THE USE OF CHEMICALS IN THE CONTROL OF CERTAIN HERBACEOUS PERENNIAL WEEDS

by

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TABLE OF CONTENTS

INTRODUCTION

A large percentage of the pernicious weeds of the United States and Canada are alien species. Most of these were introduced from Eurasia, their introduction being associated with the movement of peoples (44).

The distribution and extent of many noxious weeds have increased with alarming rapidity, in spite of various preventive measures and greater realization of the menace of weeds to agriculture. Recognition of the necessity for detecting incipient infestations of alien species, evaluating their potential hazard, and, if pernicious, promptly exterminating them is of paramount importance.

The annual loss from weeds is estimated to exceed the combined losses from (1) animal diseases, (2) plant diseases, and (3) insects, rodents, and predatory animals. According to Dunham (11), the weed losses in the United States in 1952 were recently estimated at five billion dollars, an increase of two billion dollars over a similar estimate made in 1930 by the Agricultural Service Department of the United States Chamber of Commerce.

It is difficult to define a weed in a manner which is acceptable in all situations. A plant such as Johnson grass (*Sorghum halepense*) may or may not be a weed, depending upon the particular area wherein it occurs. Pieters (41) has suggested the following definition, "A weed is a plant whose potentialities for harm are greater than its potentialities for good and has a habit of intruding where it is not wanted."

Successful control of weeds presupposes a thorough knowledge and understanding of their life cycles, growth habits, and growth requirements. The most effective and judicious method of control is often determined by habitat and other environmental habits.

Perennial plants live for three or more years and are classified as simple, bulbous, or creeping. Simple perennials reproduce almost solely by seed, but can reproduce from severed pieces of the fleshy tap root. Bulbous perennials propagate by means of bulbs, bulblets, and seeds. Creeping perennials may reproduce by stolons, rhizomes, roots, and seeds. Perennial plants go through a normal annual cycle of vegetation, reproduction, storage, and dormancy. Any disturbance of this cycle tends to lower the vigor of the plant (46).

The method of control of perennials has, until recently, consisted mainly of attempts to starve out the root system by restriction of growth with such practices as intensive cultivation or frequent destruction of the top growth by close cutting, pasturing, or burning. Little progress was made in the scientific investigation or practical use of weed killing chemicals until the latter part of the nineteenth century when the discovery of the selective action of copper salts resulted by accident from trials on the control of fungus diseases. The value of the chemicals used for weed control during the first four decades of the twentieth century depended chiefly upon inherent morphological differences between certain crop plants and particular weeds.

The discovery of the selective action of the synthetic growth-regulating substances, in 1940, has placed greater emphasis upon the differences in physiological responses of crop plants and weeds.

The object of the present study was an attempt to ascertain the most efficient concentration of various formulations of growth regulator herbicides and several other chemicals for the control and possible eradication of four noxious perennial weeds.

REVIEW OF LITERATURE

Wild garlic (Allium vineale), also known as field garlic, (33), is a bulbous perennial reproducing by bulbs, bulblets, and seeds. It thrives in grain fields, meadows, pastures, lawns, and waste places (22, 33), generally on sandy or gravelly soils, but not restricted to these soil types (33). Wild garlic differs from wild onion (Allium canadense) in that wild garlic produces two kinds of underground bulbs, soft bulbs and hard bulbs (49), whereas wild onion produces only one kind of underground bulb. There are other taxonomic differences which need not be enumerated here. The soft bulbs germinate during the first autumn, while the hard bulbs lie dormant during the winter and germinate the following year or later (22, 33, 48). The subterranean bulbs mature in winter or early spring, whereas the aerial bulblets mature in early summer. Seeds also are produced, although rarely (48). The plant flowers from May to June (22, 33).

Wild garlic was introduced from Europe and is found commonly along the Atlantic coast from Massachusetts to Georgia and westward to Missouri(33), the eastern half of Kansas (22), and southward to Mississippi (33).

Zahnley (64) reported upon the application of various 2, 4-D (2, 4-dichlorophenoxyacetic acid) formulations on wild garlic at 1.5 pounds acid equivalent per acre on April 2, 1946. The application was made at the rapid growth stage, when aerial bulblets were about to form. The average percent survival, as noted in the fall, was 70 to 79. No difference was noted between the effects of the ester, amine, and sodium salt formulations.

Freeman, et al. (17), reporting on the use of 2, 4-D in a heavily grazed bluegrass pasture, indicated 98 percent control after spraying with 2.0 pounds per acre of 2, 4-D ester applied in early April, in three successive years, 1948 to 1950. A single application of 2.0 pounds per acre of the ester, applied in early April, 1950, gave 62 percent control. Three applications of the ester at the rate of 2.0 pounds per acre applied in early November, 1949, early April, 1950, and early November, 1950, resulted in 24 percent survival compared with 46 percent for the untreated check area.

In 1951, Zalik (68) reported successful results in wild garlic control with an isopropyl ester of 2, 4-D at rates of 2.0, 4.0, and 8.0 pounds per acre and with maleic hydrazide at 6.0, 12.0, and 24.0 pounds per acre, applied in the spring and fall. With the 2, 4-D treatments, progressive reduction in stand was observed as the rate of application increased and as the stage of growth of the garlic progressed. The maleic hydrazide treatments were reported effective at all rates and dates of application, with the exception of the 6.0 pounds per acre rate applied in late fall. The early fall and late spring applications were reported as particularly outstanding.

Hansen and Freeman (22), in 1952, reported 60 to 70 percent control of wild garlic with 2.0 pounds per acre of the butoxy ethanol and ethyl esters, and the alkanolamine salt of 2, 4-D, when applied to wild garlic occurring in a mixed population of pasture grasses, legumes, and weeds. Rapid chlorosis and the prevention of aerial bulblet formation were outstanding effects of the treatment. Maleic hydrazide at 4.0 and 8.0 pounds per acre was also applied. Chlorosis was not evident and the reaction proceeded more slowly, but 90 percent reduction of stand was obtained by both rates.

Hansen and Freeman (23) also reported applications of the butoxy ethanol ester of 2, 4-D at rates of 0.5, 1.0, and 1.5 pounds per acre on March 20, April 8, and April 30, 1952. Aerial bulblet formation was prevented by the treatments applied on the first two dates, but the treatments applied on the last date were ineffective. Derscheid and Stahler (10), in 1952, had listed wild garlic as highly resistant to 2, 4-D.

Harris (25) reported the application of maleic hydrazide to wild onion (Allium canadense) on November 14, 1949 and March 17, 1950, at rates of 1.5, 3.0, 6.0, and 12.0 pounds per acre in 20 gallons of water containing 0.05 percent of DuPont Spreader Sticker per acre. The November, 1949 treatment gave 98 percent control at 3.0 pounds per acre and approached eradication at 12.0 pounds per acre. The March, 1950 treatment showed excellent control at all rates, but the onions were not completely eradicated from any of the test plots. This experiment is cited here because of the close relationship of wild onion and wild garlic.

Holm (27) reported that evidence indicated one treatment of maleic hydrazide will suffice for three years or longer when applied to wild onion or wild garlic.

Field bindweed (Convolvulus arvensis), also known as wild morning glory (33), is a deep-rooted perennial reproducing by seeds, creeping roots, and rhizomes (14, 18, 29, 33). The plant thrives in cultivated fields, grain fields, and waste places (33), under conditions of moderate to light rainfall (14, 49), and moderate to warm temperatures. Irrigation has permitted the weed to invade many semiarid and desert regions (49). It is not restricted to any particular soil type.

The aerial portion of field bindweed consists of one or more prostrate trailing vines which develop into a mat when without support and into a climbing vine when support is available. The subterranean portion consists of a freely branching, deeply penetrating, fleshy root system which buds readily (14, 18, 49). Frazier (14) found that a plant grown from seed had a maximum vertical root penetration of 23 feet at the end of 30 months. The plant had acquired a radial spread of 10.5 feet and a vertical penetration of four feet after only seven months.

The plant is capable of flowering and setting seed the first year, if competition and growing conditions permit, flowering from May to August (18). Seed setting takes place from July until frost and is favored by hot, dry weather, with 38 percent, or more, of the blossoms setting seed under optimum conditions (13, 14, 33, 49).

