-phenyl-4-amino-5-chloro-pyridazone-6 plus N-cycloocty1-N-dimethylurea.
H.S.119	1-phenyl-4-amino-5-chlor-pyridazone-6.
Ipazine	2 chloro-4-diethylamino-6-isopropyl-amino-S-triazine.
Linuron	3-(3, 4-dichlorophenyl)-1-methoxy-1-methylurea.
Niagara-2995	methyl-N-(3, 4-dichlorophenyl) carbamate.

APPENDIX 23 Continued

Herbicide Name or Designation	Chemical
Prometryne	2, 4-bis(isopropylamino)-6-methylmercapto -S-triazine.
R-2061	N-propyl-ethyl-N-butythiol-carbamate.
Solan	N-(3-chloro-4-methylphenyl)-2-methyl-pentamide.
Stoddard solvent	Refined petroleum oil.
Tenoran	N-4(p-chlorophenoxy)-phenyl-N^1, N^1-dimethylurea.
Trifluralin	a,a,a,-trifluoro-2, 6-dinitro-N, N-dipropyl-p-toluidine.
Varsol	Refined petroleum oil.

APPENDIX 24. Approximate Cost of Herbicides Evaluated

Herbicide #	Approximate Cost /lb. Active Ingredient ##
CIPC	$2.90
CDAA	$2.45
DCPA	$3.35
Linuron	$6.20
Amiben	$5.50
Solan	$5.64
Trifluralin	$8.13
Varsol	$0.40 (per gallon)

\# Prices for experimental herbicides not available

\## Based on retail prices F.O.B. Winnipeg, 1964.

APPENDIX 25. List of Weeds

Common Name	Scientific Name
barnyard grass	Echinochloa crusgalli (L.) Beauv.
biennial wormwood	Artemisia biennis Willd.
Canada thistle	Cirsium arvense (L.) Scop.
common lamb's quarters	Chenopodium album L.
common mallow	Malva neglecta Wallr.
field bindweed	Convolvulus arvenis L.
field horsetail	Equisetum arvense L.
field pennycress	Thlaspi arvense L.
giant ragweed	Ambrosia trifida L.
green foxtail	Setaria viridis (L.) Beauv.
green smartweed	Polygonum scabrum Moench
knotweed (doorweed)	Polygonum aviculare L.
maple-leaved goosefoot	Chenopodium hybridum L.
Perennial sow thistle	Sonchus arvensis L.
prostrate pigweed	Amaranthus graecizans L.
purslane	Portulaca oleracea L.
red root pigweed	Amaranthus retoflexus L.
rough cinquefoil	Potentilla norvegica L.
Russian thistle	Salsola kali (L.) var. tenuifolia Tausch
strawberry blite	Chenopodium capitatum (L.) Aschers
thyme-leaf spurge	Euphorbia serpyllifolia Pers.
wild buckwheat	Polygonum convolvulus L.
wild mustard	Brassica kaber (D.C.) L.C. Wheeler var. pinnatifida L.C. Wheeler
wild oats	Avena fatua L.