Field bindweed is a native of Europe and Asia (14, 18, 33). It was first reported in this country in Virginia in 1739 (13, 14), and first reported in Kansas at Topeka in 1877 (14). According to Frazier (14), field bindweed was probably brought to Kansas in seed wheat from the Ukranian region of Russia, between 1870 and 1875.

Field bindweed was the first weed to be recognized as a national menace and was subjected to an intensive research program by the United States Department of Agriculture. The plant has been declared noxious in Kansas, where it is rated as the most troublesome perennial weed (18). Control is mandatory by anyone on whose property it may appear (14, 28). The weed is presently widespread throughout the northern and western United States and southern Canada. In the United States it is most abundant and troublesome in the western states (33).

In 1946, Hanson (24) reported the findings of a series of bindweed experiments with 2, 4-D. With the exception of results received from Manitoba, Canada, there were no reports of a complete eradication of the weed, even after four treatments. The amount of soil moisture and its subsequent effect on the activity of bindweed growth was designated as the most important factor influencing the differential results obtained. Temperature and humidity apparently had little effect upon the results. Other investigators, Finnerty and Shafer (13), Knowles (30), Phillips (40), and Wood (62) have indicated that treatments applied during or near dormancy, have not been as effective as treatments applied under more optimum growth conditions, with abundant top growth.

Although differences of opinion exist relative to the stage of growth of treatment for optimum results, all investigators agree that the plant must be in an active state of growth. Hanson (24), Knowles (30), and Stahler (57) reported best results were obtained after the plants were treated during a period of active growth, either at full emergence to the initiation of blooming in the spring, or after regrowth of the plants in the fall. The results of treatments applied on slow-growing plants during midsummer were disappointing (13, 24).

The various types of 2, 4-D formulations applied include the ester, amine, acid, and basic salts. Various investigators (7, 9, 12, 30, 40, 51, 61) have reported that the ultimate effects of repeated treatments with all formulations are approximately equal. However, the esters have been found to give a greater reduction in stand with a single application at lower rates, and under adverse conditions (7, 12, 13, 30, 60, 61).

The amount of chemical necessary for effective bindweed control varies with the growing conditions and the climate in general. Shafer (55) states that the rate of application of 2, 4-D on field bindweed must increase, for a particular area, as the annual precipitation decreases. In the states west of the Mississippi River, North and South Dakota, Nebraska, Kansas, Oklahoma and Texas, 1.0 pound per acre of 2, 4-D is generally necessary for effective control, whereas 0.5 to 0.75 pound per acre is generally adequate in the states east of the Mississippi River

(13, 55).

Pavlychenko (37) in 1945, treated field bindweed at the bloom stage with 1.0, 1.5, and 2.0 pounds per acre of Weedone ethyl ester of 2, 4-D. Fall counts in 1947 showed 61, 2, and 0 percent regrowth.

Derscheid and Stahler (8, 9) applied a series of 2, 4-D formulations at full emergence, full bloom, and fall regrowth stages at rates ranging from 0.63 to 2.67 pounds per acre. Good results were obtained at all three stages of growth with most formulations and rates, ranging from 85 to 95 percent control.

Timmons (59, 60) applied a series of 2, 4-D formulations at the full emergence, bud stage, full bloom, and fall regrowth stages of growth at rates from 1.0 to 4.0 pounds per acre. The treatments were repeated in two successive years. The butyl ester was as effective at the low rates as at the higher rates and gave more consistent results than the amines and salts under drought conditions.

Elder (12) reported there was little difference between esters, amines, and salts when more than 2.0 pounds per acre was applied. Derscheid (7) reported little difference between the three formulations when more than 1.33 pounds per acre was applied.

Russ (51) reported application of 2, 4-D at the bud stage was more effective than application during full bloom or fall regrowth. Heavier rates were more effective during full bloom and fall regrowth, indicating greater resistance of field bindweed at these stages. The sodium salt, amine, and ester appeared equally effective at the bud stage, with the ester apparently more effective on fall regrowth, but giving eratic results when applied at full bloom.

Phillips (40), in 1950, reported that under favorable conditions 1.0 pound per acre of the acid equivalent of either the ester or salt of 2, 4-D will give maximum kill, with 0.75 pound per acre of the ester adequate under optimum conditions. When applied under less favorable conditions, 1.5 pounds per acre of the amine and sodium salts were recommended. Treatments applied at complete emergence and first bloom yielded more than 90 percent reduction in stand, but treatments applied at full bloom and fall regrowth gave disappointing results.

The research committee of the North Central Weed Control Conference in 1952 (42) recommended 0.5 to 1.0 pound per acre of 2, 4-D to be applied in late fall or in bud to bloom stage, with repeat treatments necessary for a satisfactory kill and the control of seedlings.

The research committee also recommended CMU (3-parachlorophenyl-1-1-dimethyl urea) at rates of 64 to 96 pounds per acre in 320 to 640 gallons of water and recommended a 2 to 1 mixture of soluble borate and sodium chlorate at 8 to 10 pounds per square rod.

Russ (53) applied polyborchlorate at rates of 6, 8, and 10 pounds per square rod in the fall of 1949, with -6.3, 94.9, and 91.8 percent control, respectively, when evaluated in the fall of 1950. Equivalent rates applied in the late spring of 1950 yielded 96.6, 99.6, and 100 percent control, respectively, when evaluated in the fall of 1950, and the same treatments showed 99.3, 98.7, and 99.3 percent control when evaluated in the fall of 1951.

Hoary cress (Cardaria draba L.), also known as perennial peppergrass, is a deep-rooted perennial reproducing from seeds, rhizomes, and creeping roots (15, 19, 34). The nature and rate of root development is similar to that of field bindweed. Frazier (15) reported that when not subjected to competition, a maximum vertical penetration of 3.5 feet and a maximum radial spread of 6.0 feet have been attained by a seedling by the end of one growing season (6.5 months). After two growing seasons (18 months) the vertical penetration of the same plant was 11.0 feet and the radial spread was 12.0 feet.

The shoots arising from seeds or root-borne stem buds (15) form rosettes upon emergence. The following year these rosettes send up stems which attain heights of from 1 to 2.5 feet.

Hoary cress was introduced from Eurasia (15, 19, 34) and is found in the United States from the north Atlantic states to the mid-western states and the Pacific coast states, being most troublesome in the Rocky Mountain region (34). The plant thrives in cultivated fields, meadows and pastures, along roadsides, and in waste places. It flowers from May to June and sets seed from June to August (19, 34).

The plant has been declared noxious in Kansas (28), being one of the three most noxious, and according to Gates (19), its effect on crops is more harmful than that of field bindweed.

Zahnley (63), in 1946, reported the results of three applications of 2, 4-D, in two successive seasons, at a rate of 2.0 pounds per acre. The treatments were applied in the spring at the pre-bud stage of growth, when applied the first year. The second year the applications were made in the spring, at the pre-bud stage, and in the fall rosette stage during the ensuing fall. The ester formulation appeared to act more rapidly, and somewhat less regrowth was noted, with 95 to 98 percent reduction in stand at the end of the second season.

Zahnley (65) in 1947, summarizing research reports of that year, reported esters more effective than salts when applied at comparable rates, with quicker action, more complete top-kill, and slower recovery resulting. Fall applications appeared more effective than spring applications, with 2.0 to 4.0 pounds per acre necessary for effective control.

Brown (4), in 1947, reported the application of 2, 4-D ester, amine, and sodium salt at rates of 1.0 and 2.0 pounds per acre, applied at full emergence and pre-bud stages of growth. All formulations resulted in complete top-kill of plants, with the ester most rapid, amine intermediate, and sodium salt least rapid. Only little root-kill was reported with one application, but a high percentage of root-kill was reported with retreatment.

Timmons (61), in 1946, reported the treatment of hoary cress in the bud to early bloom stage and retreatment in the fall rosette stage with the ethyl and butyl esters, amine salt, and sodium salt of 2, 4-D at rates of 1.6, 2.4, and 3.2 pounds per acre. For the 3.2 pounds per acre rate, the percentages of regrowth were 1.2, 8.3, 5.0, and 12.6 percent respectively, for the above formulations. The salts were ineffective in the spring and gave results comparable to that of the esters only with fall retreatments and when applied at concentrations twice that of the esters.

Zahnley (66), in 1947, reported 1.92 pounds per acre of the butyl ester to be as effective as 4.32 pounds per acre of the sodium salt of 2, 4-D. Differences in effectiveness of the ester and sodium salt were less pronounced after the first retreatment.

Zahnley (67), in 1949, and Corns (5), in 1952, reported the possibility of complete eradication of hoary cress with repeated treatments, results being more readily obtained on noncultivated land, such as grass sod. The minimum dosage required was reported as 2.0 pounds per acre, with 4.0 pounds per acre giving the best results. Ester formulations were reported preferrable to other formulations.

Sterling (58), in 1950, reported control of top growth and prevention of seed set with 0.5 pound per acre of 2, 4-D on the Canadian prairies. Regrowth was extensive with single applications, but repeated applications of 1.0 to 2.0 pounds per acre gave 90 to 100 percent kill. Shafer (55) reported prevention of seed production and substantial reduction of stand with repeated applications of 2.0 pounds per acre. McCurdy (31), in 1951, reported the presence of only a few slow-growing shoots at the end of the second season after two applications per season with 2.0 pounds per acre of 2, 4-D.

Pavlychenko (38, 39) treated an established stand of hoary cress at the flowering stage with 1.0 and 6.0 pounds per acre of Weedone LV 4, Weedone Concentrate 48, an amine (ACP-127), and another formulation designated ACP-649. In early fall, only a slight difference was noted between the low and high rates.

Derscheid and Stahler (10) recommended repeated applications of 1.0 pound per acre. The first application should be made when the buds begin to turn white, the second application three weeks later, to kill the plants which had not emerged at the time of the first treatment, and a third treatment in the fall, if plants emerge. Retreatments should be made in the same manner the following year, if any plants survive.

Shafer and Sands (56) reported the application of isopropyl and butoxy ethanol esters of 2, 4-D at rates of 2.0 and 10.0 pounds per acre in the fall of 1950 and in the spring and fall of 1952. Percentage kills of 91 and 98 percent were obtained with the 2.0 and 10.0 pound per acre rates of the isopropyl ester and 97 and 100 percent with the equivalent rates of the butoxy ethanol ester.

Shafer and Sands (56) also applied 10, 20, and 30 pounds per acre rates of micronized 2, 4-D acid in the spring of 1951 and 1952. Applied dry, 88, 95, and 97 percent kills, respectively, were obtained, whereas application in 40 gallons of water per acre yielded 96, 97, and 99 percent kills, respectively.

The recommendations of the research committee of the North Central Weed Control Conference in 1952 (42) called for 0.5 to 1.0 pound per acre of 2, 4-D, applied at the bud stage, to stop top growth of hoary cress in crops. Retreatments of the fall rosettes with 1.0 to 2.0 pounds per acre was stipulated. This type of treatment should give complete elimination of the weed in two or three years, according to the committee.

Swamp smartweed (Polygonum coccineum pratincolum) also known as perennial smartweed, is a deep-rooted perennial weed reproducing by a long, tough, well-developed rhizome and fibrous root system. The root system has been found to penetrate to a depth of 8 feet, or more (29). The plant seldom reproduces by seeds. Swamp smartweed thrives in low, wet areas, both on cultivated land and in meadows, in fertile fields, along roadside ditches, and along streams. It is not confined to low places, however, often becoming a serious menace on well-drained land (20, 26, 29). The plant thrives from Quebec and Maine to Florida and westward, being found throughout Kansas, but mostly in the eastern half of the state. It flowers from August to October.

The literature pertaining to swamp smartweed provides little information relative to the use of chemicals for control of the weed. Until recently, the weed has been controlled chiefly by intensive cultural practices.

Maleic hydrazide, a relatively new herbicide, holds promise for control of swamp smartweed. Hoffman and Sylwester (26) obtained 75 to 100 percent control of swamp smartweed with 8.0 pounds per acre of maleic hydrazide when followed by removal of the foliar portion by cutting or spraying with kerosene.

MATERIALS AND METHODS

Wild Garlic (Allium vineale)

The area selected for the wild garlic experiment was a Kentucky bluegrass lawn located on the Kansas State College campus. The soil is a fertile, brown, silt-loam, sloping gently to the east, well drained and neutral in reaction. The stand of wild garlic, with clumps ranging up to 12 inches in height, was heavy and well distributed throughout the moderately dense bluegrass sod.

The details of the plot design will be discussed under Results and Conclusions.

The chemicals applied were: (1) ethyl ester of 2, 4-D, (2) butoxy ethanol ester of 2, 4-D, (3) diethanolamine salt of MCP, and (4) the 15 percent formulation of maleic hydrazide. All chemicals were applied on the basis of acid equivalent per acre.

A 2.5 gallon capacity, knapsack sprayer, equipped with a pressure guage, was used to apply the treatments. A fan-type nozzle designated as teejet 8003 was used to produce fine droplets and insure complete coverage of the garlic plants with the chemical solutions. Each plot was sprayed with 10.7 ounces of water solution at 35 pounds pressure. Two pieces of pressed paperboard, two feet by five feet, were hinged together and used as a wind-break to reduce or prevent drift of the chemicals while spraying. Observations of the effects of the chemical were made on May 9, 1953 and November 11, 1953. Final evaluation was on the basis of the average percent of wild garlic surviving on the three replications for each of the rates of each formulation.

Field Bindweed (Convolvulus arvensis)

The field bindweed experiment was located approximately 1/4 mile northeast of the Kansas State College campus. The site was situated on a fertile, dark, grey-brown, silt-loam soil, sloping moderately to the west, adequately drained, and comprising a colluvial fan. A section of the area had been disturbed by tillage approximately six months prior to treatment, and was infested by such annual weeds as sunflower (Helianthus annus), lamb's quarters (Chenopodium album), and Japanese bromegrass (Bromus japonicus), in addition to a heavy infestation of bindweed. The remainder of the area had been virtually undisturbed and was characterized by a medium-thick stand of bromegrass (Bromus inermis), interspersed liberally with heavy bindweed growth.

The details of the plot design will be discussed under Results and Conclusions.

The chemicals employed in the experiment, Table 1 of appendix, consisted of: (1) ethyl ester of 2, 4-D, (2) butoxy ethanol ester of 2, 4-D, (3) isooctyl ester of 2, 4-D, (4) dimethylamine salt of 2, 4-D, (5) diethanolamine salt of MCP, (6) chlorinated benzoic acid, (7) polyborchlorate, (8) CMU, and (9) IN-12895. The growth-regulator type chemicals, namely the 2, 4-D, MCP, and chlorinated benzoic acid, were applied on the basis of acid equivalent per acre. The soil sterilants, polyborchlorate, CMU, and IN-12895, were applied on the basis of pounds of active material per unit (per square rod for the former and per acre for the latter two).

The apparatus used was the same as that described in the preceding section on wild garlic, with the exception that different nozzle tips were used. An 8006 nozzle tip was used for all treatments except the polyborchlorate, for which an 8008 nozzle tip was used to prevent clogging. All treatments, except the polyborchlorate, were applied in one gallon of water per plot.

The polyborchlorate was applied with one gallon of water for every three pounds of chemical.

Shoot counts were taken June 9 and 10, 1953, from a representative one-square yard area within each plot. A cloth tape was stretched taut diagonally across the plot and a metal square one yard square placed beneath the tape so that the tape dissected the square diagonally. The distance from the corner reference stake of the plot to the nearest corner of the metal square was recorded in each case. This permitted sampling of the exact same area at the fall count, October 2 and 3, 1953.

Hoary Cress (Cardaria draba)

The hoary cress experiment was located on two sites. The first site selected was an established stand in one of the bromegrass pastures of the Animal Husbandry Department at Kansas State College. The area is located approximately 1/4 mile due north of the campus on a fertile, grey-brown, silt-loam soil, neutral in reaction, well-drained, sloping gently to the west, and comprising a colluvial fan. The bromegrass stand was medium-heavy, 18 to 24 inches in height, and heavily infested with hoary cress.

The second site was located on the Agronomy farm of Kansas State College. The soil is a fertile, brown, silt-loam, adequately drained, sloping moderately to the northwest, and neutral in reaction. The area was heavily infested with hoary cress and also contained a high percentage of lamb's quarters (Chenopodium album) and pigweed (Amaranthus retroflexus).

The plot designs will be discussed under Results and Conclusions.

The chemicals applied on the first site were the: (1) ethyl ester of 2, 4-D, (2) butoxy ethanol ester of 2, 4-D, (3) isooctyl ester of 2, 4-D, and (4) diethanolamine salt of MCP. On the second site, chlorinated benzoic acid, and the ethyl and butoxy ethanol esters of 2, 4-D were applied.

The apparatus for applying the herbicides was the same as that described in the preceding two sections. An 8008 nozzle tip was used on the first site in order to effect penetration through the thick stand of bromegrass, and an 8006 nozzle tip was used on the second site. All treatments were applied in one gallon of water per plot.

Shoot counts were taken on June 10 and 11, 1953, using the method outlined in the bindweed experiment. Counts of fall rosettes were taken by the same method October 2 and 3, 1953.

Swamp Smartweed (*Polygonum coccineum pratincolum*)

The site selected for the swamp smartweed experiment was located approximately one mile south of Manhattan, Kansas, on south Manhattan Avenue. The area consisted of an established stand of swamp smartweed on an old meander, with a fertile, grey-brown, silty-loam soil, poorly drained, neutral in reaction and covered with a six inch medium sand overwash. The area was heavily infested, but only a relatively small area was suitable for treatment, since a large part of the foliar growth had been ravaged by small, green, metallic type insects and their larvae.

The plot design will be described under Results and Conclusions.

The chemicals applied, Table 1 of Appendix, were the: (1) ethyl ester of 2, 4-D, (2) isooctyl ester of 2, 4-D, (3) butoxy ethanol ester of 2, 4, 5-T (4) chlorinated benzoic acid, (5) the 30 percent maleic hydrazide, and (6) ammate. The spraying apparatus was the same as that described in the preceding sections. An 8006 nozzle tip was used. All treatments were applied in one gallon of water per square rod plot. Plot evaluations were made July 24, 29, and September 16, 1953 by estimating the percent control for each plot.

EXPERIMENTAL RESULTS AND CONCLUSIONS

Wild Garlic (Allium vineale)

The wild garlic infestation, 30 feet by 60 feet, was subdivided into 72 plots, of 25 feet square each. The various chemicals were applied side by side, in order of increasing concentration and were replicated three times. The last plots in each replication received cumulative treatments; i.e., total concentration applied in three applications spaced one month apart. The various formulations were placed side by side so as to afford a direct visual comparison of equivalent or near equivalent rates of treatment. Four formulations were applied, with two rows of check plots so spaced as to locate a check plot beside each treatment.

The two 2, 4-D formulations were applied at rates of 1.5, 2.0, and 2.5 pounds per acre and 1.5 pounds applied in three 0.5 pound per acre dosages spaced approximately one month apart. The

MCP was applied at 1.0, 1.5, and 2.0 pounds per acre and 1.5 pounds in 0.5 pound per acre dosages spaced one month apart. The maleic hydrazide was applied at rates of 4.0, 6.0, and 8.0 pounds per acre and 6.0 pounds applied in three applications of 2.0 pounds at intervals of one month. The treatments were applied on Apr. 28, 1953. The last two applications of the cumulative treatments were made on May 30 and July 7, 1953, respectively.

The general effect of the various chemicals applied to wild garlic was similar, but there was a wide difference in the degree of effectiveness of the MCP and the other three formulations. Very good control was obtained with the 2, 4-D formulations and maleic hydrazide. Cumulative treatment with the high volatile ethyl ester of 2, 4-D was much less effective than a single application of the same amount of chemical. Results with MCP were rated as poor although the influence upon growth of the garlic was somewhat similar to that of 2, 4-D. The trend and extent of the effect of various chemicals is shown graphically in Plate I.

Applications of the low volatile butoxy ethanol ester of 2, 4-D at rates of 1.5, 2.0, and 2.5 pounds per acre and 1.5 pounds applied as 0.5 pound per acre treatments at intervals of approximately one month yielded 99.3, 99.0, 99.3, and 96.0 percent control, respectively. With equivalent rates, the high-volatile ethyl ester of 2, 4-D yielded 98.3, 98.3, 97.7, and 68.3 percent control, respectively. The maleic hydrazide at 4.0, 6.0, and 8.0 pounds per acre and 6.0 pounds applied as 2.0 pounds per acre applications at intervals of approximately one month yielded 99.0, 99.0, 99.3, and 89.7 percent control, respectively. The

MCP at 1.0, 1.5, and 2.0 pounds per acre and 1.5 pounds applied as 0.5 pound per acre applications at intervals of approximately one month yielded 33.3, 38.3, 55.3, and 38.3 percent control, respectively.

The results of all treatments indicate that no advantage was gained when concentrations greater than 1.5 pounds per acre of 2, 4-D and 4.0 pounds per acre of maleic hydrazide were applied, and no advantage was obtained when the chemicals were applied in a cumulative manner over a period of two months. The decrease in control of the cumulative treatment of the butoxy ethanol ester of 2, 4-D could very well be attributed to influences of the combined factors governing the experiments such as gradient of terrain, available soil moisture, and competition, since only one of the replicates was responsible for the variation. The cause of the relatively low percent of control of the cumulative treatment of the ethyl ester of 2, 4-D is not known at the present time. The cumulative treatments of the maleic hydrazide resulted in a lower percent of control probably because of the initial inhibition of the growth processes of the plants, rendering successive applications either less effective or virtually ineffective. The result obtained with the cumulative treatment of MCP was identical with the result obtained when the same amount of chemical was applied all at one time. Therefore, it appears evident that the rates of application of MCP were too low for effective control of the wild garlic with one application.

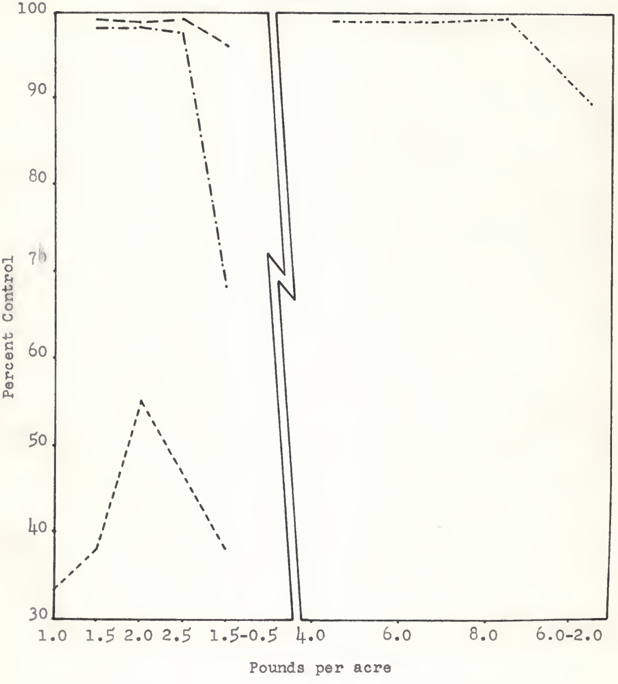
The foregoing results indicate that wild garlic can be controlled by spraying in the spring with 2, 4-D in the ester form

EXPLANATION OF PLATE I

Wild garlic--experimental results

— — — —	Butoxy ethanol ester of 2, 4-D
—·—·—	Ethyl ester of 2, 4-D
- - - - - -	MCP
-·-·-·-	Maleic hydrazide

PLATE I


100
90
80
70
60
50
40
30
Percent Control
1.0
1.5
2.0
2.5
1.5-0.5
4.0
6.0
8.0
6.0-2.0
Pounds per acre

at a rate of 1.5 pounds per acre or with maleic hydrazide at the rate of 4.0 pounds per acre.

Field Bindweed (Convolvulus arvensis)

The bindweed infestation was subdivided into 88 square rod plots. The design of the experiment was such as to permit direct visual comparison of four of the various chemical formulations. The design employed excluded the possibility of performing a statistical analysis of the data, due to the inherent bias within the experiment.

The 2, 4-D and MCP formulations were applied at 0.5, 1.0, and 1.5 pounds per acre and 1.5 pounds applied as 0.5 pound per acre applications on consecutive days. The chlorinated benzoic acid was applied at 3.0 and 6.0 pounds per acre and 6.0 pounds applied in three 2.0 pound per acre applications on consecutive days. The polyborchlorate treatments were applied at 6.0, 8.0, and 10.0 pounds per square rod and 8.0 pounds in 2.0 pound per square rod dosages applied on consecutive days. The CMU and IN-12895 were applied at 40.0, 60.0, and 80.0 pounds per acre and 60.0 pounds applied in 20.0 pound per acre dosages on consecutive days.

The 2, 4-D, MCP, and chlorinated benzoic acid treatments were replicated three times, the polyborchlorate treatments were replicated twice, and the CMU and IN-12895 treatments consisted of single applications per rate of concentration. The latter three chemicals were applied primarily for comparative purposes.

The isooctyl and butoxy ethanol esters of 2, 4-D were applied on June 21, 1953, the ethyl ester of 2, 4-D, amine of 2, 4-D and MCP on June 22, 1953, and the IN-12895 and polyborchlorate on June 24, 1953. All the cumulative treatments were applied on consecutive days, with the exception of the last application of polyborchlorate which was applied three days late, due to unfavorable weather conditions. The bindweed was showing good growth, being in the late bud to early bloom stage, and soil moisture was adequate, but rapidly decreasing. Rainfall data are given in Table 2 of the appendix.

The results obtained with chemicals applied to field bindweed were very erratic, but nevertheless give an indication of what may be expected of the various chemicals under certain environmental conditions. The results of the experiment, expressed as percentage of control based on percent of fall regrowth as compared to that of the check plots, are summarized in Table 3 of the appendix. Each figure, with the exception of the figures given for the soil sterilants, represents an average of three replicates. The trend and extent of the effect of the various chemicals, except chlorinated benzoic acid and the soil sterilants, is shown graphically in Fig. 1 of Plate II.

The optimum dosage of the isooctyl and butoxy ethanol esters of 2, 4-D was 1.0 pound per acre. The cumulative treatment of 1.5 pounds put on in three dosages of 0.5 pounds each showed an advantage over the 1.5 pounds per acre applied in one dose, but was inferior to the 0.5 pound per acre rate. This indicates that cumulative treatments do show an advantage if applied in dosages small enough to cause a minimum of damage to the plant foliage with the first or second application, thereby obtaining the maximum amount of translocation of herbicide to the plant roots. This trend of thought is corroborated by Mullison (36) and by Crafts (6), who have shown that rate of translocation is independent of dosage, with the maximum absorption taking place within the first 4.5 hours after application of the herbicide.

Cumulative treatment with 0.5 pound of the ethyl ester and amine applied in three doses on consecutive days, gave better control than the same total amount of herbicide applied in a single dose. The fact that the 1.0 pound per acre was inferior to all the other rates may be attributed to the normal variation of the combined factors, such as terrain, temperature, available soil moisture, and competition, governing the experiment. The indication here is that the ethyl ester and amine forms of 2, 4-D could possibly be applied at higher rates in order to obtain maximum results.

The MCP treatments indicated the greatest percent of control at the 0.5 pound per acre rate. However, the 1.5 pounds per acre rate applied in 0.5 pound per acre applications was more effective than the 1.0 and 1.5 pound per acre rates. The indication here is that cumulative treatments do show an advantage in application. However, the over-all effectiveness of MCP appears to be considerably inferior to that of the 2, 4-D formulations.

The chlorinated benzoic acid was highly ineffective, however, here again. Cumulative treatments appear to be more effective than equivalent treatments applied in a single dose. It is highly possible that the chlorinated benzoic acid would be

EXPLANATION OF PLATE II

Fig. 1 Experimental results with bindweed

Fig. 2 Experimental results with hoary cress

――――――――	Isooctyl ester of 2, 4-D
— — — — —	Butoxy ethanol ester of 2, 4-D
—.—.—.—	Ethyl ester of 2, 4-D
- - - - - - -	MCP
....	Amine of 2, 4-D

PLATE II

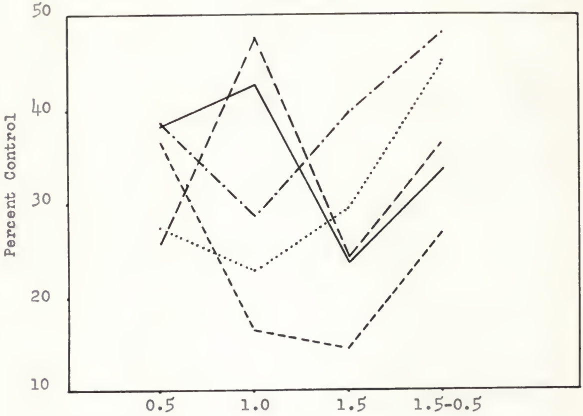


Fig. 1. Pounds per acre

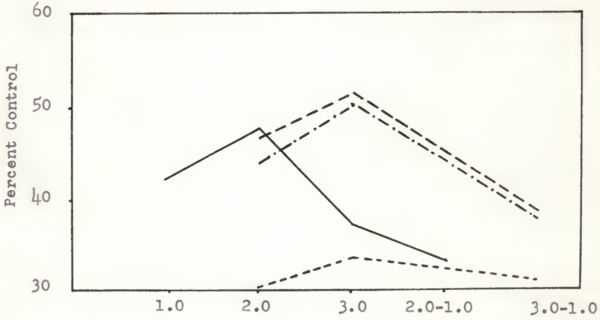


Fig. 2. Pounds per acre

more effective at another stage of bindweed growth.

Polyborchlorate and the IN-12895, classed as soil sterilants, gave good results in comparison with the CMU. The stand of bindweed in the IN-12895 plots was very weak at the time of application. However, the cumulative treatments of the polyborchlorate showed a small advantage over a single application at the same rate. The CMU gave poor results, being almost totally ineffective. The reason for the ineffectiveness of the CMU very possibly could have been the low soil moisture available after application of the chemicals. As shown in Table 2 of the appendix, less than an inch of rainfall had occurred throughout the remainder of the month of June and the month of July.

The generally arid conditions, with high winds, existing at the time of application undoubtedly decreased the growth and metabolic activity of the bindweed plants to the extent that the greater part of the chemicals applied was dissipated or rendered ineffective.

The foregoing results indicate that under adverse conditions practical control of field bindweed can be obtained with 1.0 pound per acre of the low-volatile esters of 2, 4-D, 1.5 pounds per acre of the high-volatile ester and the amine of 2, 4-D, and with 8.0 pounds per square rod of polyborchlorate.

Hoary Cress (Cardaria draba L.)

The first replicate of the hoary cress treatments located on the first site was laid out in a manner similar to that of the bindweed experiment. The other two replicates were distributed at random. The treatments on the second site, except the 2, 4-D treatments which were not replicated, consisted of two replications and were distributed at random.

The ethyl ester and butoxy ethanol ester of 2, 4-D and the MCP were applied at 2.0 and 3.0 pounds per acre and 3.0 pounds in 1.0 pound per acre applications at approximately two day intervals. The isooctyl ester was applied at 1.0, 2.0, and 3.0 pounds per acre and 2.0 pounds in 1.0 pound per acre applications at approximately two day intervals. On the second site the chlorinated benzoic acid was applied at 3.0 and 6.0 pounds per acre. The ethyl and butoxy ethanol esters of 2, 4-D were each applied at 2.0 pounds per acre.

The first replication on the first site was applied May 23, 1953. The second and third replications plus the cumulative treatments of the first replication were applied May 25, 1953. The remainder of the cumulative treatments was applied on May 30, 1953 and June 1, 1953. Applications of chemicals on the second site were made on June 3, 1953.

The hoary cress on the first site appeared to be growing actively, ranged up to 13 inches in height, and was in the late bud to early bloom stage of growth. On the second site, the plants ranged in height up to 16 inches and were in the full bloom stage of growth.

Hoary cress seems to be more tolerant to herbicides than field bindweed. This is indicated by the fact that in nearly all cases the higher concentrations of the chemicals used gave the greater percentage of control. The isooctyl ester is the only formulation which was most effective at the intermediate dosage rate. Cumulative treatments were generally less effective than comparable dosages applied all at one time. MCP was the only exception in which the lowest rate by the single applications gave poorer control than the cumulative treatment. These results are shown graphically in Fig. 2, Plate II. This general decreased effect conceivably could have been due to the fact that the metabolism and tissues of the plants were injured excessively with the first application. Subsequently, since the following applications were applied at approximately two day intervals instead of on consecutive days, the plants were unable to translocate additional herbicide to the roots.

The increase in percent of control from the 2.0 pounds per acre treatment to the 3.0 pounds per acre treatment with the butoxy ethanol and ethyl esters of 2, 4-D and the MCP indicate that insufficient herbicide reached the hoary cress plants. This would have been possible, since the stand of bromegrass was thick and also taller than the hoary cress plants throughout most of the area treated. The 8008 nozzle, giving relatively large droplets of spray with greater striking and penetrating ability, was used to overcome the obstacle presented by the heavy stand of bromegrass. This procedure was deemed permissible in view of statements by Barrons (1) and Mullison (36) that total quantity of herbicide applied rather than droplet size was most important.

Although complete top-kill of all the hoary cress resulted, approximately 15 days after treatment, the amount of herbicide intercepted by the bromegrass could very well have resulted in a considerable decrease in the percent of control of hoary cress. This was indicated by the much greater percent of control obtained with 2.0 pounds per acre rates of the ethyl and butoxy ethanol esters of 2, 4-D applied to the hoary cress plots situated on the second site, where the competing weeds were considerably more sparse than the bromegrass and did not intercept a large quantity of the chemical. Theoretically, the hoary cress treatments on the second site should have yielded lower percentages of control, since the plants were in the advanced bloom stage of growth and were considerably less succulent and vigorous than the plants located on the first site. That the amount of interception was considerable was indicated by the very marked burned appearance of the bromegrass after application of the treatments.

The fact that the percent of control of the isooctyl ester at 3.0 pounds per acre was less than that at the 2.0 pounds per acre rate could be attributed to the more rapid and greater amount of initial injury noticed in the isooctyl plots.

The results of the foregoing experiments indicate that under adverse conditions practical control of hoary cress can be obtained with 2.0 and 3.0 pounds per acre of the ethyl and butoxy ethanol esters of 2, 4-D and with 1.0 and 2.0 pounds per acre of the isooctyl ester of 2, 4-D. MCP and chlorinated benzoic acid appear to be ineffective under adverse conditions.

Swamp Smartweed (<u>Polygonum coccineum pratincolum</u>)

The available infestation was subdivided into eighteen square rod plots distributed at random and arranged in two adjacent rows. The ammate was applied at 1.0 and 2.0 pounds per square rod, the 2, 4, 5-T and isooctyl esters of 2, 4-D at 2.0 and 3.0 pounds per acre, the ethyl ester of 2, 4-D at 2.0 pounds per acre and the chlorinated benzoic acid and the maleic hydrazide at 6.0 pounds per acre.

The treatments were applied on July 23, 1953. The treatments were replicated twice, with the exception of the maleic hydrazide and the chlorinated benzoic acid treatments, which were applied as single treatments. Observations were made on July 24, July 29, and September 16, 1953. At the time of treatment, the plants ranged up to 3.5 feet in height.

The results of the treatments applied to swamp smartweed were disappointing. When examined one day after treatment, the following was noted: the plants treated with ammate showed a complete foliar kill; all the plots treated with 2, 4-D and 2, 4, 5-T formulations exhibited severe epinastic effects; the chlorinated benzoic acid treatments showed moderate to severe epinastic effects; the maleic hydrazide treatments appeared to exhibit slight epinastic effects. This may have been due to a small amount of drift from the 2, 4-D or 2, 4, 5-T plots.

Examination six days after treatment showed the following: the foliage of the plants treated with ammate appeared completely dead and dried; the plots treated with 2, 4-D and 2, 4, 5-T exhibited 75 percent dead and drying foliage; the chlorinated benzoic acid plots exhibited 25 percent dead and drying foliage; the foliage of the maleic hydrazide plots had been largely destroyed by small green metallic type beetles and their larvae (tentatively identified as Chrysomelidae-Colapsis favosa, Say) with the remaining foliage light green in color.

Examination of the plots on September 9, 1953, showed the following: the ethyl and isooctyl esters of 2, 4-D at 2.0 pounds per acre rates gave a top-kill to within 12 to 20 inches of the ground surface, but moderately vigorous regrowth occurred from the old stems which had remained viable; the 2, 4, 5-T treatments at the 2.0 pounds per acre rate gave results similar to the 2.0 pounds per acre rate of the ethyl and isooctyl esters of 2, 4-D, but showed more vigorous regrowth; the 3.0 pounds per acre rate of the isooctyl ester of 2, 4-D had killed most of the foliage to the ground, but there was a healthy regrowth of approximately 80 percent of the plants; the 3.0 pounds per acre rate of 2, 4, 5-T showed results similar to that of the 3.0 pounds per acre rate of the isooctyl ester of 2, 4-D, but with a regrowth of approximately 75 percent; the chlorinated benzoic acid treatments showed incomplete top kill, with luxuriant, spindly, viny-type regrowth from the base of the plants which had been killed; the maleic hydrazide plots showed very little effect from the chemical, but insect damage had been severe and had apparently resulted in the destruction of the foliage before the chemical could be absorbed; the 1.0 pound per square rod treatment of ammate gave a stem kill to within 2 feet of the ground surface, but showed strong vigorous regrowth; the 2.0 pounds per square rod treatment of ammate showed 50 percent of the plants completely killed down to the ground, but new shoots emerged from the base of the old plants.

It seems reasonable to assume that at the time of treatment the swamp smartweed plants had attained the greatest part of their above-ground growth, in view of the height of the plants, and were at a low phase of metabolic activity. Also, the arid weather conditions, with only 0.96 inch of rainfall during July, 1953, as indicated in Table 2 of the appendix, coupled with high temperatures, were not conducive to active translocation of the herbicides.

The maleic hydrazide apparently increased the sugar content of the swamp smartweed leaves, since foliar destruction was virtually complete and immediate upon application of the chemical. Zukel, as quoted by Hoffman (26), stated that maleic hydrazide is absorbed slowly, 1/3 of the chemical being absorbed 18 hours after application. In this light it is apparent that the potential effect of the maleic hydrazide was destroyed.

The foregoing experiments indicate that control of top growth of swamp smartweed is possible with repeated applications of 3.0 pounds per acre of 2, 4-D and 2, 4, 5-T and with 2.0 pounds per square rod of ammate.

SUMMARY

Four pernicious perennial weeds, wild garlic (*Allium vineale*), field bindweed (*Convolvulus arvensis*), hoary cress (*Cardaria draba*), and swamp smartweed (*Polygonum coccineum pratincolum*) were treated with a group of chemicals at Manhattan, Kansas, in the spring and early summer of 1953. The former is a bulbous perennial, whereas the other three are deep-rooted creeping perennials.

The wild garlic was treated with the ethyl and butoxy ethanol

esters of 2, 4-D, with the diethanolamine salt of MCP, and with the 15 percent maleic hydrazide. With the exception of the MCP and the cumulative treatment of the ethyl ester of 2, 4-D, excellent results were obtained with all rates and formulations. The MCP appeared to have been applied at concentrations which were too low for effective control.

The ethyl and butoxy ethanol esters of 2, 4-D gave 98.3 and 99.3 percent control, respectively, with 1.5 pounds per acre. The maleic hydrazide gave 99.0 percent control at 4.0 pounds per acre.

Field bindweed was treated with the ethyl, butoxy ethanol, and isooctyl esters and the dimethylamine salt of 2, 4-D, the diethanolamine salt of MCP, chlorinated benzoic acid, polyborchlorate, CMU, and IN-12895. The results of the ethyl ester and amine of 2, 4-D indicated an insufficient amount of chemical had been applied. The butoxy ethanol and isooctyl esters indicated best control at the 1.0 pound per acre rate. The MCP showed the best results at 0.5 pound per acre, but the percent control was low. All the chlorinated benzoic acid treatments were poor, yielding less than 25 percent control. The polyborchlorate treatments showed good control at the higher rates, 8 and 10 pounds per square rod and 10 pounds per square rod applied in four applications. The IN-12895 showed very good percentages of control at 60 and 80 pounds per acre, but this could have been due to the weak stand of bindweed in the plots at the time of treatment. The CMU treatments were extremely poor. The indication for all of the growth-regulator type chemicals was that cumulative treatments do have an advantage, if applied in small enough applications to effect a maximum of absorption and translocation.

Hoary cress was treated with the diethanolamine salt of MCP, the ethyl, butoxy ethanol, and isooctyl esters of 2, 4-D, and chlorinated benzoic acid. The results of the chlorinated benzoic acid treatments were extremely poor. The MCP treatments yielded poor results, with the best control indicated at 3.0 pounds per acre. The ethyl and butoxy ethanol esters of 2, 4-D yielded fair results, indicating the most effective control at 3.0 pounds per acre. The isooctyl ester was most effective at 2.0 pounds per acre, but again yielded only fair results. In all cases, the cumulative treatments were inferior to the other treatments, indicating too large an interval of time between the separate cumulative applications.

The results of the swamp smartweed treatments were disappointing. With the exception of the chlorinated benzoic acid and maleic hydrazide, all treatments had resulted in complete foliar kill. However, when examined in the early fall, all plots showed moderate to vigorous regrowth. It is doubtful if any of the treatments applied to swamp smartweed injured the root system to the extent that complete recovery will not result during the ensuing growing season.

It should be borne in mind that it is extremely difficult to draw definite conclusions from the results of one season's work with perennial weeds. Also, the arid weather conditions, existing throughout the majority of the growing season, greatly reduced the effectiveness of the chemicals applied.

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APPENDIX

Table 1. Chemicals used in combined experiments.

Name of chemical	Manufacturer	% active material	Description and commercial name
Ethyl ester of 2, 4-dichlorophenoxy-acetic acid 1/	American Chemical and Paint Co., Ambler, Pa.	33.9% - 3 lb./gal.	(high volatile) Weedone Concentrate 48
Butoxy ethanol ester of 2, 4-D	Same	43% - 4 lb/gal.	(low volatile) Weedone LV-4
Isooctyl ester of 2, 4-D	Pittsburgh Agricultural Chemicals Co., Neville Island, Pennsylvania.	45% - 4 lb./gal.	(low volatile) Ester Weed Killer D-4
Dimethylamine salt of 2, 4-D	Pittsburgh Agricultural Chemicals Company.	41% - 4 lb./gal.	Amine Weed Killer No. 40
Diethanolamine salt of 2-methyl, 4-chlorophenoxyacetic acid 2/	American Chemical and Paint Co.	20.6% - 2 lb./gal.	Weedar MCP
Chlorinated benzoic acid	Pennsylvania Salt Mfg. Co., Philadelphia, Pa.	50%	NP-1239 D-50
Butoxy ethanol ester of 2, 4, 5-trichlorophenoxyacetic acid 3/	American Chemical and Paint Co.	41.5% - 4 lb./gal.	Weedone 2, 4, 5-T

Table 1 (concl.)

Name of chemical	Manufacturer	% active material	Description and commercial name
Polyborchlorate	Pacific Coast Borax Co., Los Angeles, California.	98%	Polyborchlorate Grass and Weed Killer
Ammonium sulfamate 4/	E. I. DuPont de nemoirs, Wilmington, Delaware.	80%	(granulated) Ammate Weed Killer
3-(parachlorophenyl)-1 1-dimethyl urea 5/	Same	80%	(wettable powder) 80% Weed Killer D
Phenyl dimethyl urea 6/	Same	80%	(wettable powder) IN-12895
2-ethyl hexoyl maleic hydrazide 7/	United States Rubber Co., Nangatuck, Chemical Div., Nangatuck, Conn.	15%	(liquid in oil) MH
Diethanolamine salt of maleic hydrazide	Same	30%	(Water soluble powder)

1/ 2, 4-dichlorophenoxyacetic acid, hereinafter abbreviated 2, 4-D.
2/ 2-methyl, 4-chlorophenoxyacetic acid, hereinafter abbreviated MCP.
3/ 2, 4, 5-trichlorophenoxyacetic acid, hereinafter abbreviated 2, 4, 5-T.
4/ Hereinafter designated as ammate.
5/ Hereinafter designated as CMU.
6/ Hereinafter designated as IN-12895.
7/ Hereinafter designated as maleic hydrazide.

Table 2. Temperature and precipitation data for April through October, 1953 at Manhattan, Kansas.

Date	April Min.	April Night min.	April Max.	April Precip.	May Min.	May Night min.	May Max.	May Precip.
1	40	35	61		44	40	63	
2	35	30	65	0.17	40	41	43	
3	30	26	57		41	38	58	
4	26	40	67		38	47	62	0.30
5	40	30	55		47	48	56	0.17
6	30	26	60	0.08	48	38	68	
7	43	47	54	0.13	38	38	68	
8	47	47	70		38	58	74	
9	44	31	50		58	59	84	0.28
10	31	35	53	0.06	56	45	76	
11	35	29	46	0.35	45	40	77	
12	29	27	49		40	38	71	0.02
13	27	47	66		38	31	51	T
14	47	42	68		31	40	66	
15	42	22	57		40	54	76	0.11
16	22	33	66		54	54	70	1.31
17	32	27	58		54	48	71	
18	51	28	49		48	46	74	
19	28	21	51		46	60	77	
20	21	42	62		60	56	88	T
21	42	56	87		56	63	78	
22	56	58	94		63	56	81	
23	58	57	79	0.04	68	61	92	
24	57	43	71		61	75	92	
25	43	35	67		75	68	99	
26	35	29	61		68	61	95	4.75
27	29	52	78		61	61	84	0.43
28	52	57	86	0.11	61	71	87	
29	54	47	71	0.72	71	72	91	
30	47	44	65		58	67	89	
31					58	67	89	

Table 2 (cont.)

Date	June Min.	June Night min.	June Max.	June Precip.	July Min.	July Night min.	July Max.	July Precip.
1	67	61	84		73	75	102	
2	61	75	88	T	75	66	93	0.37
3	75	74	95		66	74	85	
4	74	63	92	0.10	74	68	101	
5	60	57	84		68	63	102	0.13
6	57	64	71	0.11	63	60	80	
7	64	59	90	0.08	60	65	89	T
8	59	77	97		65	53	85	0.09
9	76	79	101		57	57	82	
10	79	75	101		57	63	85	
11	75	71	106		62	57	80	
12	71	76	100		60	57	83	
13	76	72	107		57	63	86	
14	72	71	94	0.49	63	63	89	
15	71	63	99		63	60	85	
16	63	63	88		60	59	87	
17	63	81	98		59	63	91	
18	81	80	104		63	63	94	
19	80	75	100	T	63	70	96	
20	75	65	93	0.23	70	69	91	0.02
21	65	64	96		69	68	94	
22	64	66	96	T	68	56	92	
23	66	72	94		56	61	96	
24	72	59	101	0.12	61	71	96	
25	59	56	91					
26	56	70	92	0.44	74	71	100	
27	70	67	99	0.08	71	73	99	
28	67	69	88	0.16	73	71	102	
29	69	72	93		71	68	103	
30	72	73	89	T	68	73	101	
31					73	79	104	

Table 2 (cont.)

Date	August				September			
	Min.	Night min.	Max.	Precip.	Min.	Night min.	Max.	Precip.
1	79	76	105		70	72	90	
2	71	69	102		72	65	97	1.32
3	69	72	91	0.03	56	45	87	0.95
4	72	70	89		45	47	72	T
5	70	61	91	1.13	46	48	84	
6	62	68	90	0.02	48	51	84	
7	68	54	81	0.02	51	60	81	T
8	54	57	81		60	69	90	
9	54	66	90		60	66	90	
10	66	70	93		66	58	90	
11	70	55	85	T	58	45	80	
12	55	53	88		45	49	90	
13	53	55	94		49	53	90	
14	55	65	99		53	47	88	
15	65	64	89		47	52	88	
16	64	62	83	0.18	52	71	95	
17	62	55	82	0.02	71	64	102	
18	55	51	85		58	42	90	0.01
19	51	55	86		42	53	89	
20	55	61	85		51	40	77	
21	61	54	87		40	37	71	
22	54	55	90		37	52	79	
23	55	73	93		52	53	87	
24	73	62	93	T	53	54	79	
25	62	66	95		54	56	89	
26	66	63	95		56	41	92	
27	63	67	95		41	68	91	
28	67	72	96		68	69	106	
29	72	74	98		69	42	91	
30	74	71	97		42	47	83	
31	71	70	97					

Table 2 (concl.)

Date	October			
	Min.	Night min.	Max.	Precip.
1	47	68	91	
2	68	68	94	
3	61	52	79	
4	52	31	72	
5	31	37	79	
6	37	32	65	
7	32	41	69	
8	41	34	84	
9	34	38	83	
10	72	38	79	0.09
11	38	43	86	
12	43	43	82	
13	43	53	86	
14	53	49	88	
15	49	58	86	
16	58	64	84	
17	64	67	87	
18	67	66	90	T
19	66	62	86	
20	62	63	78	0.58
21	61	50	74	0.28
22	50	40	73	
23	40	33	62	
24	33	49	63	0.48
25	49	42	59	
26	40	26	56	
27	26	33	57	
28	33	29	68	
29	29	43	71	
30	43	42	75	
31	42	29	76	

Table 3. Percent control of bindweed with chemicals.

	Pounds per acre										
	0.5	1.0	1.5	1.5-0.5 1/	3.0	6.0	6.0-2.0 2/	40	60	80	60-20 3/
MCP	36.4	16.3	14.5	26.9							
Ethyl ester of 2, 4-D	38.3	28.7	39.6	48.1							
Butoxy ethanol ester	25.6	47.8	24.3	36.0							
Isooctyl ester of 2, 4-D	38.2	42.6	23.6	33.8							
Amine of 2, 4-D	27.1	22.9	29.3	45.2							
Chlorinated benzoic acid					12.6	18.9	21.4				
CMU								3.3	0.0	16.6	34.0
IN-12895								23.7	74.0	74.0	14.2
	Pounds per square rod										
	6.0	8.0	10.0	8.0-2.0 4/							
Polyborchlorate	26.6	50.5	63.2	56.4							

Table 4. Percent control of hoary cress with chemicals.

	Pounds per acre							
	1.0	2.0	3.0	2.0- 5/ 1.0	3.0- 6/ 1.0	2.0	3.0	6.0
MCP		30.3	33.7		31.2			
Ethyl ester of 2, 4-D		43.7	50.2		37.9			
Butoxy ethanol ester of 2, 4-D		46.6	51.2		39.0			
Isooctyl ester of 2, 4-D	42.8	47.9	37.1	33.1				
Chlorinated benzoic acid							-38.0	-36.6
Ethyl ester of 2, 4-D						77.5		
Butoxy ethanol ester of 2, 4-D						89.3		

1/ 1.5 pounds per acre applied in 0.5 pound per acre applications.
2/ 6.0 pounds per acre applied in 2.0 pounds per acre applications.
3/ 60.0 pounds per acre applied in 20.0 pounds per acre applications.
4/ 8.0 pounds per square rod applied in 2.0 pounds per square rod applications.
5/ 2.0 pounds per acre applied in 1.0 pound per acre applications.
6/ 3.0 pounds per acre applied in 1.0 pound per acre applications.

THE USE OF CHEMICALS IN THE CONTROL
OF CERTAIN HERBACEOUS PERENNIAL WEEDS

by

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A large percentage of our most pernicious weeds, predominantly alien species, have increased with alarming rapidity in spite of a greater realization of the menace of weeds to agriculture. The losses due to weeds are second only to the losses due to erosion. Further, the losses due to weeds exceed the combined losses of the other three groups of agricultural pests, namely, (1) plant diseases, (2) animal diseases, and (3) insects, rodents, and predatory animals.

Effective weed control presupposes an understanding of the life cycles, growth habits and growth requirements of the weeds in question. The weeds included in the present study, wild garlic (Allium vineale), field bindweed (Convolvulus arvensis), hoary cress (Cardaria draba), and swamp smartweed (Polygonum coccineum pratincolum), are perennials. The former is a bulbous perennial, whereas the remaining three are creeping perennials.

The method of control of perennials, until recently, has consisted mainly of attempts to starve out the root system by restriction of top growth by such practices as intensive cultivation or frequent destruction of top growth by close cutting, pasturing, or burning. Little progress was made in the practical use of weed killers until the accidental discovery of the selective action of copper salts, during the latter part of the nineteenth century. The value of the subsequently developed herbicidal chemicals depended chiefly upon inherent morphological differences between certain crop plants and particular weedy species. The discovery of the selective action of certain synthetic growth-regulating substances in 1940 has placed greater emphasis upon differences in physiological responses of crop plants and weeds.

The object of the present study was to ascertain the most efficient chemicals and concentrations, primarily of growth-regulator type herbicides, for the control and possible eradication of four troublesome perennial weeds, namely, wild garlic, field bindweed, hoary cress, and swamp smartweed.

Wild garlic, an introduction from Europe, is commonly found from the Atlantic coast westward to the eastern half of Kansas, and southward to Mississippi. Reproducing by bulbs, bulblets, and seeds, the plant thrives in grain fields, meadows, lawns, and waste places.

Wild garlic was treated in mid-spring with the ethyl and butoxy ethanol esters of 2, 4-D, with MCP, and with the 15 percent maleic hydrazide. Excellent results were obtained with all rates and formulations of the chemicals used with the exception of MCP, which appeared to have been applied at concentrations too low for effective control.

Field bindweed, an introduction from Eurasia, is widespread throughout southern Canada and the northern and western states of the United States. A deep-rooted perennial, the plant reproduces by seeds, creeping roots, and rhizomes, thriving in cultivated fields, grain fields, and waste places.

Field bindweed was treated with the ethyl ester, butoxy, ethanol ester, isooctyl ester, and the dimethylamine of 2, 4-D, diethanolamine salt of MCP, chlorinated benzoic acid, polyborchlorate, CMU, and IN-12895. The results of the ethyl ester and amine indicated an insufficient amount of chemical had been applied. The plots treated with the butoxy ethanol and isooctyl esters indicated best control at 1.0 pound per acre. The MCP treatments showed the best results at 0.5 pound per acre, but the percent control was low. All chlorinated benzoic acid treatments were poor. The plots treated with polyborchlorate showed good results at the higher rates. The IN-12895 treatments indicated good results, but the CMU treatments were extremely poor. The indication for all of the growth-regulator type chemicals applied was that cumulative treatments do have an advantage if applied in small enough dosages to obtain a maximum of absorption and translocation.

Hoary cress, also an introduction from Eurasia, is found in the United States from the North Atlantic states to the midwestern states and the Pacific coast. This deep-rooted perennial reproduces by creeping roots, rhizomes, and seeds, thriving in cultivated fields, meadows, grain fields, along road sides, and in waste places.

Hoary cress was treated with the diethanolamine salt of MCP, the ethyl, butoxy ethanol, and isooctyl esters of 2, 4-D, and chlorinated benzoic acid. The MCP, ethyl ester and butoxy ethanol ester were most effective at the 3.0 pounds per acre rate, although the results of the MCP were poor. The isooctyl ester of 2, 4-D was most effective at the 2.0 pounds per acre rate. The chlorinated benzoic acid treatments yielded extremely poor results. In all cases, except the MCP treatments, the cumulative treatments were inferior to the other rates of application, indicating too large an interval of time between successive cumulative applications.

Swamp smartweed, a deep-rooted perennial reproducing by a long, tough, well-developed rhizome and fibrous root system is found from Quebec and Maine to Florida and westward to Kansas, thriving in low, wet areas, on cultivated land and in meadows, on fertile upland, along roadside ditches, and along streams.

The weed has, until recently, been controlled chiefly by intensive cultural practices. Maleic hydrazide, a relatively new herbicide, has been used successfully to control swamp smartweed.

Swamp smartweed was treated with the ethyl and isooctyl esters of 2, 4-D, with the butoxy ethanol ester of 2, 4, 5-T, chlorinated benzoic acid, the 30 percent maleic hydrazide, and ammate.

The results of the experiments were disappointing. The treatments with the ethyl and isooctyl esters of 2, 4-D at the 2.0 pounds per acre rate gave a top-kill to within 12 to 20 inches of the ground, but this was followed by moderately vigorous regrowth. Applications of 3.0 pounds per acre of the isooctyl ester of 2, 4-D killed most of the foliage to the ground, but later there was a healthy regrowth of approximately 80 percent of the plants. The 3.0 pounds per acre rate of 2, 4, 5-T gave similar results, with 85 percent regrowth of the plants. The 2.0 pounds per square rod of ammate killed 50 percent of the foliage, but new shoots came up from the base of nearly all of the plants.

It is doubtful if any of the treatments applied to the swamp smartweed injured the root system to the extent that complete recovery will not result during the next growing season.

It is extremely difficult to draw definite and accurate conclusions from the results of one season's work with perennials. Arid weather conditions, such as existed throughout most of the 1953 growing season, greatly reduce the effectiveness of the chemical treatment of perennial weeds.